POSTHARVEST PROCESSING TECHNOLOGY FOR FOOD AND NUTRITIONAL SECURITY

TRAINING MANUAL 2025

Agricultural Engineering Unit
Natural Resources Management Division
Bangladesh Agricultural Research Council

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FOREWARD

Postharvest processing plays a pivotal role in ensuring food security and nutritional well-being for communities worldwide. As we navigate through the challenges of feeding a growing population with finite resources, the importance of efficient postharvest practices cannot be overstated. This training manual on "Postharvest Processing Technology for Food and Nutritional Security" is a testament to our commitment to address these pressing issues.

As we strive to feed a growing global population while facing challenges such as climate change, resource scarcity, and food loss, the importance of optimizing postharvest processes becomes increasingly evident. This manual addresses these challenges head-on by providing practical insights, innovative techniques, and evidence-based strategies for improving postharvest handling and processing.

In this manual, readers will find a comprehensive overview of various postharvest processing techniques and technologies aimed at preserving the quality and nutritional value of agricultural produce. From drying and packaging methods to value addition and storage practices, each chapter delves into the intricacies of postharvest processing with clarity and precision. Furthermore, this manual emphasizes the significance of postharvest processing not only in enhancing food security but also in promoting nutritional diversity and mitigating food loss and waste. By adopting the best practices outlined in this manual, stakeholders across the agricultural value chain can contribute to building more resilient and sustainable food systems.

It is my hope that this training manual will serve as a guiding light for practitioners, policymakers, and researchers striving to make meaningful advancements in postharvest processing technology for the betterment of global food and nutritional security.

I extend my heartfelt gratitude to the authors, editors, and contributors who have dedicated their expertise, time, and passion to the creation of this invaluable resource. It is my sincere hope that this training manual will serve as a catalyst for positive change in the realm of postharvest processing, ultimately leading to improved food security and nutritional well-being for all.

Finally, I wish to thank the scientists of the Agricultural Engineering Unit for their sincere efforts in preparing this training manual and organizing this important training course.

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Postharvest Processing Technology from Farm to Fork: A Comprehensive Overview

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Background

Agriculture is the most important sector of Bangladesh economy due to its role in food security, employment and livelihood. The agriculture of Bangladesh is dominated by crops which accounts almost half of the total agriculture GDP (13.29%). There are number of mentionable successes in Bangladesh agriculture. Bangladesh is 4th largest rice producer, 3rd largest vegetable and inland water fish producer in the world. Bangladesh has also attained self-sufficiency in egg and meat production. On the other hand, Agricultural land is decreasing by 0.5% every year (FAO, 2014) due to urbanization and industrialization. Post-harvest losses of cereals, fruits and vegetables are from 14 to 44% (PHLIL-2021; Hasan et. al., 2010), amounting US$4000 million a year (Bangladesh Delta Plan 2100). However, significant amount of wastes is generating from agriculture and household food consumption which are contributing in GHG emission. Application of too much chemical fertilizer is deteriorating soil health where urgent need of replenishment with organic matter and fertilizer in order to enhance crop productivity. Coastal zone and the low lying area of Bangladesh are highly vulnerable, especially to cyclones and storm surges. In addition, salt-water intrusion, floods, sea level rise intensify with vulnerability of the community of the areas. These problems likely to become even worse due to climate change adverse impact.

Global food security agenda is summed up in sustainable development goal (SDG) no 2 i.e. zero hunger. SDG 2 aims to end hunger, achieve food security, improve nutrition and promotes sustainable agriculture. The zero hunger challenges are: (a) all food systems from production to consumption are sustainable, (b) an end to rural poverty by doubling small scale producer incomes and productivity, (c) adapt all food systems to eliminate loss or waste of food, (d) access adequate food and healthy diets for all peoples all year round and end to malnutrition in all its forms. But, Bangladesh food and agricultural production systems are linear where losses and wastes are occurred along the value chain. Therefore, transformation of our food systems is necessary for achieving SDG no 2.

Food and Agriculture Systems

The concept of a “food system” contrast with the traditional view of agriculture, food production, and consumption as a straightforward, linear path from farm to table. Food systems are complex networks that contain all of the inputs and outputs related with agricultural and food production and consumption. Food systems can change significantly from place to place and over time, depending on local factors. The food systems concept provides a complete framework for a ssessing the social, economic, and environmental aspect of sustainability.

These systems include various components such as farming practices, food processing, distribution channels, market mechanisms, policy frameworks, and consumer behaviours. Some key elements of the systems are as follows:

1. Production
2. Processing and Distribution
3. Supply Chain
4. Market Dynamics
5. Policy and Governance
6. Sustainability
7. Consumer Behaviour and Nutrition

Agricultural Production

Agricultural production operations encompass a series of stages that transform inputs into agricultural products, from cultivation to harvest and postharvest handling. These stages involve a combination of planning, management, and execution to ensure optimal productivity, quality, and efficiency. The distinctive stages in the agricultural production cycle includes- (1) Planting & sowing (2) Irrigation and fertilizer application (3) Harvesting (4) Postharvest handling (5) Drying (6) Storage (7) Packaging & Marketing (8) Transportation (9) Distribution & consumption. Each commodity in the agricultural production chain goes through the aforementioned stages between farms to consumer. The losses in agriculture mainly occur at the post-harvesting stages.

Handling

In agriculture, postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting etc. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Postharvest handling is a crucial phase in crop production that begins immediately after harvest. It involves a series of activities aimed at preserving the quality of the harvested produce from the field to the consumer. Key steps include cooling, cleaning, sorting, grading, packing, transportation etc. Each step requires careful management to minimize damage and spoilage. The science of postharvest handling focuses on understanding the biological and physical processes of harvested crops and the technologies to maintain their quality. Effective postharvest handling is essential to reduce food loss, ensure food safety, and maintain nutritional quality.

Different handling operations

1) *Cooling and pre-cooling:* Field heat is usually high and undesirable at harvesting stage of many fruits and vegetables and should be removed as quickly as possible before any postharvest handling activity. Precooling minimises the effect of microbial activity, metabolic activity, respiration rate, and ethylene production. Harvested fruit must be precooled to remove excessive field heat if harvested at times other than the recommended periods.
2) *Cleaning & disinfecting:* Proper hygiene is a major concern to all produce handlers, because of not only postharvest diseases, but also incidence of food-borne illnesses that

can be transmitted to consumers. In places where water is not a constraint, the use of disinfectants in water either for washing or for cooling can reduce both postharvest and food-borne diseases in fruits and vegetables.

3) *Sorting*: Sorting involves the separation of agricultural products based on various criteria such as size, shape, colour, ripeness, and quality. It is typically done manually or with the help of machinery such as conveyors, rollers, or optical sorting systems. Sorting helps eliminate damaged, diseased, or defective items, facilitates uniformity and consistency of products.

4) *Grading*: Grading involves categorizing agricultural products into different classes or grades based on predetermined standards or criteria. These standards may include factors such as size, weight, colour, texture, flavour, and maturity. Grading can be done manually by visual inspection or with the assistance of grading machines equipped with sensors or cameras.

5) *Transportation*: Safe transportation of agricultural products refers to the practices and measures implemented to ensure the secure and hygienic movement of agricultural goods from production areas to distribution points or markets. This includes various modes of transportation such as trucks, trains, ships, and airplanes, as well as storage and handling facilities along the supply chain.

Preservation of Agricultural Produce

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms. Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food. Preserving agricultural produce, or food preservation, helps to retain the freshness, quality, and nutritional value of food for longer periods of time. It also helps to prevent food waste, contamination, and infection.

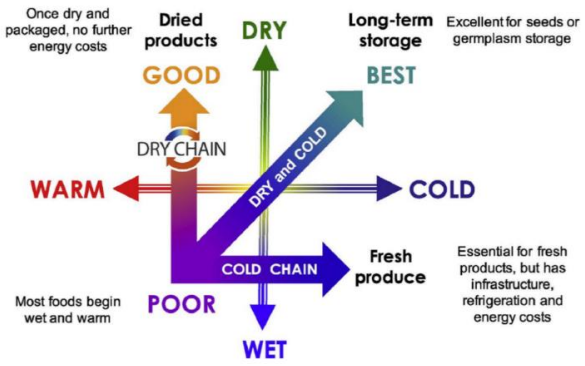

Figure 1: Cold and Dry chain for commodity storage

The post-harvest processing and preservation operations could be conducted in two ways- the “cold chain” system and the “dry chain” system (Fig. 1). The cold chain involves the use of temperature controlled, thermally protected storage systems. It’s applicable for the horticultural produces that cannot be dried and the only available option is to cool the

products quickly and keep them refrigerated during transportation and storage. But this way of post-harvest handling has infrastructure requirements including refrigeration and energy costs. On the contrary, the dry chain entails the process of removing the moisture from the perishable products to a level that is suggested and required for safe storage.

Drying

Drying is a process that involves simultaneous heat and mass transfer. In this process, the moisture levels of the products are brought to a safe limit that restricts the growth of microorganisms. Drying of products provide bulk reduction, ease of handling and transportation, improved taste and texture, preservation and storage, and protection from spoilage and microbial contamination. Open drying of products in the sun is a common and traditional practice to ensure a longer storage life. But it has many limitations such as, extreme sunlight dependency, uncontrolled drying rate, large space requirements, product quality deterioration etc.

The solar drying systems are primarily classified into open sun drying and solar drying. The solar energy drying systems are divided into two major groups: (a) active drying systems and (b) passive drying systems. Both are again classified into 3 sub-classes on the basis of system design and mode of heat utilization: (a) integral-type, (b) distributed-type, and (c) mixed-mode type. Both open sun drying and solar drying are largely dependent upon solar radiation. To establish a weather-independent drying, researchers have developed hybrid drying systems that incorporate an additional heating source.

Agricultural crops are classified as durable (e.g., grains and legumes) and perishable (e.g., fruits, vegetables, and fish), based upon the amount of water they contain during harvesting. The drying operation of agricultural products primarily depends upon certain parameters such as, moisture content, drying air temperature, relative humidity (RH), air velocity, pretreatment etc. Optimum drying conditions help significantly in conducting a fast-drying operation and achieving better quality dried products. If proper conditioning of the critical parameters is not done, then there could be economical loss due to prolonged drying time, product discoloration, and excess energy usage.

Benefits of solar drying over open sun drying: Solar drying is advantageous over open sun drying in 5 ways:

(1) Faster drying
(2) Increased drying efficiency
(3) Controlled environment drying
(4) Hygienic and healthier products
(5) Cost saving and better financial returns.

Solar hybrid dryers:

Hybrid drying is taken as an optimized process, involving the advantages of different methods of drying and showcasing low specific energy consumption. Solar hybrid dryers have an auxiliary heating unit that supplies heat during periods of no or low sunshine and

high humidity. The auxiliary heat can be provided using different energy sources, i.e., electricity, LPG, biomass etc. The solar hybrid dryers provide a faster, weather-independent, and efficient drying operation. The solar hybrid dryers can be broadly categorized into- (a) solar-electric hybrid dryers, (b) solar-biomass hybrid dryers, (c) solar-PV hybrid dryers, & (d) solar-LPG hybrid dryers (e) solar-TESS hybrid dryer.

Smart dryers:

The innovations and advancements in computer, control and sensor technology has motivated the establishment of smart dryers. These dryers are intricately monitored and controlled, with improved flexibility and performance. Microcontrollers, novel sensing technologies (i.e., electronic nose, computer vision etc.), and IoT-based interfaces are few of the components that control systems of the smart solar hybrid dryers may include. Microcontrollers can control, analyze and actuate different components (exhaust fan, heating elements) and parameters (temperature, humidity) of solar dryers.

Electronic sensors, mainly temperature and humidity sensors, are used to record dryer temperature profile and actuate accordingly. They convert physical phenomena into electric signals that are usable for electronic devices. DHT11, DHT22, BME280, LM35 are some common sensors used in monitoring and controlling of dryers. Weather, light, and weight sensors are also used in the control section. The availability and use of a wide range of sensors will improve the complexity and efficiency of the control unit.

Storage

Storage of agricultural products is the process of keeping harvested crops in a controlled environment to maintain their quality and freshness for extended periods. This process is a part of the post-harvest system and is essential for food security and to ensure that products reach consumers in optimal condition. Storage involves creating environments that minimize the impact of external factors such as temperature, humidity, pests, and diseases. Without proper storage conditions, crops can deteriorate quickly, leading to significant losses for farmers and food suppliers.

The storage of agricultural products generally requires moderate low temperature and cannot be excessively humid and protected from light. In particular, some agricultural products with harsh storage conditions, such as ripe bananas and tomatoes, require not only low temperature but also proper humidity to keep them fresh.

Requirements for storage

Storage requirements for agricultural products vary depending on factors such as the type of product, its moisture content, perishability, and intended duration of storage.

For efficient storage, the following parameters are needed to be controlled:

1) Temperature: Controlling temperature in cold storages is crucial for preserving food quality, preventing spoilage, and reducing postharvest losses. It inhibits microbial growth, extends shelf life, ensures food safety, and facilitates market access, thus

contributing to food security, economic viability, and sustainable agricultural practices.

2) Relative humidity: Proper RH levels prevent moisture buildup, mold growth, and product degradation. This ensures longer shelf life, reduces spoilage, and maintains the integrity of stored goods, ultimately supporting food safety, market competitiveness, and consumer satisfaction.
3) Gas Ratio: Gas ratio (O_2 and CO_2) is critical in storage systems to regulate respiration and decay processes in perishable goods. Optimal ratios inhibit microbial growth, slow ripening, and maintain product quality.
4) Pretreatment: Pretreatments can improve the storage life of fruits and vegetables by inactivating enzymes that cause browning and oxidation. Some pretreatment methods include blanching, osmotic dehydration, ultrasonic pretreatment etc.

Methods of storage:

(1) Refrigeration — cold storage room store

Low temperature **cold storage room** can reduce the respiratory intensity of agricultural products, reduce water loss, and inhibit the growth of microorganisms. And it can delay the activity of microorganisms and inhibit the activity of enzymes, so as to weaken the physiological and chemical changes of agricultural products during storage and maintain their due quality. The characteristic of this storage method is that the effect is good, but the cost is higher.

(2) Dry or dehydrated

There are two kinds of natural drying and artificial drying. The purpose of drying is to reduce the humidity of the storage environment and the agricultural products themselves, to eliminate the conditions for the growth and reproduction of microorganisms, and to prevent the agricultural products from becoming moldy. The physiological activities of dry agricultural products have been reduced to a very low level, which can effectively inhibit the activities of microorganisms and are suitable for long-term storage.

(3) Control the gas in the storage environment

Changing the concentration of breathing gas in the storage environment can inhibit the respiration of agricultural products and other metabolic reactions. With the development of the times and the progress of the country, the storage and preservation technology of agricultural products has been developing, such as the current mature cold storage.

Types of Storage Systems:

The storage systems are different according to the moisture level of the freshly harvested produce. The harvested crops can be classified into low moisture crops (grains etc.) and high moisture crops (fruits and vegetables etc.). The low moisture crops are generally stored in either bulk, bag, and hermetic storage technology. High moisture crops are more prone to damage and losses and thus they are stored in a controlled environment i.e., cold storage.

Hermetic bags are an efficient option for storing grains for a longer period of time without facing any damage or rodent infestation. Hermetic bags are airtight storage solutions designed to preserve the quality of agricultural commodities by creating a controlled environment that prevents moisture and oxygen from entering. Typically made from multi-layered materials such as plastic, these bags are effective in protecting stored grains, seeds, and other perishable goods from pests, mold, and spoilage. The lack of oxygen inside the bag inhibits the growth of insects and microorganisms, extending the shelf life of the contents. Hermetic bags are particularly beneficial in regions with high humidity or pest infestations, offering an affordable and environmentally friendly option for postharvest preservation and food security.

Smart cold storage is an innovative solution tailored for high-moisture crops, optimizing preservation and quality maintenance. Utilizing advanced technology like IoT sensors and data analytics, smart cold storage systems monitor and regulate temperature, humidity, and air circulation within the storage facility. This precision control prevents moisture buildup, reducing the risk of spoilage, mold, and bacterial growth in crops prone to high moisture content. Additionally, these systems can provide real-time alerts and remote access, enabling proactive management and timely intervention to uphold crop integrity. Smart cold storage enhances efficiency, prolongs shelf life, and ensures the freshness and safety of high-moisture crops throughout the supply chain.

There are multiple factors to consider in the technology and site selection of a cold storage facility:

Location: the location chosen should be easily accessible and close to market hubs and/or produce collection points
Electricity: the access to and the supply of electricity to the cold storage facility should be given. Electricity supply has an impact on the size and equipment feasible of the cold storage
Drainage and waste disposal: good drainage options and waste management equipment needs to be readily available
Water: supply of water is important for matter of sanitation. Also the removal of wastewater generated has to be given
Economic viability: the value generated though cold storage needs to justify investment and running costs

Importance of Storage of agricultural products:

1) *Preservation of Quality*: Proper storage helps maintain the quality of agricultural products by minimizing physical damage, reducing exposure to pests and diseases, and controlling environmental factors such as temperature, humidity, and light, which can lead to spoilage and deterioration.
2) *Market Stability*: Storage facilities enable producers to store surplus harvests during times of plenty and release them gradually into the market during periods of scarcity.

This helps stabilize prices and ensures a consistent supply of agricultural products throughout the year, reducing price volatility and food shortages.

3) *Extension of Shelf Life*: Effective storage techniques, such as refrigeration, controlled atmosphere storage, and drying, can extend the shelf life of perishable agricultural products, allowing them to be stored for longer periods without significant quality loss. This enables producers to access distant markets and meet consumer demand beyond the harvest season.
4) *Value Addition*: Properly stored agricultural products can undergo value addition processes such as packaging, processing, and grading, which enhance their marketability and profitability. Value-added products command higher prices and create additional income opportunities for farmers and agribusinesses.
5) *Food Security*: Adequate storage infrastructure is essential for ensuring food security by preventing postharvest losses and waste. By storing surplus agricultural products, countries can build strategic reserves to meet emergency food needs during times of natural disasters, conflicts, or other disruptions to food supply chains, thereby safeguarding against hunger and malnutrition.

Packaging

Food packaging can be defined as 'a complex and dynamic system aiming to safely prepare foods for transportation, distribution, storage, retailing, handling, and end-use, and safely deliver these foods to the consumer in a sound condition (maximum quality) at a minimum cost' (Floros, 1993). The Packaging Institute International (PII) defines packaging as the enclosure of products, items or packages in a pouch, bag, box, cup, can, tray, tube, bottle or other container form to perform one or more of the following functions: containment, protection and preservation, communication, utility, and performance. Food packaging defends against chemical, biological, and physical impurities. It protects products from outside factors like light, moisture, air, and microorganisms that can contaminate or spoil.

Materials used for packaging

Packaging materials come in a variety of shapes and serve multiple roles. It is critical for packaging materials to strike a balance between shape and function. The best packaging material for a specific type of food is determined by the purposes that the packaging is intended to serve. Metal food packaging comes in a variety of shapes, including cans, tubes, containers, films, caps, and closures. The two most common types of glass packaging for food and beverages are narrow-neck bottles and wide-opening jars and pots. Wood is used to make crates and cooking equipment. Paper is commonly used for temporary food containment and protection due to its high permeability and inability to seal with heat. Paper is occasionally utilized as a component in multilayered structures. Plastics are the most prevalent and diverse materials used for food packaging.

Antimicrobial food packaging

Different types of components, as well as polymeric materials, are commonly used in the creation of biofilm-based active packaging systems. This not only extends the shelf life of the product but also improves its safety. Because of the increased demand for preservative-free products and less processed food, packaging should have low amounts of preservatives

when in contact with food or other natural preservatives. The development of antimicrobial food packaging materials by integrating natural antimicrobial agents into a polymeric material is a revolutionary method in the food processing/packing sector.

Development of smart packaging

Food packaging plays an important role in the modern food industry since it helps to retain food product quality and ensures food safety during its shelf life. Traditional food packaging serves four main purposes: protection and preservation, containment, communication and marketing, and convenience. Packages are used to protect products from decomposition and damage caused by environmental variables such as microorganisms, insects, light, heat, oxygen, water vapor, odors, dirt, and so on. They can take a variety of shapes and sizes to keep food products, with the goal of increasing logistics efficiency. They communicate with the consumer using written materials and the brand logo. They adapt to consumers' lifestyles, for example, by saving time (ideal for ready-to-eat meals) or facilitating their handling (easy to open, re-closable, or microwaveable).

Active and Intelligent Packaging

Active packaging is the addition of active substances or components to the packaging material that interact with the food to extend its shelf life and maintain its quality. For example, oxygen scavengers can be used to remove oxygen from the packaging, slowing down oxidation and preventing rotting. Similarly, moisture absorbers and emitters can control humidity levels, preventing moisture-related problems including mold growth and product drying. Intelligent food packaging is the application of modern technology and materials in packaging systems to improve the safety, quality, and shelf life of foods. It uses a variety of elements, including sensors, indications, and tracking systems, to monitor and communicate information about the state of packaged food.

Transportation and Distribution

Transport systems are the most important part of efficient agriculture. The main role of transport is to deliver agricultural products from farms to markets and to cities worldwide. Correct logistics is the key to managing the assets or goods from the point of origin to the consumers. Transport enables farmers to invest more, boost output, and reach global markets. Without agricultural transportation, business expansion is difficult because everything must be transported, conveyed, or carried to the customer. Furthermore, substantial volumes may be squandered if farm-to-market transportation is inefficient, resulting in quality deterioration. In fact, how crops are carried has a significant impact on farmers' reputations and businesses.

Safe transportation is crucial for agricultural products for several reasons:

1) Preserving Product Quality: Many agricultural products, especially perishables like fruits, vegetables, and dairy, are sensitive to temperature, humidity, and handling conditions. Safe transportation ensures that these products reach their destination in optimal condition, preserving freshness, flavor, and nutritional value.
2) Minimizing Losses: Proper transportation practices help minimize losses due to spoilage, damage, or contamination during transit. This is essential for farmers and distributors to maximize their returns on investment and maintain profitability.

3) Meeting Regulatory Standards: Food safety regulations require that agricultural products be transported under hygienic conditions to prevent contamination and ensure consumer safety. Compliance with these standards is necessary to avoid legal penalties and maintain consumer trust.
4) Maintaining Market Access: Many countries have strict import regulations for agricultural products, including requirements for transportation and handling practices. Safe transportation is essential for exporters to meet these standards and maintain access to international markets.
5) Consumer Confidence: Safe transportation practices contribute to consumer confidence in the food supply chain. Consumers expect that the products they purchase are handled and transported safely to protect their health and well-being.
6) Reducing Food Waste: Food waste is a significant issue globally, and inefficient transportation practices contribute to this problem. Safe transportation helps reduce food waste by ensuring that products are delivered in optimal condition and have a longer shelf life.
7) Protecting Brand Reputation: For food producers and distributors, maintaining a positive brand reputation is crucial for long-term success. Safe transportation practices help protect brands from negative publicity associated with food safety incidents or quality issues during transit.

Distribution of agricultural products:

The distribution of agricultural products involves a complex network of processes and players that facilitate the movement of goods from farms to consumers. Agricultural products are distributed through channels, which are sets of interdependent organizations that make products available for consumption. These organizations are called intermediaries and include merchants, agents, and brokers. Merchants buy and resell products, while agents and brokers act on behalf of the producer.

A direct circuit, which eliminates intermediaries, can give producers large margins and allow them to set their own selling prices. It also allows producers to create a more personal relationship with consumers and promote their company's know-how.

Here's an overview of how distribution typically occurs:

1) Harvesting: The process begins with the harvesting of agricultural products on farms. This can involve manual labor, machinery, or a combination of both, depending on the type of crop.
2) Packaging and Grading: After harvest, the products are often sorted, graded, and packaged according to quality standards. Packaging may vary depending on factors such as the product's perishability, transportation method, and market destination.
3) Transportation from Farm to Distribution Centers: Once packaged, the products are transported from farms to distribution centers or warehouses. This transportation may involve trucks, trains, ships, or a combination of modes, depending on the distance to be covered and the infrastructure available.

4) Wholesale Distribution: At distribution centers, wholesalers purchase agricultural products in bulk from producers and consolidate them for redistribution to retailers, food service providers, and other buyers. Wholesalers may also perform functions such as storage, repackaging, and quality control.
5) Retail Distribution: From wholesalers, agricultural products are distributed to retailers such as supermarkets, grocery stores, farmers' markets, and specialty shops. Retailers display the products for sale to consumers, often organizing them by category and providing information on origin, price, and quality.
6) Direct-to-Consumer Sales: In addition to traditional distribution channels, some agricultural producers sell their products directly to consumers through farm stands, online platforms, community-supported agriculture programs, and farmers' markets. This allows producers to bypass intermediaries and establish closer connections with consumers.
7) Export Distribution: For agricultural products intended for export, distribution involves additional steps such as compliance with international trade regulations, customs clearance, and transportation via air, sea, or land to reach overseas markets.

Consumption

Global food consumption is, quite simply, the amount of food and calories that are consumed by people. According to the FAO, the average minimum daily energy requirement is approximately 8,400 kilojoules (2,000 kcal) per adult and 4,200 kilojoules (1,000 kcal) a child. The volume of global food consumption has been ever-increasing since 2015. In 2021, the global consumption of food reached 2.5 billion metric tons. There are many impacts of global food consumption, such as food insecurity, environmental issues, and impacts on health etc. The volume of global food consumption has been ever-increasing since 2015. In 2021, the global consumption of food reached 2.5 billion metric tons. Bread and cereal products were the largest category of consumption, accounting for 626 million metric tons in that year. In 2022, the average person in Bangladesh consumed 2,393 kilocalories per day, which is an increase from 2,210.4 kilocalories in 2016 and 2,318.3 kilocalories in 2010. The daily per capita consumption of major foods, including vegetables, fish, meat, pulses, milk, and fruits, increased from 734.7 grams in 2016 to 820.8 grams in 2022.

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Postharvest Loss and Waste from Farm to Fork: Status and Strategies to Minimize Food Loss and Waste

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Background

The reduction of food loss and waste (FLW) is getting major attention for meeting the food and nutrition demand of an ever-increasing global population. Projection studies estimate that approximately 600 million people will face chronic hunger in 2030 (FAO, 2023). In most of the developing countries, deprivation from food and nutrition is not because of insufficient agricultural production, but due to improper postharvest handling and storing techniques. In 2020, fruits and vegetables (F&V) accounted for 37% of the total value of crop production (FAO, 2022). The worldwide losses of F&V are found between 40 and 50% (54% of which occur at the production, postharvest handling, and storage stages; while the remaining 46% are found at the processing, distribution, and consumption stages (Santos *et al, 2019)*. On the other hand, up to 35% of the global production in fisheries and aquaculture is either lost or wasted every year. This loss is driven by the inefficiencies in the food value chains, most importantly, inadequacy of the infrastructure, poor handling, preservation and storage facilities etc. In South Asia, lack of appropriate postharvest technologies leads to a loss of 14% for paddy (PHLIL 2021) and 20 to 40% in case of fruits and vegetables in Bangladesh (Hasan, 2010), a developing country in Asia, has postharvest losses (PHL) of F&V in the range of 23.6 to 43.5%, and similar trend is also noticed in case of other Asia-Pacific countries (OECD, 2023).

Postharvest Loss

Postharvest losses refer to the reduction in quantity and quality of food that occurs between the time crops are harvested and the time they are consumed. These losses can happen due to various factors including improper handling, storage, transportation, and processing of agricultural products.

Types of losses:

Postharvest losses can occur at any stage of the supply chain, from the farm gate to the consumer's plate. They can be classified into two main categories:

1) Quantitative Losses: These refer to the reduction in the quantity of food available for consumption. Quantitative losses can occur due to factors such as spillage during transportation, spoilage caused by pests and diseases, inadequate storage facilities leading to physical damage or deterioration, and inefficient handling practices.
2) Qualitative Losses: These refer to the deterioration in the quality of food, even if the quantity remains the same. Qualitative losses can occur due to factors such as improper handling leading to bruising or damage, exposure to unfavorable environmental

conditions such as temperature and humidity fluctuations, contamination by microorganisms, and chemical changes such as enzymatic reactions.

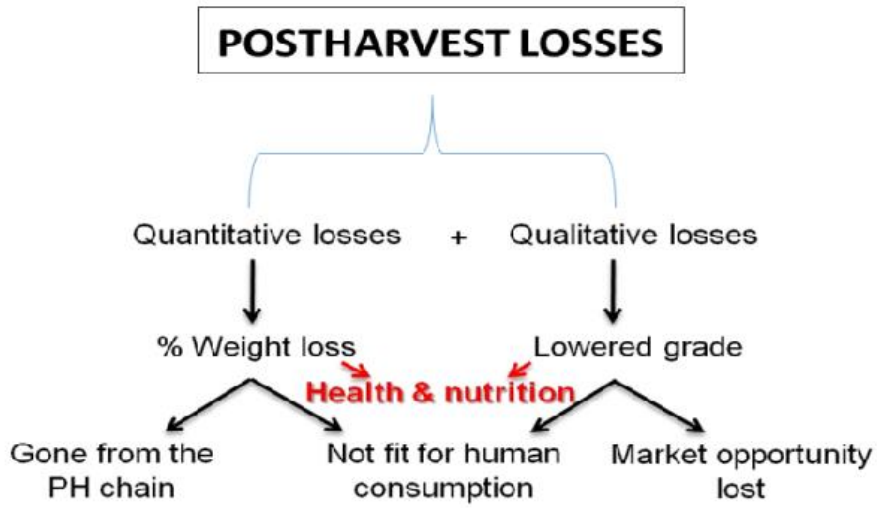

Figure 1: Type of Post-harvest losses (Adapted from Palumbo et al., 2022)

Food waste

Food "waste" refers to food that is fit for consumption but consciously discarded at the retail or consumption phases. Food waste occurs along the entire spectrum of production, from the farm to distribution to retailers to the consumer. Reasons include losses from mold, pests, or inadequate climate control; losses from cooking; and intentional food waste.

Global food loss and waste

Globally, around 13 percent of food produced is lost between harvest and retail, while an estimated 17 percent of total global food production is wasted in households, in the food service and in retail all together. The worldwide losses of fruit and vegetables are found between 40 and 50%. The 54% of which occur at the production, postharvest handling, and storage stages; while the remaining 46% are found at the processing, distribution, and consumption stages.

Food that is lost and wasted accounts for 38 percent of total energy usage in the global food system and also responsible for approximately between 691 and 783 million people to face hunger in 2022. When food waste is dumped at landfill sites it rots and produces large volumes of methane – a potent greenhouse gas. Food waste accounts for an estimated nine percent of global food system greenhouse gas emissions, which in 2015 totaled 17.9 billion metric tons of CO_2 equivalents.

China and India produce more household food waste than any other country worldwide at an estimated 92 million and 69 million metric tons every year, respectively. This is unsurprising, considering both countries have by far the largest populations globally. Food waste has often been thought to be concentrated in wealthier countries; however, in terms

of food waste per capita, there are similarities between developed and developing countries. It is estimated that per capita food waste production is highest in Western Asia and Sub-Saharan Africa.

The global population produced approximately 931 million metric tons of food waste in 2019. This represented roughly 17 percent of total food made available. Household food waste was the main source of food waste that year, accounting for 61 percent of the total. The second main source of food waste was the foodservice sector.

Reducing food loss and waste

The reduction of food loss and waste is getting major attention for meeting the food and nutrition demand of an ever-increasing global population. The postharvest losses can be reduced by preserving the fruits, vegetables & fishes in several ways such as cold storage, chemical treatment or drying. Chemical treatment is expensive and also not very effective in farmer's level. Drying prior to storage becomes the promising solution for the smallholder farmers of developing nations since it is an important post handling process of horticultural crops as well as fishes and they can easily adapt the technology.

To mitigate the postharvest loss and waste, the followings need to be assessed first:

1) ***Extent of Losses:*** Postharvest losses vary by region, crop type, and stage of the supply chain. According to the Food and Agriculture Organization (FAO), globally, around one-third of all food produced for human consumption is lost or wasted each year. In developing countries, postharvest losses can be as high as 50% for certain perishable crops.
2) ***Causes of Losses:*** Postharvest losses stem from a combination of factors, including inadequate infrastructure and storage facilities, poor handling practices, lack of access to markets, inefficient transportation systems, and limited technical knowledge among farmers and food handlers. Climate change-related events, such as extreme weather events and pests and diseases, further exacerbate the problem.
3) ***Impact on Food Security:*** Postharvest losses have significant implications for food security, particularly in developing countries where a large proportion of the population depends on agriculture for their livelihoods and food supply. Reduced food availability and increased prices resulting from losses can exacerbate food insecurity and malnutrition.
4) ***Economic Implications:*** Postharvest losses represent a waste of valuable resources, including labor, land, water, and energy, leading to economic inefficiencies and reduced incomes for farmers and stakeholders along the supply chain. Addressing postharvest losses has the potential to improve economic outcomes for farmers and enhance the profitability of the agricultural sector.
5) ***Environmental Impact:*** Food loss and waste contribute to environmental degradation by squandering resources used in food production, such as water, land, and energy, and generating greenhouse gas emissions from the decomposition of organic matter in

landfills. Minimizing postharvest losses can help reduce the environmental footprint of agriculture and mitigate climate change.

6) ***Challenges Ahead:*** Despite progress in addressing postharvest losses, significant challenges remain, including funding constraints, limited access to technology and resources, inadequate infrastructure, and systemic issues within the food supply chain. Addressing these challenges will require sustained efforts and collaboration across sectors and stakeholders.

Minimizing postharvest loss and waste from farm to fork requires a multi-faceted approach involving stakeholders across the food supply chain. Following strategies to address this issue could be a vital approach:

1) **Improving Harvesting Techniques**: Implementing proper harvesting practices, such as using sharp tools, harvesting at the right time, and handling produce carefully, can minimize physical damage and bruising, reducing losses during harvesting.
2) **Investing in Storage Infrastructure**: Building and upgrading storage facilities, including cold storage, warehouses, and drying facilities, can help extend the shelf life of perishable produce and reduce losses due to spoilage and deterioration.
3) **Enhancing Transportation and Logistics**: Improving transportation networks, including roads, railways, and cold chain logistics, can help reduce transit times and minimize temperature fluctuations, ensuring that produce reaches markets in optimal condition.
4) **Adopting Postharvest Technologies**: Utilizing postharvest technologies such as refrigeration, controlled atmosphere storage, and modified atmosphere packaging can help slow down the ripening and deterioration of fruits and vegetables, extending their freshness and shelf life.
5) **Educating Farmers and Food Handlers**: Providing training and technical assistance to farmers and food handlers on best practices for postharvest handling, storage, and packaging can help improve awareness and skills, reducing losses throughout the supply chain.
6) **Implementing Quality Standards and Grading Systems**: Establishing quality standards and grading systems for produce can help ensure consistency and uniformity, reducing the risk of rejection and increasing market access for farmers.
7) **Reducing Consumer Food Waste**: Educating consumers about proper storage, meal planning, and portion control can help reduce food waste at the household level, contributing to overall waste reduction efforts.
8) **Policy Support and Investment**: Governments can play a critical role in supporting initiatives to minimize postharvest loss and waste by providing incentives, funding research and development, implementing supportive policies, and strengthening regulatory frameworks.

By implementing these strategies in a coordinated manner, stakeholders can work together to minimize postharvest loss and waste, ensuring a more sustainable and resilient food system for the future.

Circular Food System

The circular food system or circular bioeconomy can be defined as the production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy (San Juan et al., 2022). The circular food system approach may help to reduce post-harvest losses and wastes.

Bioeconomy examples can effectively contribute to some IPCC mitigation options, drawing a link between bioeconomy and climate change mitigation. Nine bioeconomy examples have been chosen in three main macrosectors that relate to agrifood systems: primary production (agriculture, forestry and other land use (AFOLU) and fisheries); bio-based industries; and circularity and by-product use (Figure 2). These are linked to climate smart agriculture i.e. resource efficiency, productivity, and reuse.

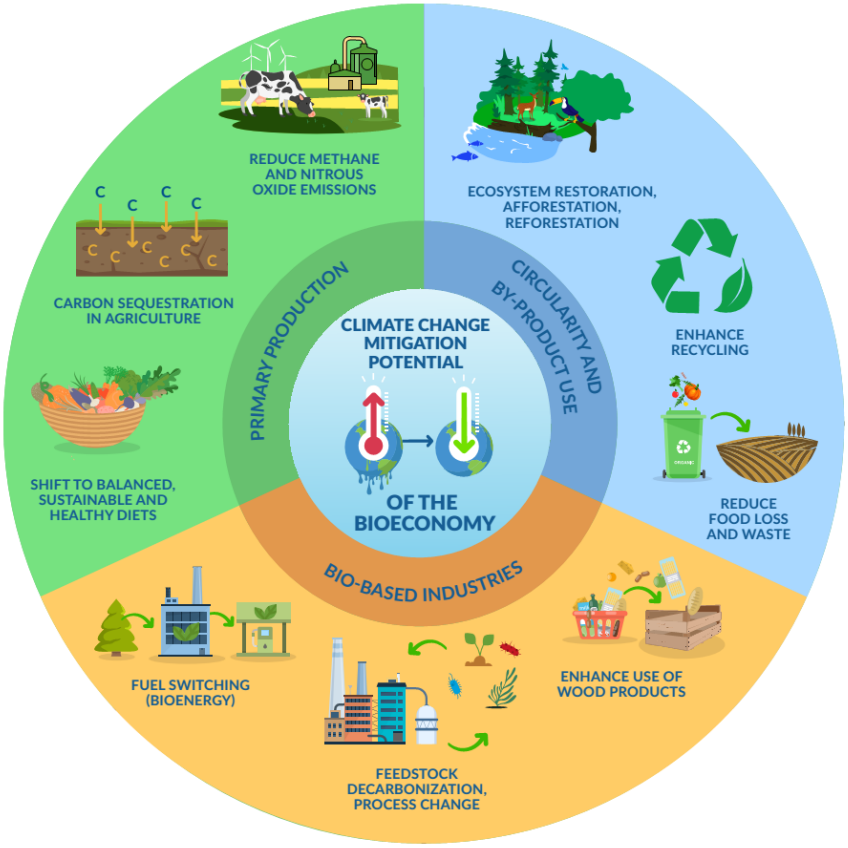

Figure 2. IPCC mitigation options that bio-economy can support along the whole agrifood system (San Juan et al., 2022)

Now, the question is how to ensure circular food systems and zero hunger challenges in Bangladesh by overcoming all the adverse conditions as stated earlier. First of all, we might consider integrated production approach including crop-fisheries and livestock together (Figure 2). However, adaption of mechanization and precision farming are also needed to be integrated for sustaining this approach. As for example, paddy transplanting and harvesting by machines can save cost 30 to 60%. On the other hand, ensuring comfort with adequate fresh air can help to increase milk production of existing dairy farms. Adaption

of modern fish farming like biofloc technology can help to increase fish production in many folds.

Beside open field production, controlled environment food and agricultural systems are unique food and agriculture system which can be adapted in saline and drought prone areas of Bangladesh. One of the best examples of controlled environment food and agriculture system is greenhouse system. Greenhouse production systems are more sustainable than conventional production system because they greatly reduce need of water, land and chemicals. The CO_2 level is often enriched to complement the enhanced lighting level & increased production in many folds. As for example, Bangladesh produces 4 to 10 kg tomato per square meter in open field; on the other hand, Netherlands and India produce 50 to 70 and 25 to 30 kg tomato per square meter, respectively in the greenhouse in a year. However, vertical farms and plant factories adapt advanced manufacturing concepts to the production of plant based materials for food and other uses, such as pharmaceuticals and chemical feedstock. They are suitable for the areas that are not conducive to conventional food production and in location impacted by disasters.

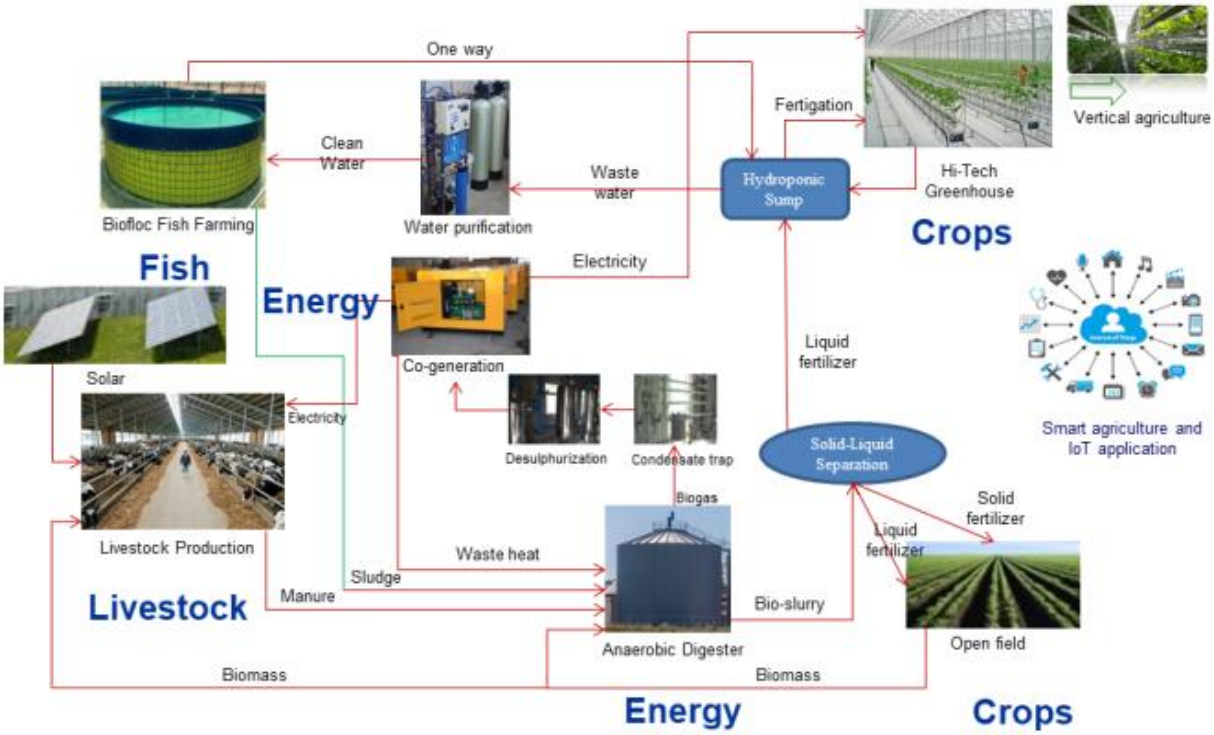

Figure 3: Circular Production System with solar-biogas-internet of things (IoT) nexus

As stated earlier, reduction of post-harvest loss is one of the zero hunger challenges in achieving SDG no 2. For reducing post-harvest loss of cereals, vegetables and fruits, adaption of appropriate post-harvest management and processing technologies are necessary to add large amount food in the food baskets. As for example, appropriate mechanized harvesting, drying and storage solutions at farmers and traders level can save 7.1 million ton of paddy per year. Despite huge production of fruits and vegetables in seasons, we could not ensure healthy and nutritious high value crop like fruits and vegetables year round due to lack of adequate appropriate storage facilities. Only ensuring

cold storage for potato, we can add 0.6 million ton more potato every year. There are also lack of cold storage and appropriate transportation facilities like cool vane for other fruits and vegetables. However, affordable low cost dry chain of fruits and vegetables are not developed yet in Bangladesh due to our food consumption habit & lack of appropriate drying, packaging & storage solutions as well as awareness. However, there is a potential export market of dried and processed fruits and vegetables. We need to take drastic initiative, make proper guideline and programs for reducing post-harvest losses, making available healthy food, and earn foreign revenue.

On the other hand, waste generated from crop, livestock and fishes as well as process crop residues and city wastes can be useful sources of bioenergy. Approximately 61 million ton of residues/wastes are being generated every year which can be utilized to produce biogas 10,000 million m^3 through anaerobic co-digestion (Saha, 2021). This produced biogas can be converted to renewable electricity which is about 19000 gWh per year. Even if we can utilize 50% of biogenic residues and wastes for renewable energy production, this will help to fulfill to some extent the government goal of 20% electricity from renewable resources by 2030 which is linked to SDG 7-affordable clean energy. Bio-slurry that comes out from biogas plants after digestion can be a good source of bio-fertilizer or soil conditioners for improving soil health and crop yield. At the same time, one of our calculation shown that biogas production through anaerobic co-digestion can reduce global warming potential or greenhouse gas emission from agriculture by 93% in comparison to open land filling.

Therefore, adoption of circular food system and appropriate drying and storage technologies for cereals, fruits and vegetables may help to reduce post-harvest losses, and waste as well as reduction of greenhouse gas emission by recycling and reusing biomass and wastes.

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Advanced Food Science and Technology: From Instrumental Analysis to Modern Preservation Techniques

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Introduction

Modern food processing technologies play an essential role in ensuring the quality, safety, and longevity of food products. By incorporating both thermal and non-thermal preservation methods, industries can enhance food shelf life and meet consumer preferences for fresh, nutritious, and eco-friendly options. Thermal techniques such as pasteurization and sterilization involve controlled heat application to eliminate harmful microorganisms, ensuring food safety. Meanwhile, non-thermal methods like high-pressure processing (HPP), pulsed electric fields (PEF), and cold plasma preserve food without compromising its nutritional value or sensory qualities. These advancements align with the growing emphasis on sustainability and resource efficiency, thereby transforming the food industry.

Applications in Advanced Food Technology

Size Reduction

Size reduction is a critical process in food manufacturing, involving the breaking down of large food particles into smaller sizes to facilitate processing. Attrition mills, commonly known as plate mills or disc pulverizers, are widely used for small-scale milling operations. These mills operate based on shearing and cutting principles. Material is introduced between two circular plates with roughened surfaces, where one plate remains stationary, and the other rotates. The result is effective crushing and shearing of materials, improving their texture and suitability for further processing.

Mixing and Pasteurization

Mixing is a fundamental operation in the food industry, ensuring the uniform distribution of components in a mixture. Despite its ubiquity, it remains one of the least understood processes. Effective mixing requires a clear understanding of material properties and operational parameters. Pasteurization, another vital process, involves heating food to a specific temperature to destroy harmful microorganisms while preserving its quality. This ensures both safety and an extended shelf life for products.

Evaporation

Evaporation is a key operation for concentrating aqueous solutions by removing water through vaporization. This process is critical in producing products like condensed milk, fruit concentrates, and syrups. Modern evaporators are designed to efficiently

transfer heat, minimize energy consumption, and retain the desired properties of the concentrated product.

Preservation Technologies

Spray rying

Spray drying is an advanced technique for transforming liquid feeds, such as emulsions or suspensions, into dried particles by spraying them into hot air. This method is ideal for producing consistent, high-quality powders and granules, which are widely used in industries such as dairy, pharmaceuticals, and flavor manufacturing. While the initial costs are high, the efficiency and quality of the final product make spray drying a preferred method for large-scale operations.

Electromagnetic Spectrum (EMS)

Electromagnetic spectrum technologies leverage energy waves such as infrared and microwave radiation for food preservation. These waves efficiently penetrate food products, converting stored energy into heat. This technique is particularly effective for drying and sterilization, offering a sustainable and energy-efficient alternative to conventional methods.

Nanotechnology

Nanotechnology is revolutionizing food preservation by introducing innovative materials like nanoparticles for packaging and edible coatings. These advanced materials extend the shelf life of perishable goods, reduce microbial spoilage, and enhance food safety. Nanotechnology also provides eco-friendly solutions, addressing environmental concerns through biodegradable alternatives to traditional plastics.

Modern Packaging Technology

Packaging is an integral part of food preservation, influencing both the quality and safety of the product. Interactions between the food and packaging materials, such as permeation, migration, and sorption, can affect the sensory and nutritional properties of food. Materials like metal and glass have lower transfer rates and provide better protection compared to plastic. Active packaging technologies and advanced integrity testing methods, such as vacuum leak tests, help mitigate risks and ensure long-term food safety.

Extrusion Method for Biodegradable Packaging

The extrusion method is a preferred technique for producing biodegradable packaging materials due to its energy efficiency and cost-effectiveness. This dry process involves feeding, kneading, and heating to form films with desired properties. Parameters like screw speed, feed moisture, and barrel temperature play a critical role in determining the flexibility and mechanical strength of the final product. Extrusion also supports sustainability by minimizing water and solvent use, making it an eco-friendly alternative to traditional packaging production methods.

Conclusion

Innovations in food science and technology have revolutionized the way we ensure food quality, safety, and sustainability. From modern preservation techniques like high-pressure processing and nanotechnology to advanced packaging solutions and sustainable farming practices, these advancements address critical challenges in the food industry. They enhance food safety, retain nutritional value, extend shelf life, and reduce environmental impacts. By integrating cutting-edge science and eco-friendly approaches, the food industry is better equipped to meet the evolving demands of consumers while promoting global food security.

Recommendation

To maximize the benefits of these innovations, stakeholders in the food industry should:

- Invest in research and adoption of advanced preservation and packaging technologies.
- Implement sustainable farming and production practices to reduce environmental impact.
- Prioritize quality assurance and regulatory compliance to maintain food safety standards.
- Promote interdisciplinary collaboration to innovate solutions tailored to market demands.
- Educate consumers on the importance of these technologies and sustainable practices for healthier and safer food systems.

Innovations in Food Production: Ensuring Quality, Safety, and Nutritional Value from Farm to Fork

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Introduction

Ensuring food quality and safety is critical in addressing public health concerns and improving the quality of life worldwide. The increasing complexity of food supply chains, driven by globalization and technological advancements, has necessitated robust safety measures to mitigate the risks of foodborne diseases, contamination, and nutrient degradation. Traditional food processing methods have evolved to include innovative techniques such as nanotechnology, cryogenics, and controlled fermentation, which enhance food preservation, extend shelf life, and improve nutritional content. These advancements are vital in tackling contemporary challenges such as population growth, climate change, and resource scarcity while meeting the growing consumer demand for functional and health-promoting foods.

Key Trends in Food Processing

Nanotechnology

Nanotechnology operates at the molecular and atomic scale, allowing precise manipulation of food structures to improve quality, safety, and functionality. Encapsulation techniques protect sensitive nutrients from degradation, enhance their bioavailability, and allow controlled release, ensuring better absorption in the human body.

Cryogenics

Cryogenics employs extremely low temperatures for food preservation, ensuring that products retain their freshness, taste, and nutritional value.

- Extended Shelf Life
- Nutrient Retention
- Reduction in Food Waste

Controlled Fermentation

This traditional method has been revolutionized by modern applications, making it a cornerstone for both preservation and enhancement of food products. It involves the intentional use of microorganisms to achieve desired qualities:

- Improved Safety: Controlled fermentation suppresses the growth of harmful pathogens, ensuring microbiological safety.
- Enhanced Nutritional Profile: Fermentation enriches foods with probiotics and bioactive compounds, promoting gut health and immunity.

- Unique Flavor Profiles: By leveraging specific microbial strains, controlled fermentation creates diverse and appealing flavors, expanding gastronomic possibilities.

Functional Foods and Nutrient-Enriched Products

- Functional foods and nutrient-enriched products provide health benefits beyond basic nutrition, helping prevent diseases, enhance physical and mental well-being, and address nutrient deficiencies.
- Functional foods include probiotics, prebiotics, fortified foods, and bioactive compounds like omega-3s and antioxidants, promoting gut health, reducing cholesterol, and combating oxidative stress.
- Nutrient-enriched products use techniques like fortification, biofortification, and encapsulation to enhance the nutritional profile of foods, addressing deficiencies such as iron, iodine, and vitamin A.

Ensuring Food Quality and Safety

Hazard Analysis and Critical Control Points (HACCP)

- Principle 1: Conduct a hazard analysis.
- Principle 2: Determine the Critical Control Points (CCPs).
- Principle 3: Establish critical limit(s).
- Principle 4: Establish a system to monitor control of the CCP.
- Principle 5: Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
- Principle 6: Establish procedures for verification to confirm that the HACCP system is working effectively.
- Principle 7: Establish documentation concerning all procedures and records appropriate to these principles and their application.

Challenges in maintaining food quality across global supply chains.

Strategies by FAO/WHO to enhance safety

Challenges and Ethical Considerations

- HACCP: Identifies and controls hazards in food production.
- Nanotechnology: Detects pathogens and prevents microbial growth.
- Cryogenic Preservation: Rapid freezing to inhibit bacteria.
- Controlled Fermentation: Uses beneficial microbes for safety.
- Agricultural Practices: Minimizes pesticide residues and contamination.
- Food Irradiation: Kills bacteria and parasites using ionizing radiation.
- Consumer Education: Promotes safe food handling and storage.

Regulatory frameworks and public awareness

Regulatory Frameworks:

- International standards (Codex Alimentarius, WHO, FAO).
- National laws on food safety, labeling, and contamination.
- HACCP implementation and compliance enforcement.

Public Awareness:

- Consumer education on food handling and hygiene.
- Transparency in nutritional labeling and allergy warnings.
- Community workshops and NGO involvement.

Balancing innovation with ethical food production

- Promote sustainable and eco-friendly practices.
- Ensure fair trade and ethical labor conditions.
- Provide transparency in production and labeling.
- Prioritize health and safety in innovations.
- Balance affordability with advanced technologies.
- Respect cultural food practices and traditions.
- Comply with ethical and regulatory standards.

Sustainability in Food Production

- Reducing Waste Through Advanced Preservation
- Cryogenic Freezing: Preserves food freshness and prevents spoilage.
- Vacuum Sealing: Extends shelf life by reducing oxidation.
- Modified Atmosphere Packaging (MAP): Replaces air with inert gases to slow decay.
- Nanotechnology: Prevents microbial growth and enhances packaging durability.
- Edible Coatings: Extends produce life using biodegradable, nutrient-rich layers.

Supporting Environmental Sustainability with Innovative Farming Practices

- Precision Agriculture: Uses technology (e.g., drones, sensors) to optimize resource use.
- Vertical Farming: Grows crops in controlled indoor environments with minimal land use.
- Renewable Energy Integration: Utilizes solar and wind power in farming operations.
- Biotechnology: Develops pest-resistant and drought-tolerant crop varieties.

Conclusion and Future Directions

Innovations in food production are essential for ensuring food security, improving nutrition, and promoting sustainability. Advanced technologies like nutrient-enriched foods, cryogenic preservation, and MAP extend shelf life, reduce waste, and enhance food safety. Functional foods and nanotechnology improve dietary outcomes and consumer health.

Technology drives a sustainable food system through precision agriculture, alternative proteins, and climate-resilient crops. Renewable energy integration reduces carbon footprints, and circular economy practices convert waste into valuable resources. Together, these advancements address global challenges, creating a more sustainable and resilient food supply.

Standards for Fresh Produce and Processed Products

Dr. Md Monirul Islam
Former Member Director, BARC

Introduction

Standards for fresh produce and processed products are essential to ensure quality, safety, and fair-trade practices in the agricultural and food processing industries throughout the supply chain. These standards are established by regulatory bodies, industry organizations, and international agreements to guide producers, processors, and consumers.

Key Components of Standards:

1. **Quality Parameters:**
    a. **Freshness:** Assessing the freshness of produce based on factors such as appearance, texture, aroma, and taste.
    b. **Size and Uniformity:** Standards often specify acceptable size ranges and uniformity criteria to meet market preferences.
    c. **Color and Appearance:** Defining acceptable color characteristics and visual appearance to indicate ripeness and quality.
    d. **Blemishes and Defects:** Identifying permissible levels of blemishes, bruises, and defects in produce or processed products.
    e. **Shelf Life:** Establishing standards related to shelf life and storage conditions to maintain product quality over time.
2. **Safety and Hygienic Standards:**
    a. **Pesticide Residue Limits:** Setting maximum residue limits (MRLs) for pesticides and agrochemicals to ensure food safety.
    b. **Microbiological Criteria:** Defining acceptable levels of bacteria, molds, and other microorganisms to prevent foodborne illnesses.
    c. **Contaminant Levels:** Regulating the presence of contaminants such as heavy metals, toxins, and allergens to safeguard consumer health.
    d. **Sanitary Practices:** Enforcing hygiene and sanitation standards throughout the production and processing chain to prevent contamination.
3. **Labelling and Packaging Requirements:**
    a. **Product Identification:** Requiring accurate labeling with product name, origin, grade, and other relevant information for consumer transparency.
    b. **Nutritional Information:** Mandating nutritional labeling to provide consumers with information about the product's nutrient content.
    c. **Packaging Materials:** Specifying packaging materials and requirements to maintain product freshness, integrity, and safety.
4. **Grading and Classification Systems:**
    a. **Grading Criteria:** Establishing grading systems based on quality attributes such as size, color, shape, and flavor.

b. **Classifications:** Differentiating products into various classes or categories based on quality standards and market demand.

Regulatory Framework

- Standards for fresh produce and processed products are developed and enforced by government agencies such as the Food and Drug Administration (FDA) in the United States, the European Food Safety Authority (EFSA) in the European Union, and national food regulatory bodies in other countries.
- International organizations like the Codex Alimentarius Commission establish global standards and guidelines to promote harmonization and facilitate international trade.

Importance of Standards

- **Ensuring Consumer Confidence:** Standards help build trust and confidence among consumers by assuring them of the quality and safety of the products they purchase.
- **Facilitating Trade:** Harmonized standards promote trade by reducing barriers and facilitating the movement of goods across borders.
- **Enhancing Competitiveness:** Compliance with standards enhances the competitiveness of producers and processors by enabling access to domestic and international markets.
- **Protecting Public Health:** Standards play a crucial role in safeguarding public health by preventing foodborne illnesses, contamination, and adulteration.

Benefits of Standards:

1. Quality Assurance: Standards ensure that products meet predetermined quality criteria, enhancing consumer satisfaction and confidence.

2. Market Access: Compliance with standards facilitates access to domestic and international markets by demonstrating product quality and safety.

3. Fair Trade: Standards promote fair competition among producers by establishing uniform criteria for product evaluation and pricing.

4. Public Health Protection: Safety regulations included in standards help protect consumers from foodborne illnesses and other health risks.

Challenges:

1. **Complexity:** Standards may vary between countries or regions, leading to complexity and potential barriers to trade.

2. **Compliance Costs:** Meeting standards can be costly for producers, especially small-scale farmers and processors.

3. **Enforcement Issues:** Ensuring compliance with standards requires effective monitoring and enforcement mechanisms, which may be challenging in some contexts.

Conclusion:

Standards for fresh produce and processed products serve as essential guidelines to ensure quality, safety, and fairness in the agricultural and food processing industries. By adhering to these standards, producers, processors, and consumers can benefit from improved product quality, safety, and market access.

These notes cover the key aspects of standards for both fresh produce and processed products, including quality parameters, safety standards, labeling requirements, grading systems, regulatory frameworks, and the importance of standards in ensuring consumer confidence, facilitating trade, enhancing competitiveness, and protecting public health.

Safe, Healthy, and Nutritious Food and Beverage

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Safe, healthy, and nutritious food and beverages are essential for maintaining overall well-being and vitality. They provide the body with the necessary nutrients, vitamins, and minerals needed for optimal functioning. Beyond mere sustenance, they play a critical role in preventing diseases and promoting longevity.

The impact of healthful eating habits extends beyond physical health to mental and emotional well-being. A balanced diet supports cognitive function, enhances mood stability, and fosters better stress management. Moreover, consuming wholesome foods reduces the risk of chronic illnesses such as obesity, diabetes, cardiovascular diseases, and certain cancers. In the context of public health, access to safe and nutritious food is a fundamental human right. It is imperative for policymakers, communities, and individuals to prioritize food security and advocate for sustainable agricultural practices. By investing in nutrition education, promoting food safety standards, and ensuring equitable access to healthy options, we can build healthier societies and improve quality of life for all.

Various controversies surround the safety and quality of food items in the public mind. Despite many chemicals being harmless when used within approved limits, there exists a pervasive fear among the public regarding their use. This paper aims to elucidate whether such fears are founded in truth or merely rumors. Furthermore, it underscores the importance of considering the quality of household and personal care products, such as cosmetics, dyes, lipstick, instant henna, and plastic products, to ensure overall safety and well-being.

Notably, Food safety involves a set of practices and roles to ensure that food is handled, prepared, and stored in a way that minimizes the risk of contamination and protects consumer health. Here is a summary of basic food safety roles:

1. Food Handlers/Cooks:

- Emphasize personal hygiene and proper hand washing.
- Adhere to safe food handling and temperature control practices.
- Use separate tools for raw and cooked foods.

2. Managers/Supervisors:

- Implement and enforce food safety policies.
- Provide staff training and monitor compliance.
- Conduct regular inspections to identify and address hazards.

3. Kitchen Staff:

- Maintain a clean kitchen and prevent cross-contamination.
- Follow FIFO principles for inventory rotation.

- Report and address pest issues promptly.

4. Wait staff/Servers:

- Serve food using sanitary practices.
- Communicate customer dietary needs to the kitchen.
- Address and report customer complaints promptly.

5. Cleaning Staff:

- Regularly clean and sanitize surfaces and equipment.
- Dispose of waste properly and follow cleaning schedules.

6. Quality Assurance/Health Inspectors:

- Conduct inspections to ensure compliance.
- Investigate complaints and guide corrective actions.

7. Farmers/Producers:

- Implement good agricultural practices for raw ingredients.

8. Government Regulators:

- Develop and enforce food safety regulations.
- Inspect establishments and respond to outbreaks.

It is noted that that collaboration among these roles is crucial to uphold food safety standards and protect both the industry and consumers.

Challenges to Ensuring Safe Food:

- **Changes in Food Production and Consumption:** Evolving trends in food production and consumption patterns pose challenges in maintaining safety standards and regulations.
- **Changes in Environment and Development:** Environmental changes and rapid development can impact food safety through pollution and other environmental factors.
- **Poverty and Pollution:** Poverty-stricken areas often face heightened pollution levels, which can contaminate food sources and compromise safety.
- **Travel and Migration:** Increased travel and migration patterns contribute to the spread of foodborne illnesses across regions and countries.
- **Trade in Food, Feed, and Animals:** Global trade in food, feed, and animals introduces complexities in ensuring the safety of imported goods.
- **New and Emerging Pathogens:** The emergence of new pathogens presents challenges in identifying and mitigating risks to food safety.
- **Antimicrobial Resistance:** The rise of antimicrobial resistance in pathogens poses a threat to food safety and public health.
- **Increase in Street Food:** The popularity of street food presents challenges in maintaining hygiene and safety standards in informal food markets.

- **Education and Promotion of Food Safety:** Limited awareness and education about food safety practices hinder efforts to ensure safe food consumption.
- **Surveillance and Monitoring:** Insufficient surveillance and monitoring systems can lead to undetected food safety hazards and outbreaks.
- **Uncontrolled Urban Growth:** Rapid urbanization can strain food safety infrastructure and lead to inadequate monitoring of food production and distribution.

Increased Foodborne Outbreaks Due to:

- **The Emergence of New Foodborne Pathogens:** Newly identified microorganisms contribute to outbreaks and pose challenges in containment.
- **Imported Foods:** Imported food products may not adhere to local safety regulations, increasing the risk of contamination and outbreaks.
- **Composition of Food:** Changes in food composition and processing techniques can introduce safety risks.
- **Takeout Meals:** Consumption of takeout meals may lead to foodborne illnesses if proper hygiene practices are not followed during preparation and handling.
- **Changing Demographics**: Growing population sizes and demographic shifts can strain food safety management systems.
- **Lack of Food Safety Management Systems in Small Operations:** Small-scale food operations may lack robust safety management systems, increasing the risk of contamination.

Additional Challenges to Ensure Safe Food Include:

- **Time and Money:** Limited resources and time constraints can impede efforts to implement and maintain food safety measures.
- **Language and Culture:** Language barriers and cultural differences may hinder effective communication and understanding of food safety practices.
- **Literacy and Education:** Low literacy rates and inadequate education about food safety contribute to unsafe food handling practices.
- **Unapproved Suppliers:** Sourcing ingredients from unapproved suppliers increases the risk of contamination and foodborne illnesses.
- **High-risk Customers:** Serving populations with compromised immune systems or specific dietary needs requires extra precautions to ensure food safety.
- **Staff Turnover:** High turnover rates in the food industry can lead to inconsistent adherence to safety protocols and training standards.

Importance and Impact of safe, healthy, and nutritious food and beverage

- **Health Impact:** Consuming safe and nutritious food is essential for maintaining optimal health. It provides the body with the necessary nutrients, vitamins, and minerals needed for proper functioning, growth, and development. A balanced diet

can help prevent various health issues such as malnutrition, obesity, diabetes, cardiovascular diseases, and certain types of cancer**.**

- **Cognitive Function:** Proper nutrition supports cognitive function, including memory, concentration, and learning abilities. Children who have access to nutritious meals perform better academically, while adults can enhance their productivity and decision-making abilities by maintaining a healthy diet.
- **Immune System:** A well-balanced diet strengthens the immune system, making the body more resilient to infections and diseases. Adequate intake of vitamins, minerals, antioxidants, and phytonutrients from fruits, vegetables, and whole grains helps the body fight off illnesses and recover faster.
- **Quality of Life:** Access to safe and nutritious food and beverages improves quality of life by promoting physical and mental well-being. It contributes to higher energy levels, better mood regulation, and overall happiness.
- **Economic Impact:** Investing in food safety and nutrition programs can have significant economic benefits. By reducing healthcare costs associated with diet-related illnesses and increasing productivity, societies can allocate resources more efficiently and sustainably.

In conclusion, ensuring access to safe, healthy, and nutritious food and beverages is not only a matter of individual health but also a fundamental human right and a key driver of societal progress and prosperity.

Safe Food Handling Practices

The basic principles of food safety (4Cs): Cleanliness; Cross Contamination/Separation; Cooking and Chilling. Unsafe food handling practices can lead to foodborne illness, here are some short tips to ensure safe food handling:

- Wash hands thoroughly with soap and water before handling food.
- Keep raw meats separate from ready-to-eat foods to avoid cross-contamination.
- Cook foods to their proper internal temperature to kill harmful bacteria (by using thermometer)
- Refrigerate perishable foods promptly (within 2 hours) to prevent bacterial growth.
- Avoid thawing foods at room temperature; use the refrigerator, cold water, or microwave.
- Clean and sanitize kitchen surfaces, utensils, and cutting boards regularly.
- Don't leave perishable foods out in the "danger zone" (between 40°F and 140°F) for more than 2 hours (or 1 hour if the temperature is above 90°F).
- Don't taste food that looks or smells suspicious; when in doubt, throw it out.
- Importance of proper food handling

Understanding Nutrition

Understanding nutrition is essential for maintaining optimal health and well-being. It involves comprehending the role of various nutrients in the body, such as carbohydrates, proteins, fats, vitamins, and minerals, and how they support bodily functions. Nutrition education enables individuals to make informed food choices that meet their nutritional

needs, prevent deficiencies, and reduce the risk of chronic diseases like obesity, diabetes, and heart disease. By understanding nutrition, people can cultivate healthier eating habits, promote longevity, and enhance overall quality of life.

- Essential nutrients and their functions:
  - Carbohydrates; Proteins; Fats; Vitamins; Minerals and Water
- Recommended daily intake for different age groups and lifestyles
- Reading food labels: interpreting nutritional information

Components of a Healthy Diet

A healthy diet typically consists of a variety of foods from different food groups to ensure adequate intake of essential nutrients. Here's a short summary of of a healthy diet components:

- Fruits and vegetables: These are rich in vitamins, minerals, fiber, and antioxidants. Aim for a colorful variety to get a wide range of nutrients.
- Whole grains: Opt for whole grains like brown rice, quinoa, oats, and whole wheat bread instead of refined grains. They provide fiber, vitamins, and minerals.
- Protein sources: Include lean protein sources such as poultry, fish, tofu, beans, lentils, and nuts. These provide essential amino acids for muscle repair and growth.
- Healthy fats: Incorporate sources of healthy fats such as avocados, nuts, seeds, and olive oil. These fats are important for brain function, hormone production, and absorption of fat-soluble vitamins.
- Dairy or alternatives: Choose low-fat or non-fat dairy products, or plant-based alternatives like fortified soy milk. These provide calcium and vitamin D for bone health.
- Limit added sugars: Minimize consumption of foods and beverages high in added sugars, such as sugary drinks, sweets, and processed snacks.
- Moderate salt intake: Limit sodium intake by reducing the consumption of processed and packaged foods and avoid adding extra salt to meals.
- Hydration: Drink plenty of water throughout the day to stay hydrated. Limit intake of sugary drinks and excessive caffeine.
- Portion control: Pay attention to portion sizes to avoid overeating, even of healthy foods.
- Balance and variety: Aim for a balanced diet with a variety of foods to ensure you get all the essential nutrients your body needs.

By focusing on these components, you can create a well-rounded and nutritious diet that supports overall health and well-being.

- Importance of balance and variety in diet
- Incorporating fruits and vegetables
- Choosing whole grains
- Lean protein sources and Healthy fats
- Limiting processed foods and added sugars

- Dietary guidelines for different dietary needs (eg. Vegetarian, vegan, gluten free etc.)

Importance and Sources of Hydration

Hydration is essential for health, regulating body functions, and preventing dehydration. Aim for 8 glasses of water daily, replenish electrolytes, especially during exercise, and listen to your body's signals for hydration needs.

-Importance

Hydration is crucial for bodily functions. Aim for 8 glasses of water daily. Signs of dehydration include thirst and fatigue. Get electrolytes from food and drinks. Stay hydrated during exercise and reap health benefits like better skin and digestion.

Food Safety and Nutrition Challenges

a. Common Foodborne Illness and Way to Prevention

Common foodborne illnesses include salmonella, E. coli, norovirus, and listeria. To prevent them, ensure proper food handling by washing hands, utensils, and surfaces, cooking meat thoroughly, avoiding cross-contamination, refrigerating perishable foods promptly, and practicing good hygiene in food preparation and consumption.

b. Addressing Food Insecurity and Access to Nutritious Food

Addressing food insecurity and improving access to nutritious food involves a multifaceted approach. This includes implementing policies that support income stability, such as minimum wage increases and social safety nets, expanding access to affordable and nutritious food through initiatives like community gardens, farmers' markets, and food assistance programs, promoting nutrition education and cooking skills, and addressing systemic issues like food deserts and inequities in distribution and availability of healthy food options. Collaborative efforts involving government, non-profit organizations, businesses, and communities are essential to create sustainable solutions.

c. Strategies for promoting healthy Eating Habits in Communities

Promoting healthy eating habits in communities involves education, access, and cultural sensitivity. Strategies include nutrition education, community gardens, farmers' markets, subsidized healthy food programs, school initiatives, workplace wellness programs, cultural tailoring, peer support, policy advocacy, and social marketing campaigns. By addressing these aspects, communities can create environments conducive to healthier eating habits for all residents.

e. Environmental Sustainability and its Relationship to Food Choices

Food choices directly impact environmental sustainability by influencing resource use, greenhouse gas emissions, biodiversity loss, water consumption, waste generation, and transportation emissions. Opting for plant-based foods, reducing food waste, supporting sustainable agriculture, and choosing locally sourced options can mitigate these environmental impacts.

Beverages and Soft Drinks

- Beverages are an important component of our diet and can significantly impact our health.
- Water is essential for hydration and plays a critical role in bodily functions. Encouraging adequate water intake is important for overall health.
- Sugary beverages such as soda, energy drinks, and fruit juices can contribute excess calories and sugar to the diet, increasing the risk of obesity, diabetes, and other health problems.
- Healthier beverage option include water, unsweetened tea and coffee, lo-fat milk, 100 % fruit juice in moderation.

In addition, rumors and reality regarding some of important fresh fruits and vegetables and other food items are briefly described below:

Rumors and Panic Surrounding Chemicals Used in Food Items

Fruits, Fish, and Formalin

Formalin, a chemical often associated with food safety concerns, is highly soluble in water and volatile. When it comes to fruits and vegetables, which are fibrous foods, formalin gradually evaporates due to its volatile nature. Interestingly, various fruits and vegetables naturally produce glucose, fructose, and formaldehyde, which contribute to their own preservation process. Moreover, formaldehyde is naturally present in various fruits and vegetables at average levels ranging from 3 to 60 mg/kg, as per the World Health Organization (WHO). Upon entering the body, formaldehyde reacts with tissue, primarily the skin, and is converted into less toxic formic acid or formate. Approximately 70% of formaldehyde is rapidly excreted from the body through urine, while the remaining portion (30%) is converted into carbon dioxide and exhaled through respiration. Given its rapid decomposition in the metabolic process, formaldehyde is not significantly absorbed by the body or released into the environment.

Notably, according to the standards set by the European Union Food Safety Authority (EFSA), individuals can safely consume 100 parts per million (ppm) of formalin daily without encountering any health hazards. Typically, sea fish and fresh water fish contain 1-40 mg/kg of naturally occurring formaldehyde, with sea fish containing 1.4-7.35 micrograms/gram. However, in of 1985, the Italian Ministry of Health Authority set maximum allowable levels of formaldehyde in fish and shrimp consumption at 60 and 10 micrograms per kilogram (µg/kg), respectively. Furthermore, according to the US Food and Drug Administration (FDA), individuals can safely consume up to 0.2 micrograms of formalin per gram of body weight per day without posing any health risks.

Fruits and Ripening Chemicals

Ethepon is a chemical widely used worldwide for ripening fruits, and it is considered extremely safe. During ripening, various fruits naturally produce small amounts of ethylene

gas, which activates genes within the fruit, leading to changes in color, sweetness, and texture as the fruit ripens.

Research findings indicate that both laboratory-sprayed samples (ranging from 250 to 10,000 ppm) and samples from marketed/farmers' field (banana, papaya, tomato, mango, etc.) showed rapid removal of ethylene from the applied fruit bodies after application. Within 24 hours, the residue levels of ethepon fell below the maximum intake level (2 ppm) prescribed for human consumption.

Apart from Maximum Residue Limits (MRLs), the harmful effects of ethepon also depend on the Acceptable Daily Intake (ADI) level. According to the recommendations of CODEX/FSSAI, a person can consume up to 0.05 ppm per kg of body weight per day without any health risk. For instance, if a person weighs 60 kg, they can safely consume a maximum of (60 x 0.05) 3 ppm of ethepon per day. Therefore, if a fruit contains 0.50 ppm of ethepon residue per kg, a person would need to consume at least 6 kg of fruit per day to exceed the recommended intake level.

Chemical Uses in Apples and Grapes

- Waxes in Horticulture Crops: Fruits and vegetables, categorized as horticulture crops, contain a high percentage of water (40-96%). To prevent weight loss during storage, widely used waxes are applied. Paraffin Wax or Edipeel is commonly used to protect against disease-causing organisms, maintain gloss, guard against fungal attacks, facilitate long-term storage, prevent sensitivity during cold storage, and protect against moisture loss and external injuries. There are no health risks associated with the waxes used in apples.
- Natural Coating on Grapes: The white powdery substance sometimes found on grape skins is entirely natural and known as bloom, blush, or old dust. This coating, composed of Saccharomyces cerevisiae (yeast), acts as a natural barrier, protecting grapes from rotting, spiders, and moisture. Additionally, it aids in the initial stages of fermentation during winemaking. Similar coatings can also be observed on palm fruits.

It's a common mistake to wash grapes immediately after purchase, as this can reduce their shelf life. Grapes are humidity-friendly but not moisture-friendly. Therefore, it's advisable to wash only the required amount before consumption to maintain their freshness for longer.

Vegetables and Pesticides: Analysis of Raw, Washed, and Cooked Samples

It's notable that approximately 98 percent of the pesticides utilized today are fungicides and insecticides, which have rapid action, and their toxicity significantly decreases within three days. Most pesticides are water-soluble, allowing them to be removed to some extent through washing. Research findings indicate that washing vegetables can eliminate about 70-85% of pesticide residues present on the surface.

Moreover, a study observed that even after cooking, certain samples of cooked vegetables retained residues of pesticides such as Dimethoate, Cypermethrin, Chlorpyrifos, and Carbendazim. However, in all cases, the levels of these residues were far below the maximum tolerable levels prescribed for human consumption. The residue levels of pesticides in raw, washed, and cooked vegetable samples are depicted in Figures 1a and 1b.

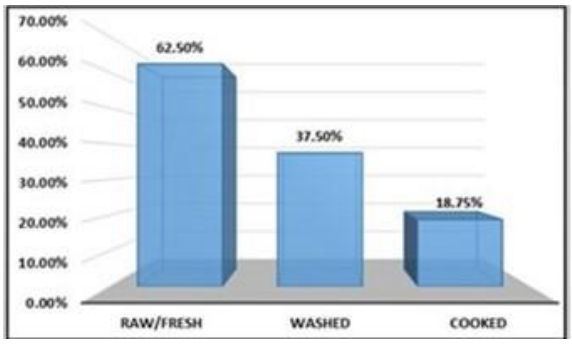

Fig 1a. Residue at Raw, Washed and Cooked Vegetables

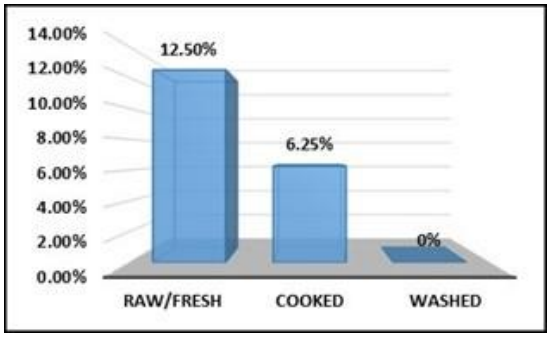

Fig 1b. Residue above MRL at Raw, Washed and Cooked Vegetables

These findings suggest that while some pesticide residues may persist on vegetables even after cooking, the levels present are typically within safe limits for human consumption. Proper washing and cooking practices can further reduce pesticide exposure, ensuring the safety of vegetable consumption.

Hotel and Restaurant Semi-Cooked and Cooked Vegetables Sample Analysis

An analysis of semi-cooked and cooked vegetable samples from various categories of hotels, including elite, premium, and normal hotels, revealed the presence of pesticide residues in a small percentage of samples. However, these residues were found to be well below the maximum tolerable levels prescribed for human consumption, indicating no significant health risks.

For instance, mixed semi-cooked fried vegetable samples obtained from Hotel Intercontinental and Radisson showed residues of Fenvelerate at 0.012 mg/kg and Imidacloprid at 0.014 mg/kg. Despite the Maximum Residue Limits (MRL) for Fenvelerate and Imidacloprid being 2.0 mg/kg and 0.50 mg/kg respectively, the levels detected were significantly lower. Considering the Acceptable Daily Intake (ADI) values, both Fenvelerate (0.02 mg/kg) and Imidacloprid remained below the estimated residue levels (0.012 mg/kg).

Similarly, cooked okra samples from premium hotels exhibited Chlorpyrifos and Thiamethoxam residues at levels of 0.030 mg/kg and 0.011 mg/kg respectively, both lower than the recommended value of 0.2 mg/kg. In contrast, cooked cabbage samples from normal hotels showed Chlorpyrifos and Cypermethrin residues at levels of 0.046 mg/kg and 0.063 mg/kg respectively, also below the recommended values of 0.2 mg/kg and 2.0 mg/kg respectively.

It's worth noting that approximately 30% of pesticides may contain adulterants, meaning they do not contain effective ingredients in prescribed doses. This deception not only cheats farmers but also contributes to the development of pesticide-resistant insects, posing challenges in pest management strategies.

Dried Fish and Pesticides

Currently, no DDT residues have been found in dried fishes. However, during the monsoon season, certain insecticides like Sorbicon, Lider, Mapon, and Emitap are commonly used to protect against insect attacks. Modernization in the method of preparing dried fish has led to the adoption of hygienic and safe practices, such as using yellow-pepper powder in a 1:1 ratio and employing advanced drying methods with vacuum packaging. Investigations have confirmed that pesticide residues in dried fishes remain well below the maximum tolerable levels prescribed by the Food and Agriculture Organization (FAO), which is 0.5 mg/kg. Additionally, government initiatives have led to the discontinuation of formalin dipping in high-value fishes like kachki and mola, ensuring safer fish consumption.

Safe and Nutrition Issues of Street Food

Research has observed that almost 100% of street food is contaminated with bacteria or microorganisms, making it unsafe for consumption. The processing and serving processes involved in street food preparation are often unhygienic, with unclean utensils and unsafe water being common issues. Bacteria such as E. coli and coliforms are prevalent in these foods, primarily originating from the environment, including soil, water, and vegetables, especially those contaminated with human and animal excreta. These factors collectively pose significant health hazards associated with street food consumption.

Antibiotic Situation in Poultry Production and Marketing Process

Concerns have been raised regarding the presence of arsenic, lead, and chromium in animal or chicken feed. However, it's important to note that the majority (98%) of arsenic found in food items is organic arsenic, which is not harmful to human health. Chromium exists naturally in two forms: chromium-3 and chromium-6, with chromium-6 being more harmful. It's crucial to clearly identify whether the obtained chromium is trivalent (chromium-3) or hexavalent (chromium-6). The maximum tolerable levels for these heavy metals are 20-30 mg/kg for chromium, 0.5 mg/kg for lead, and 1.0 mg/kg for arsenic.

Industrial expansion and processing plants without Effluent Treatment Plants (ETP) have contributed to the natural deposition or presence of arsenic, lead, chromium, and other heavy metals in soil and water. Despite efforts, it's challenging to completely prevent their presence, even in developed countries.

A study on chicken feeds revealed that out of 15 brands tested (9 broiler feeds and 6 layer feeds), approximately 12.5% were contaminated with antibiotic residues, specifically Lincomycin and Oxytetracycline, exceeding the prescribed maximum tolerable levels. This highlights a concerning issue in poultry production and marketing processes, emphasizing the need for stricter regulations and monitoring to ensure food safety.

Milk

A concerning percentage of raw/open milk samples, ranging from 25% to 70%, were found to contain nitrites. This presence of nitrites indicates that the water mixed with these milk samples likely originates from untreated sources such as ponds or rivers.

Moreover, a significant portion (ranging from 40% to 100%) of milk sold in the open market is adulterated by sellers, with water being added in proportions of up to 20%. Additionally, formalin, in concentrations varying from 5% to 100%, is often added to the milk as a preservative (approximately 4-5 drops per liter). Artificial milk preparations typically include low-quality powdered milk, flour, arrowroot, sulfuric acid, mustard oil, hydrogen peroxide, urea, chalk powder, ammonium sulfate, mobil, among other substances. These practices pose serious health risks to consumers and underscore the need for stricter regulation and oversight in the milk industry.

Rice Bran Oil

Rice bran oil has gained popularity for its purported health benefits, particularly its association with γ-oryzanol, which is believed to make it heart-friendly. However, analysis of 15 brands of rice bran oil available in the market revealed adulteration in 25% of the samples. According to standards, rice bran oil should contain at least 1% γ-oryzanol, but in some marketed oils, this compound was either below the prescribed level or absent altogether. This indicates possible mixing with low-quality ingredients or other oils. Additionally, the ratio of omega-3 to omega-6 fatty acids in rice bran oil is unbalanced, with approximately 1:33 instead of the ideal ratio of 1:5. While rice bran oil is generally considered a healthy edible oil, caution should be exercised regarding its regular consumption due to this imbalance. It's advisable to consume rice bran oil intermittently rather than regularly to avoid potential adverse effects resulting from the disproportionate ratio of omega-3 to omega-6 fatty acids.

Heavy Metals in Rice

Industrial waste is a primary source of groundwater and soil contamination by heavy metals, emphasizing the need for rigorous measures to safeguard the safety of crops cultivated in industrialized regions. To mitigate environmental pollution, advocacy campaigns should discourage farmers from utilizing low-quality fertilizers, while strict waste management regulations need implementation in industrial facilities. Consistent monitoring and legal penalties for offenders are imperative.

The majority of tested rice varieties exhibit acceptable arsenic levels, with 98% being organically sourced, thus posing minimal health hazards. Although trace amounts of heavy metals like chromium and arsenic are beneficial in small doses, thorough rinsing of rice effectively reduces arsenic content, further diminished by 25-30% during cooking.

Drinking Water

An alarming 96% of jar water samples were found to contain coliform bacteria, indicating contamination with human or animal excrement. The maximum levels of total coliform and

fecal coliform in all samples were recorded at 1600 and 240 g/100 ml, respectively, posing a significant risk to public health.

Furthermore, water jars supplied by bottled water suppliers are often made of non-food-grade plastic, which poses additional health risks. It is imperative to ensure that the supplied water jars are transparent and food-grade. Additionally, these jars must be properly labeled with the name of the manufacturing company, date of manufacture, expiry date, and information about the quality of the water produced. Such measures are necessary to safeguard public health and prevent the spread of waterborne diseases.

Conclusion

In conclusion, ensuring access to safe, healthy, and nutritious food and beverages is paramount for maintaining overall health and well-being. Poor food choices can lead to various health issues, including obesity, malnutrition, cardiovascular diseases, and foodborne illnesses. Conversely, a balanced diet rich in fruits, vegetables, whole grains, and lean proteins can promote optimal health and reduce the risk of chronic diseases. By prioritizing food safety, nutritional quality, and healthy eating habits, individuals can positively impact their health and quality of life.

Harvesting, Handling and Drying of Non-Rice Crops: Technologies and Practices

ড. মোঃ নুরুল আমিন
মুখ্য বৈজ্ঞানিক কর্মকর্তা (ভারপ্রাপ্ত)
ফার্ম মেশিনারী এন্ড পোস্টহারভেস্ট প্রসেস ইঞ্জিনিয়ারিং বিভাগ
বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউট, গাজীপুর

কৃষি যান্ত্রিকীকরণ হলো কৃষি কাজের প্রতিটি স্তরে কৃষিযন্ত্রের ব্যবহারের মাধ্যমে কৃষি কাজকে ত্বরান্বিত করা। দেশে কৃষি কাজে শ্রমিক সংখ্যা দিন দিন কমে যাচ্ছে। দেশে শিক্ষার হার বৃদ্ধির ফলে শিক্ষিত বেকারের সংখ্যাও বৃদ্ধি পাচ্ছে। কৃষকের সন্তান হওয়া সত্ত্বেও তারা সনাতন পদ্ধতিতে কৃষি কাজ করতে অনীহা প্রকাশ করে। কৃষি কাজ শ্রম ঘন এবং রোদ, বৃষ্টিতে ভিজে কাজ করতে হয় বিধায় শ্রমিকরা কৃষি কাজ করতে চায় না। বর্তমানে দেশে কৃষি শ্রমিকের হার শতকরা ৩৬ ভাগের নিচে (২ কোটি ২০ লক্ষ) এবং তা ক্রমহ্রাসমান। অনেক যুবক অধিক রোজগারের উদ্যেশ্যে বিদেশে পাড়ি জমাচ্ছে। স্থানীয় শ্রমিকেরা হালকা শ্রমযুক্ত বিভিন্ন শিল্প, পরিবহন ও সেবা খাতের দিকে ঝুকে পড়ছে। ফলে, ফসল কাটার ভরা মৌসুমে শ্রমিকের প্রাপ্যতা হ্রাস পায় ও শ্রমিকের মূল্য অস্বাভাবিকভাবে বৃদ্ধি পায়। কৃষিযন্ত্র ব্যবহারের মাধ্যমে সময়মত কৃষি কাজ সম্পাদন করা ও কৃষি উৎপাদন খরচ হ্রাস করে কৃষিকে লাভজনক করা যেতে পারে। এমতাবস্থায়, কৃষি উৎপাদন বৃদ্ধি বা অর্জন ধরে রাখতে হলেও কৃষি যান্ত্রিকীকরণের কোন বিকল্প নেই। যান্ত্রিক উপায়ে কৃষি কাজ করতে সাধারনত যুবকেরা স্বাচ্ছন্দ বোধ করে। সুতরাং কৃষিতে কায়িক শ্রম লাঘব আধুনিক কৃষি যন্ত্রপাতি ব্যবহার নিশ্চিত করলে গ্রামের শিক্ষিত যুবকদের কৃষি কাজে সম্পৃক্ত করা সম্ভব। এক্ষেত্রে শিক্ষিত বেকারদের কৃষি যন্ত্রপাতি পরিচালনা, রক্ষণাবেক্ষণ এবং সঠিক ব্যবস্থাপনার প্রশিক্ষণের মাধ্যমে প্রশিক্ষিত করতে পারলে কৃষির উৎপাদন বৃদ্ধি ও তরান্বিত হবে যা দেশের অর্থনৈতিক সমৃদ্ধি ও প্রবৃদ্ধি অর্জনে গুরুত্বপূর্ণ ভূমিকা রাখবে। কৃষি শ্রমিকের ক্রমহ্রাসমান ঘাটতি মোকাবিলা করে ফসল উৎপাদনের ধারা টেকসই রাখার জন্য জন্য কৃষি যান্ত্রিকীকরণের বিকল্প নেই।

ফার্ম মেশিনারি এন্ড পোস্টহারভস্টে প্রসেস ইঞ্জনিয়িারিং বিভাগ (এফএমপিই), বাংলাদশে কৃষি গবষেণা ইনস্টিউট-এ ১৬টি গবেষণা বিভাগের মধ্যে একটি বিভাগ। বিভাগটি সৃষ্টিলগ্ন থেকে এদেশের কৃষি ও কৃষকের উপযোগী কৃষিযন্ত্র উদ্ভাবন করে আসছে। এ বিভাগ হতে এযাবৎ ৫৩টি কৃষিযন্ত্র উদ্ভাবন করা হয়েছে। সারণী-১ এ কয়েকটি সংগ্রহোত্তর কৃষিযন্ত্রের মাঠ পর্যায়ে বর্তমান অবস্থা দেখানো হলো।

সারণী ১. বারি উদ্ভাবিত কয়েকটি সংগ্রহোত্তর কৃষি যন্ত্রপাতির মাঠ পর্যায়ে অবস্থা

যন্ত্রের নাম	সংখ্যা	ব্যবহার
বারি শস্য মাড়াই যন্ত্র	২,১০০০০	দেশের প্রায় ৩০% ধান, ৯০% গম ও ৪০% ডাল এই যন্ত্র দ্বারা মাড়াই হয়
বারি ভুট্টা মাড়াই যন্ত্র	৭০০০০	দেশের প্রায় ১০০% ভুট্টা এই যন্ত্র দ্বারা মাড়াই হয়
বারি বাদাম মাড়াই যন্ত্র	১০০	কার্যক্ষমতা: ১০০ কেজি/ঘন্টা, বেকারী ও বীজ সংগ্রহের জন্য ব্যবহৃত হয়
বারি সূর্যমুখী মাড়াই যন্ত্র	৮০	কার্যক্ষমতা: ৬০০-১০০০ কেজি/ঘন্টা, সূর্যমুখী উৎপাদন এলাকায় ব্যবহৃত হয়
বারি আলু উত্তোলন যন্ত্র	৪০০	প্রচলিত পদ্ধতির তুলনায় ৫১% খরচ ও ৬৫% শ্রমিক সাশ্রয় হয়
বারি মূলজাতীয় ধৌতকরণ যন্ত্র	৫৫	কার্যক্ষমতা: ১০০০ কেজি/ঘন্টা, গাজর উৎপাদন এলাকায় ব্যবহৃত হয়
বারি ফল শোধন যন্ত্র	৭০	বর্তমানে বিদেশে রপ্তানির প্রায় ৮০% আম শোধন করা হচ্ছে
বারি কম্পোস্ট সেপারেটর	৪৫০	কার্যক্ষমতা : ১,৫০০ কেজি/ঘণ্টা (ভার্মিকম্পোস্ট), ১,০০০ কেজি/ঘণ্টা (ট্রাইকোকম্পোস্ট)
বারি কফি পাল্পার	২১	এটি দিয়ে তাজা কফির খোসা ছাড়ানো হয়, কার্যক্ষমতা : ১২৬ কেজি/ঘন্টা, কফি উৎপাদন এলাকায় ব্যবহৃত হয়
বারি কফি ডিহালার	২১	যন্ত্রটি দিয়ে সহজে ও অল্প সময়ে কফির রূপালী কালারের আবরণ ও শুকনা কফির খোসা ছাড়ানো যায়, কার্যক্ষমতা: ৫০ কেজি/ঘন্টা, কফি উৎপাদন এলাকায় ব্যবহৃত হয়
বারি কফি রোস্টার	২১	কফি বীন ভাজা হয়, কার্যক্ষমতাঃ ৪.৫ কেজি/ঘন্টা, কফি উৎপাদন এলাকায় ব্যবহৃত হয়
বারি কফি গ্রাইন্ডার	২১	এটি দিয়ে তাজা কফির খোসা ছাড়ানো হয়, কার্যক্ষমতা: ১১.৫ কেজি/ঘন্টা, কফি উৎপাদন এলাকায় ব্যবহৃত হয়

বারি শস্য কর্তন যন্ত্র

বর্তমানে বাংলাদেশের কৃষকদের ধান ও গম চাষে যে সমস্যাগুলি রয়েছে তার মধ্যে ধান/গম কাটা একটি অন্যতম প্রধান সমস্যা। ধান বা গম কাটার মৌসুমে কৃষককে বেশ কয়েকটি কাজ একসাথে করতে হয়। যেমন - ফসল কাটা, মাড়াই করা, ঝাড়াই করা, শুকানো এবং পরবর্তীকালে ফসলের জন্য জমি তৈরি, বীজতলা তৈরি ইত্যাদি। কৃষি শ্রমিকের সংখ্যা হ্রাস পাওয়ায় এসময় শ্রমিকের তীব্র সংকট দেখা দেয়। এ সমস্যা দূরীকরণে স্ব-চালিত শস্য কর্তন যন্ত্রটি উদ্ভাবন করা হযেছে।

বৈশিষ্ট্য

১। যন্ত্রটি দিয়ে ধান ও গম কাটা যায়
২। কিছুটা হেলে পড়া ধান বা গমও কাটা যায়
৩। জমিতে কিছুটা পানি থাকলেও যন্ত্রটি দিয়ে ফসল কাটা যায় (এঁটেল মাটি ছাড়া)
৪। কাটা ধান বা গম ডান পাশে সারিবদ্ধভাবে পড়ে যাতে সহজে আঁটি বাঁধা যায়
৫। প্রতি ঘন্টায় জ্বালানি খরচ মাত্র ০.৮ লিটার (পেট্রোল/অকটেন)
৬। প্রতি হেক্টর ধান ও গম কাটতে প্রায় ১৫০০ টাকা খরচ হয়
৭। একজন লোক সহজেই যন্ত্রটি চালাতে পারে এবং এটি সহজে স্থানান্তর করা যায়
৮। যন্ত্রটি দিয়ে প্রতি ঘন্টায় ০.১৪-০.২০ হেক্টর (৩৫-৫০ শতাংশ) ধান এবং ০.১৮-০.২৪ হেক্টর (৪৫-৬০ শতাংশ) গম কাটা যায়
৯। যন্ত্রটির বাজার মূল্য ২০০,০০০ টাকা

চিত্রঃ বারি শস্য কর্তন যন্ত্র

আলু উত্তোলন যন্ত্র

বাংলাদেশে প্রাচিনকাল থেকেই সনাতন পদ্ধতিতে আলু উত্তোলন হয়ে আসছে যা শ্রমিক নির্ভরশীল, সময় সাপেক্ষ ও ব্যায়বহুল। এ প্রক্রিয়ায় বিঘা প্রতি (৩৩ শতাংশ) প্রায় আট জন শ্রমিক প্রয়োজন হয়, তাছাড়া হাতে আলু উত্তোলনের পর প্রায় ৮-৯% আলু মাটির অভ্যন্তরেই রয়ে যায়, ফলে কৃষক আর্থিকভাবে ক্ষতিগ্রস্ত হয়। এছাড়াও আলু উত্তোলন মৌসুমে খারাপ আবহাওয়ার কারণে অনেক সময় আলু উত্তোলন দেরি হলে কৃষক দারুণভাবে ক্ষতিগ্রস্ত হন। উন্নত বিশ্বের উদ্ভাবিত ট্রাক্টর চালিত আলু উত্তোলন যন্ত্র এ দেশের ছোট ছোট জমির জন্য উপযোগী নয়। সেক্ষেত্রে আমাদের দেশের বহুল ব্যবহৃত পাওয়ার টিলারকে কাজে লাগিয়ে ছোট জমির উপযোগী করে আলু উত্তোলন যন্ত্র তৈরি করা হয়েছে। যন্ত্রটি দামে তুলনামুলকভাবে সস্তা এবং কৃষকের ক্রয় ক্ষমতার মধ্যে। কৃষি যন্ত্র প্রস্তুতকারকগন স্থানীয় কাঁচামাল দিয়ে সহজে আলু উত্তোলন যন্ত্রটি তৈরি করতে পারেন। আলু উত্তোলন যন্ত্রটির বহুল ব্যবহার শ্রমিক ঘাটতি মিটিয়ে আলু চাষকে টেকসই ও লাভজনক করার ক্ষেত্রে বিশেষ ভুমিকা রাখবে।

বৈশিষ্ট্য

ক) ৯৬-৯৯% আলু মাটির সমতলে উন্মুক্ত করে যা সহজে সংগ্রহ করা যায়

খ) সর্বোচ্চ আলু উত্তোলনের মৌসুমে সময় ও শ্রম বাঁচায়

গ) আলু উত্তোলন যন্ত্র ব্যাবহার করে আলু উত্তোলন খরচ ৬০% কমানো যায়

ঘ) ৬৫% শ্রমিক নির্ভরতা কমায়

ঙ) আলুর বাহ্যিক ক্ষতি ১.৫% এর কম

চ) মাটির নিচে আলু থাকে না

ছ) নতুন কর্মসংস্থানের তৈরি করে

জ) এ যন্ত্রের সাহায্যে অন্যের জমিতে আলু উঠিয়ে সফলভাবে ব্যবসা করা সম্ভব

ঝ) যন্ত্রের মূল্যঃ ৫৫,০০০ টাকা (পাওয়ার টিলার ছাড়া)

চিত্রঃ বারি আলু উত্তোলন যন্ত্র

বারি শস্য মাড়াই যন্ত্র

বাংলাদেশের সব এলাকায় সাধারণত কৃষকগণ ধান কাটার পর হাতে পিটিয়ে বা গরুর সাহায্যে (মলন) মাড়াই করে থাকেন। এতে অনেক বেশি শ্রমিক লাগে বলে মাড়াই খরচ বেড়ে যায়। বৃষ্টির সময় সনাতন পদ্ধতিতে মাড়াই করা যায় না বলে প্রচুর ধান ও গম নষ্ট হয় এবং গুণগতমান কমে যায়। ফলে বাজার মূল্য হ্রাস পায়। দেশে ধান ও গমের উৎপাদন আগের তুলনায় অনেক বেড়ে গেছে। ফলে সনাতন পদ্ধতিতে বা পা-চালিত মাড়াই যন্ত্র দিয়ে মাড়াই করা দুরূহ হয়ে পড়েছে। সে জন্য শক্তিচালিত শস্য মাড়াই যন্ত্র উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- এ যন্ত্র দিয়ে ধান, গম ও ডাল শস্য মাড়াই করা যায়।
- এ যন্ত্রটি দিয়ে ৫০-৭০ সেমি দৈর্ঘ্যরে শস্য মাড়াইয়ে অপেক্ষাকৃত ভাল ফল পাওয়া যায়।
- কম আর্দ্রতা সম্পন্ন ফসল মাড়াইয়ে ব্যবহার করলে যন্ত্রটির মাড়াই ক্ষমতা বৃদ্ধি পায়।
- যন্ত্রটি উচ্চ মাত্রায় শ্রম এবং অর্থ সাশ্রয়ী।
- মাড়াই ক্ষমতা পা-চালিত মাড়াই যন্ত্রের চেয়ে প্রায় ৮ গুণ বেশি।
- সিলিন্ডার গতিবেগঃ ৫৫০-৬০০ আরপিএম।
- মাড়াই দক্ষতাঃ ৯৯ শতাংশ।
- কার্যক্ষমতা ধানঃ ৯৩০ কেজি/ঘন্টা, গমঃ ৩৪০ কেজি/ঘন্টা।
- মূল্যঃ ৮৫,০০০ টাকা (ইঞ্জিনসহ)।

চিত্রঃ **বারি শস্য মাড়াই যন্ত্র**

চিত্রঃ **বারি শস্য মাড়াই যন্ত্র দ্বারা ধান মাড়াই**

বারি শক্তি চালিত ভুট্টা মাড়াই যন্ত্র

বর্তমানে দেশের অনেক এলাকায় ব্যাপকভাবে ভুট্টা চাষ করা হচ্ছে। হস্ত-চালিত ভুট্টা মাড়াই যন্ত্র দিয়ে বেশি পরিমাণ ভুট্টা মাড়াই করা সম্ভব নয়। এ বিবেচনায় অধিক ক্ষমতাসম্পন্ন শক্তি-চালিত ভুট্টা মাড়াই যন্ত্র উদ্ভাবন করা হয়েছে। বর্তমানে এ যন্ত্রটি সারাদেশে ব্যাপকভাবে তৈরি ও ব্যবহৃত হচ্ছে।

বৈশিষ্ট্য

১। এ যন্ত্রটির নির্মাণ কৌশল সহজ
২। যন্ত্রটি পরিচালনা করা খুবই সহজ
৩। এর মেরামত করার প্রয়োজনীয়তা কম
৪। যন্ত্রটি দিয়ে ভুট্টা মাড়াই করার জন্য ৩ জন লোকের দরকার হয়
৫। যন্ত্রটি উচ্চ ক্ষমতা সম্পন্ন হওয়ায় মাড়াই খরচ খুবই কম
৬। যন্ত্রটির মূল্য- বড় : ৬৫,০০০ টাকা (ইঞ্জিন/মটর ছাড়া) , ছোট : ৫৫,০০০ টাকা (ইঞ্জিন/মটর ছাড়া)

চিত্রঃ বারি শক্তি চালিত ভুট্টা মাড়াই যন্ত্র

বারি বাদাম মাড়াই যন্ত্র

বাংলাদেশের চরাঞ্চলে বাদামের চাষ ক্রমেই বৃদ্ধি পাচ্ছে। বিস্তৃত এলাকায় বপনের জন্য প্রয়োজনীয় বাদামের খোসা ছাড়াতে ও মাঝারি ধরণের কনফেকশনারির জন্য হসত্মচালিত বাদাম মাড়াই যন্ত্র যথেষ্ট নয়। এ বিবেচনায় শ্রম সাশ্রয়ী শক্তিচালিত বাদাম মাড়াই যন্ত্র উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- যন্ত্রটি স্থানীয় প্রকৌশল কারখানায় তৈরি করা যায়
- যন্ত্রটি চালানোর জন্য একজন লোকই যথেষ্ট
- যন্ত্রটি একই সাথে মাড়াই ও ঝাড়াইয়ের সাথে সাথে মাড়াইকৃত বাদাম
- থেকে অমাড়াইকৃত বাদাম আলাদা করে দেয়
- মাত্র ০.৫ অশ্বশক্তির বৈদ্যুতিক মোটর দিয়ে চালানো যায়
- যন্ত্রের মাপ : ১০৬ × ৪১ × ১০১ সেমি
- হপারের ধারণ ক্ষমতা : ৬-১০ কেজি
- যন্ত্রের ওজন : ৭৫ কেজি
- মাড়াই ক্ষমতা : ১২০-১৫০ কেজি/ঘণ্টা
- দানা ভাঙ্গার হার : ১-২%
- ঝাড়াই দক্ষতা : ১০০% ; বাছাই দক্ষতা : ৯৫%
- মূল্য : ৩৫,০০০ টাকা (মোটরসহ)

চিত্রঃ বারি বাদাম মাড়াই যন্ত্র

বারি সূর্যমুখী মাড়াই যন্ত্র

সূর্যমুখী আমাদের দেশে একটি গৌন তেল ফসল কিন্তু এটি বিশ্বের দ্বিতীয় ভোজ্য তেল ফসল। দেশের ভোজ্য তেলের চাহিদা মেটাতে সূর্যমুখী ভাল অবদান রাখতে পারে। ফসল কর্তনের পর একটা একটা করে পুষ্পস্তবক হাতে মাড়াই করা যেমন সময় সাপেক্ষ তেমনি কষ্টকর। সূর্যমুখীর দানা বের করে আনতে এ কারনে খরচও বেড়ে যায়। এ বিষয়গুলো বিবেচনা করে সূর্যমুখী মাড়াই যন্ত্র উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- যন্ত্রটি স্থানীয় প্রকৌশল কারখানায় তৈরি করা যায়
- যন্ত্রটি চালানোর জন্য একজন লোকই যথেষ্ট
- বাছাইকৃত সূর্যমুখীর পুষ্পস্তবক দিয়ে উচ্চমাত্রার ফলাফল পাওয়া যায়
- মাত্র ৪.৫ অশ্বশক্তির ডিজেল ইঞ্জিন দিয়ে যন্ত্রটি চালানো যায়
- মাঠ থেকে পরিপক্ক পুষ্পস্তবক সংগ্রহ করে সাথে সাথেই এই যন্ত্র দ্বারা মাড়াই করা যায়
- কার্যক্ষমতা ১০০০ কেজি/ঘন্টা
- **মূল্যঃ ৫৫,০০০.০০ টাকা ।**

চিত্রঃ বারি সূর্যমুখী মাড়াই যন্ত্র

বারি শস্য ঝাড়াই যন্ত্র

বাংলাদেশের কৃষকগণ শস্য মাড়াই করার পর পরিষ্কার করার জন্য প্রাকৃতিক বাতাসের উপর নির্ভর করেন। পর্যাপ্ত বাতাসের অভাবে অনেক শস্য অপরিষ্কার অবস্থায় স্তুপাকারে রাখার ফলে অপচয় হয়। শস্যের গুণগত মান ও দাম কমে যায়। এ সমস্যা দূরীকরণে শক্তিচালিত শস্য ঝাড়াই যন্ত্র উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- ঘরোয়া পরিবেশে এবং দূর্যোগপূর্ণ আবহাওয়ায় ব্যবহার করা যায়।
- অল্প সময় ও খরচে ঝাড়াই ও পরিষ্কার করা সম্ভব।
- যে কোন মহিলা/পুরুষ এটি সহজে চালাতে পারেন।
- স্থানীয় কারখানায় এটি সহজে তৈরি করা যায়।
- ফসলঃ ধান, গম, ডাল ও তৈলবীজ।
- বাতাসের গতিঃ ৩.৫০ মিটার/সেকেন্ড।
- শক্তির উৎসঃ ০.৫ অশ্বশক্তি মটর।
- কার্যক্ষমতাঃ ধান, গম ১০০০ কেজি/ঘন্টা
- মূল্যঃ ৩৫,০০০ টাকা

চিত্রঃ বারি শস্য ঝাড়াই যন্ত্র

চিত্রঃ বারি শস্য ঝাড়াই যন্ত্র দ্বারা ধান ঝাড়াই

বারি নারিকেলের ছোবড়া ছাড়ানো যন্ত্র

নারিকেল বাংলাদেশের খুব সুপরিচিত ও জনপ্রিয় ফল। ইহা উপকূলীয় অঞ্চলে অধিক হারে উৎপাদিত হয়। সাধারণত গ্রামাঞ্চলে হাতের সাহায্যে ধারালো লোহা অথবা সারাশির সাহায্যে নারিকেলের ছোবড়া ছাড়ানো হয় যা সময় সাপেক্ষ ও কষ্টসাধ্য। এই কাজের জন্য দক্ষ শ্রমিকেরও প্রয়োজন। ফলে সকল আকারের ও স্বল্প সময়ে অধিক হারে নারিকেলের ছোবড়া ছাড়ানোর জন্য শক্তিচালিত নারিকেলের ছোবড়া ছাড়ানো যন্ত্রটি উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

১। যন্ত্রটি দিয়ে সহজে ও দ্রুত সকল আকারের নারিকেলের ছোবড়া ছাড়ানো যায়
২। এই যন্ত্র দিয়ে প্রচলতি পদ্ধতির তুলনায় দ্বিগুণ পরমিাণ নারিকেলের ছোবড়া ছাড়ানো যায়
৩। একশত নারিকেলের খোসা ছাড়াতে খরচ হয় ৪০ টাকা
৪। যন্ত্রটি প্রচলিত পদ্ধতির তুলনায় ৫৭% খরচ এবং ৫০% সময় সাশ্রয় করে
৫। স্থানীয় সেবা প্রদানকারীগণ যন্ত্রটি ভাড়া খাটিয়ে আর্থকিভাবে লাভবান হবেন
৬। যন্ত্রটির কার্যক্ষমতাঃ ৩০০ টি নারিকেল/ঘন্টা
৭। ছোবড়া ছাড়ানোর খরচঃ প্রতি নারিকেল ৪০ পয়সা মাত্র
৮। যন্ত্রটির মূল্যঃ ১০০,০০০ টাকা

চিত্রঃ বারি নারিকেলের ছোবড়া ছাড়ানো যন্ত্র

বারি আম পাড়া যন্ত্র

বাংলাদেশে আমপাড়ার জন্য সাধারণত গোলাকৃতির বাশের ঝুড়ি ব্যবহৃত হয়। যাতে একটি পোলে পাট অথবা নাইলনের তৈরি জাল ব্যবহৃত হয়। ঝুড়িটি একটি বাশের উপরে লাগানো থাকে। এই পদ্ধতিতে আম বোটার শেষ প্রান্তে ছিড়ে যায় যার

ফলে আম বোটা পঁচা রোগে আক্রান্ত হয়। এর ফলে আমের জীবনকাল এবং বাজার দর উভয়ই কমে যায়। তাই বারি কর্তৃক একটি আম পাড়ার যন্ত্র উদ্ভাবন করা হয়েছে যার দ্বারা ১০-২০ মিমি লম্বা বোটা রেখে আম পাড়া যায়। আম রপ্তানিকারক দেশে আমের বোটা পঁচা রোগ থেকে মুক্তির জন্য আমের বোটা রেখে আম পাড়া হয় যা এই যন্ত্র দিয়ে সম্ভব ।

বৈশিষ্ট্য

১। যন্ত্রটি জিআই তার, হাইকার্বন স্টীল ব্লেড, জিপি শীট , ক্লাচ ক্যাবল, লিভার এবং পাট অথবা নাইলনের রশি দ্বারা তৈরি

২। যখন আম গাছ থেকে পাড়া হয় তখন যন্ত্রটিকে বাঁশের সাথে ০ ডিগ্রিতে এবং যখন আম নিচ থেকে পাড়া হয় তখন যন্ত্রটিকে বাঁশের ৪৫ ডিগ্রি কোণে সেট করতে হয়।

৩। রিং এর ব্যাসঃ ২৫০ মি.মি.

৪। ওজনঃ ১.৭০ কেজি (বাঁশের পোলসহ)

৫। **কার্যক্ষমতাঃ** ৪০-৫০ কেজি/ঘন্টা

৬। যন্ত্রটির মূল্যঃ ১০০০ টাকা (বাঁশের পোলসহ)


চিত্রঃ বারি আম পাড়া যন্ত্র

বারি ফল শোধন যন্ত্র

বাংলাদেশে প্রচুর পরিমাণে ফল উৎপন্ন হয়। প্রধান ফলের মধ্যে আম, কলা, পেঁপে, পেয়ারা, কাঁঠাল ও আনারস ইত্যাদি রয়েছে। এ ফলগুলোর জীবনকাল খুব কম ও উচ্চ পচনশীল। যেমন আম ও কলা এ্যানথ্রাকনোস রোগের মাধ্যমে দ্রুত নষ্ট হয়ে যায়। পাকা আম ৭/৮ দিনের বেশী স্বাভাবিক অবস্থায় রাখা যায় না। তদ্রুপ পাকা কলা ৬/৭ দিনের বেশী রাখা যায় না। তাই, আমাদের দেশে সংগ্রহোত্তর অপচয় ২০-৩০%। এ অপচয় রোধে অনেক সময় রাসায়নিক দ্রব্য ব্যবহার করা হয় যা স্বাস্থ্য বা পরিবেশের জন্য ক্ষতিকর। পরিপক্ক ফলের জীবনকাল বাড়ানোর ও অপচয় কমানোর জন্য রাসায়নিক দ্রব্য ছাড়া গরম পানিতে শোধন করে ফলের জীবনকাল বৃদ্ধি করে এর অপচয় কমানো যায়। এ লক্ষ্যে ফল শোধন যন্ত্রটি উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- ✓ বড় আকারের ফল শোধন যন্ত্রে ২ কিলোওয়াটের ১০ টি বৈদ্যুতিক হিটারের মাধ্যম পানিকে গরম করা হয়
- ✓ ছোট আকারের ফল শোধন যন্ত্রে ২ কিলোওয়াটের ৬ টি বৈদ্যুতিক হিটারের মাধ্যম পানিকে গরম করা হয়
- ✓ তাপমাত্রা নিয়ন্ত্রণের জন্য ডিজিটাল তাপমাত্রা নিয়ন্ত্রক ব্যবহার করা হয়েছে
- ✓ ফল ভর্তি প্লাস্টিক ক্রেট বহনের জন্য মটর চালিত কনভেয়ার রোলার ব্যবহার করা হয়েছে
- ✓ যন্ত্রটি দিয়ে নিরবচ্ছিন্নভাবে আম শোধন করা যায়
- ✓ যন্ত্রটি চালানোর জন্য ৪ জন শ্রমিকের প্রয়োজন হয়
- ✓ এ যন্ত্র দিয়ে আমকে সুষমভাবে ৫৩-৫৫ ডিগ্রি সেলসিয়াস তাপমাত্রার পানিতে ৫–৭ মিনিট ডুবিয়ে শোধন করা হয়
- ✓ এ যন্ত্র দিয়ে কলাকে সুষমভাবে ৫৩-৫৫ ডিগ্রি সেলসিয়াস তাপমাত্রায় পানিতে ৫–৯ মিনিট ডুবিয়ে শোধন করা হয়
- ✓ শোধনকৃত আম ৭-৮ দিনের পরিবর্তে ১০-১২ দিন পর্যন্ত টাটকা থাকে এবং গায়ের রং উজ্জ্বল হয়
- ✓ শোধনকৃত কলা ৬-৭ দিনের পরিবর্তে ৮-১০ দিন পর্যন্ত টাটকা থাকে এবং গায়ের রং উজ্জ্বল হয়

- ✓ কার্যক্ষমতা - আমের জন্যঃ ১০০০ কেজি/ঘন্টা (বড় যন্ত্র); ৫০০ কেজি/ঘন্টা (ছোট যন্ত্র)
- ✓ কলার জন্যঃ ৬০০ কেজি/ঘন্টা (বড় যন্ত্র); ৩০০ কেজি/ঘন্টা (ছোট যন্ত্র)
- ✓ শোধন খরচ - আমের জন্যঃ ০.৩১ টাকা/কেজি (বড় যন্ত্র); ৫০০ টাকা/কেজি (ছোট যন্ত্র)
- ✓ কলার জন্যঃ ০.৩৮ টাকা/কেজি (বড় যন্ত্র); ০.৬৩ টাকা/কেজি (ছোট যন্ত্র)
- ✓ যন্ত্রটির মূল্যঃ ২,৮০,০০০ টাকা (বড় যন্ত্র); ১,৮০,০০০ টাকা (ছোট যন্ত্র)

চিত্রঃ বারি ফল শোধন যন্ত্র

বারি হলুদ পলিসার

বিবরণ

বাংলাদেশের হলুদ গুণগত দিক থেকে বিখ্যাত। হলুদ সংগ্রহের পর প্রক্রিয়াজাতকরণের বিভিন্ন ধাপগুলো হলো পরিস্কার করা, বাছাই করা, সিদ্ধ করা, শুকানো, পলিস করা এবং গুড়া করা। হলুদ পলিস করা বলতে বুঝায় শুকানো হলুদের চামড়া, শিকড় এবং অন্যান্য অনাকাঙ্খিত অংশ সরিয়ে উজ্জ্বল, মসৃণ এবং হলুদাভ কন্দ পাওয়া। এ কাজটি সাধারণত বস্তায় ভরে হাত দিয়ে পিটিয়ে করা হয়ে থাকে যা সময় সাপেক্ষ্য, কষ্টসাধ্য এবং শ্রমনির্ভর। কৃষকের কষ্ট লাঘব করার জন্য একটি শক্তিচালিত হলুদ পলিসার উদ্ভাবন করা হ য়েছে।

বৈশিষ্ট্য

- স্থানীয়ভাবে প্রাপ্ত লৌহ সামগ্রী দিয়ে যন্ত্রটি তৈরি করা যায়
- মাত্র ০.৫ অশ্বশক্তির বৈদ্যুতিক মোটর দিয়ে যন্ত্রটি চালানো যায়
- একজন মানুষ অতিসহজেই এ যন্ত্র চালাতে পারে
- ঘূর্ণায়মান ষড়ভুজাকৃতির ড্রামের দৈর্ঘ্য ৬১০ মিমি, বাহিরের ব্যাস ৬৯ সেমি, ভেতরের ব্যাস ৫৯ সেমি
- যন্ত্রের মাপ : ১০৪ × ৮৫ × ১৪৫ সেমি
- প্রতি ব্যাচে হলুদের ওজন : ৩০ কেজি
- যন্ত্রের ওজন : ৯০ কেজি
- কার্যক্ষমতা : ৬৫-৯০ কেজি/ঘণ্টা
- মূল্য : ৩৫,০০০ টাকা (মোটরসহ)

পলিসার

চিত্রঃ বারি হলুদ

বারি মূল জাতীয় সবজি ধৌতকরণ যন্ত্র

ধৌতকরণ হলো সবজি বাজারজাতকরণের প্রাথমিক ও গুরুত্বপূর্ণ ধাপ। মাঠ থেকে সংগ্রহের পর সতেজ সবজি পরিষ্কার পানিতে ধৌতকরণের ফলে সবজির গায়ে লেগে থাকা ধুলাবালি, ময়লা-কাদা, ক্ষুদ্র অনুজীবের স্পোর বা খন্ডাংশ এমনিক বালাইনাশকের আবিশষ্টাংশও দূরীভূত হয়। এছাড়া ধৌতকরণের ফলে সবজির অভ্যন্তরীণ তাপমাত্রা হ্রাস পায়, যার ফলে সবজি সতেজ থাকে এবং এর সংগ্রোহত্তর জীবনকাল বৃদ্ধি পায়। কাজেই ধৌতকরণের ফলে পরিষ্কার করণের পাশাপাশি একইসাথে প্রিকুলিং এর কাজ সম্পন্ন হয়। এক্ষেত্রে অবশ্যই জীবাণুমুক্ত পরিষ্কার পানি ব্যবহার করতে হবে এবং প্রয়োজন অনুসারে পানি পরিবর্তন করে নিতে হবে। তবে, হাতে সবজি ধৌত করা কষ্টসাধ্য ও ব্যয়বহুল কাজ। তাই জাতীয়ভাবে যান্ত্রিক উপায়ে সবজি ধৌতকরণ যন্ত্রের প্রয়োজনীয়তা দেখা দিয়েছে। এ লক্ষ্যে সবজি ধৌতকরণ যন্ত্রটি উদ্ভাবন করা হয়েছে। এই যন্ত্রটির মাধ্যমে লালশাক, ডাটা, করলা, বেগুন, টমেটো, সীম, গাজর, মুলা ইত্যাদি সবজি অল্প সময়ে ও কম খরচে ধোয়া যায়।

বৈশিষ্ট্য

- ✓ এটি একটি মূল জাতীয় সবজি ধৌতকরণ যন্ত্র
- ✓ এটির সাহায্যে সবজীর গায়ে লেগে থাকা ধূলা, মাটি-কাদা, কষ, আঠা ও অন্যান্য ক্ষতিকারক জীবানু ভালভাবে পরিষ্কার করা যায়
- ✓ প্রচলিত পদ্ধতির তুলনায় ৬৭% খরচ, ৪০% সময় ও ৬৭% শ্রমিকের সাশ্রয় হয়
- ✓ শক্তির উৎসঃ ২.২ কিলোওয়াট বৈদ্যুতিক মোটর
- ✓ গাজর ধোয়ার খরচঃ ৩৪০ টাকা/টন
- ✓ কার্যক্ষমতাঃ ১০ টন/ঘন্টা (প্রতি ব্যাচে ১২০ কেজি গাজর ধোয়া যায় মাত্র ৫–৬ মিনিটে)
- ✓ যন্ত্রটির মূল্যঃ ২,৩০,০০০ টাকা

চিত্রঃ বারি মূল জাতীয় সবজি ধৌতকরণ যন্ত্র

বারি মোবাইল তেল নিষ্কাশন যন্ত্র

বিবরণঃ

বাংলাদেশে কয়েক দশক ধরে ভোজ্যতেলের ঘাটতি রয়েছে। মোট ভোজ্যতেলের প্রায় শতকরা ৭০ ভাগ বিদেশ থেকে আমদানী করা হয়ে থাকে। বাংলাদেশে উৎপাদিত তৈলবীজ (সরিষা, তিল, সূর্যমুখী, সয়াবীন, চীনাবাদাম, তিসি ইত্যাদি) দ্বারা শতকরা ৩০ ভাগ চাহিদা পূরণ করা হয়ে থাকে। বাজারে প্রচলিত তৈল মিলের কার্যক্ষমতা বেশী (কমপক্ষে ১০ কেজি) হওয়ায় অনেক কৃষক অল্প পরিমাণ তৈলবীজ ভাঙ্গাতে পারেন না। তাছাড়া বাণিজ্যিক তেল মিলগুলি শহর বা উপজেলা পর্যায়ে স্থাপিত। গ্রামাঞ্চলে তেলের মিল বিরল। ফলে কৃষকগণ তৈলবীজ উৎপাদন করা সত্বেও বিশুদ্ধ তেলের স্বাদ থেকে বঞ্চিত হন। কৃষক যাতে তার উৎপন্ন অল্প পরিমাণ (কমপক্ষে ২ কেজি) তৈলবীজ তার এলাকায় ভাঙ্গিয়ে বিশুদ্ধ তৈল সংগ্রহ করতে পারেন সেলক্ষে এই মোবাইল তেল নিষ্কাশন যন্ত্রটি উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্যসমূহঃ

- ✓ স্থানীয় কারখানায় যন্ত্রটি সহজে তৈরি করা যায়
- ✓ যন্ত্রটি দিয়ে সহজে অতি অল্প সময়ে ও কম খরচে সরিষা, বাদাম, সূর্যমূখী, কালো জিরা প্রভৃতির বীজ থেকে তেল নিষ্কাশন করা সম্ভব
- ✓ যন্ত্রটি পাওয়ার টিলার অথবা ইঞ্জিন দ্বারা চালানো যায়
- ✓ যন্ত্রটি দ্বারা ক্ষুদ্র প্রান্তিক তৈল বীজ চাষী অথবা বাসা বাড়ির লোকজন সর্বনিম্ন ২ কেজি দানা ভাঙ্গাতে পারেন
- ✓ যন্ত্রটি পাওয়া টিলার চালিত হওয়ায় সহজে স্থানান্তরযোগ্য
- ✓ কার্যক্ষমতাঃ ১২-২০ কেজি/ঘণ্টা
- ✓ ওয়েল রিকভারিঃ ৩৫%
- ✓ প্রয়োজনীয় শ্রমিকঃ ২ জন
- ✓ যন্ত্রটির মূল্যঃ ১,৬০,০০০ টাকা

চিত্রঃ বারি মোবাইল তেল নিষ্কাশন যন্ত্র

বারি আলু গ্রেডিং যন্ত্র

বাণিজ্যিকভাবে এবং কৃষক পর্যায়ে বীজ সংরক্ষণ ও বাজারে বিক্রয়ের জন্য বিভিন্ন আকারে আলু ভাগ করতে হয়। বর্তমানে আলু গ্রেডিং এর কাজটি কোল্ড স্টোরের শ্রমিক ও কৃষকগণ হাতের সাহায্যে বিভিন্ন আকারে ভাগ করে থাকেন। এর জন্য প্রচুর শ্রমিক লাগে এবং অনেক সময় ব্যয় হয়। সেজন্য গ্রেডিং এর কাজে খরচ পড়ে অনেক বেশি। কম খরচে, অল্প সময়ে আলু বিভিন্ন আকারে ভাগ করার জন্য এফএমপিই বিভাগ, বিএআরআই কর্তৃক শক্তিচালিত আলু গ্রেডিং যন্ত্র উদ্ভাবন করা হয়েছে।

চিত্র ৪ বারি শক্তিচালিত আলু গ্রেডিং যন্ত্র

বৈশিষ্ট্য

- যন্ত্রটি এমএস ফ্লাটবার দিয়ে তৈরি।
- সিলিন্ডারটি ফ্রেমের মাঝে ৮ ডিগ্রি কোণে একটি শ্যাফটের সাহায্যে দুটি বিয়ারিং এর উপর বসানো থাকে।

- এমএস শীট দিয়ে ফিডিং হপার তৈরি।
- মাপঃ ৩০৫×১৫৪×১৯০ সেমি
- চালুনির সংখ্যা- ২ টি
- শক্তির উৎসঃ ০.৫ অশ্বশক্তির বৈদ্যুতিক মটর।
- কার্যক্ষমতাঃ ১.৩ টন/ঘন্টা।
- মূল্যঃ ৫০,০০০ টাকা (ইঞ্জিন/মটর ছাড়া)।

বারি স্লাইসার

বিবরণ

আলু ও মিষ্টি আলুকে স্লাইস করে শুকিয়ে চিপস্ এবং পাউডার বানিয়ে সংরক্ষণ ও প্রয়োজন অনুসারে খাদ্য হিসাবে ব্যবহার করা যায়। অপচয় হ্রাসকরণ ও এই চাহিদা পূরনে ঘরে বা ক্ষুদ্র কুটিরশিল্প পর্যায়ে আলু ও মিষ্টি আলুর চিপস তৈরি করা একটি লাভজনক প্রযুক্তি হতে পারে । কিন্তু এই পর্যায়ের উপযোগী কোন স্লাইসার নেই। হাতে আলু ও মিষ্টি আলুর স্লাইস করা কষ্টকর, সময়সাপেক্ষ ও ব্যয়বহুল। এই বিষয়গুলো উপলব্ধি করে এফএমপিই বিভাগ, বিএআরআই কর্তৃক একটি স্লাইসার উদ্ভাবন করেছে যা চিপস তৈরির জন্য আলু, মিষ্টি আলুসহ হোটেল বা ডেকোরেটর পর্যায়ে পেঁয়াজ, শসা ইত্যাদি স্লাইস করার জন্য উপযোগী।

বৈশিষ্ট্য

- যন্ত্রটি স্থানীয় প্রকৌশল কারখানায় তৈরি করা যায়।
- যন্ত্রটি দ্বারা আলু, মিষ্টি আলু, পেঁয়াজ, শসা ইত্যাদি স্লাইস করা যায়।
- যন্ত্রটি উচ্চ মাত্রায় শ্রম ও অর্থ সাশ্রয়ী।
- যন্ত্রটি চালানোর জন্য একজন লোকের প্রয়োজন হয়।
- এর দ্বারা তৈরিকৃত স্লাইস গুলো ২-৩ মিমি পুরুত্বের হয় ও পুরুত্ব কম বা বেশী করা যায়।
- কার্যক্ষমতাঃ
  আলুঃ ৬০ কেজি/ঘন্টা, মিষ্টি আলুঃ ৪০ কেজি/ঘন্টা, পেঁয়াজঃ ৩৫ কেজি/ঘন্টা
- যন্ত্রের মূল্যঃ ৮০০০ টাকা

চিত্রঃ বারি স্লাইসার দ্বারা আলু স্লাইসকরণ

বারি কম্পোস্ট সেপারেটর

ভার্মিকম্পোস্ট এমন এক ধরনের সার যা ব্যবহারে রাসায়নিক সারের ব্যবহার শতকরা ৫০ ভাগ পর্যন্ত সাশ্রয় করা সম্ভব। গোবর, খড়, পচনশীল আবর্জনা, লতাপাতা ইত্যাদি খেয়ে কেঁচো মল ত্যাগ করে ও তার দেহ হতে এক ধরনের রাসায়নিক পদার্থ নিঃসৃত হয়। এগুলো জৈব পদার্থের সাথে মিশ্রিত হয়ে মাটির পুষ্টিমান বাড়িয়ে দেয়। বর্জ্য পদার্থ যখন চা পাতার মতো ঝুরঝুরে হয় তখন বুঝতে হবে সার তৈরি হয়ে গেছে। কেঁচো সার তৈরি হতে ৩০-৩৫ দিন সময় লাগে। প্রকৃতপক্ষে কেঁচোর মলই হলো এ সার। এ অবস্থায় চালুনি দিয়ে চেলে কোকুন (কেঁচোর ডিম) এবং ঝরঝরো অংশ আলাদা করতে হয়। ভার্মিকম্পোস্ট বা কেঁচো সার তৈরিতে সবচেয়ে ব্যয়বহুল ও কষ্টসাধ্য কাজ হলো কম্পোষ্ট থেকে কেঁচো আলাদা করা ও ছেঁকে নির্দিষ্ট সাইজের গুড়া প্যাকেটজাতকরণের জন্য আলাদা করা। চালুনীর মাধ্যমে হাতে চেলে কাঙ্ক্ষিত আকারের সার পাওয়ার জন্য দক্ষ শ্রমিকের প্রয়োজন। হাতে চেলে কেঁচো আলাদা করা যেমন কষ্টের তেমনি কেঁচোর স্বাস্থ্যের জন্যও ক্ষতিকর। তাছাড়া এভাবে সার কমপক্ষে দুই বার হাতে চালতে হয়। কিন্তু এই যন্ত্রের দ্বারা একই সাথে কেঁচো আলাদা করা সহ একবারেই কাঙ্ক্ষিত সার পাওয়া সম্ভব। ট্রাইকোকম্পোস্ট বিভিন্ন জৈব পদার্থের সহিত ট্রাইকোডার্মা মিশ্রিত একটি উৎকৃষ্ট মানের জৈবসার। ট্রাইকোডার্মা এক ধরণের ছত্রাক যা মাটির সাথে বা জৈব সারের সাথে মিশ্রিত অবস্থায় সর্বদা স্বাভাবিক পরিবেশে এ্যান্টিবায়োটিক বা এনজাইম নিঃসরণ করে থাকে; যা শস্য বা উদ্ভিদকে আক্রমণকারী অন্যান্য ক্ষতিকর ছত্রাকের আক্রমণ প্রতিরোধে সহায়তা করে। এটি ব্যবহার করে বিভিন্ন ফসল ও উদ্ভিদের রোগ বালাই নিয়ন্ত্রণ বা দমন করার কথা সর্বজন স্বীকৃত। ট্রাইকোকম্পোস্টে ভিজা ও দলাকৃতির কম্পোষ্ট তৈরি হয় যা চালা অত্যন্ত কষ্টসাধ্য। কাঙ্ক্ষিত সার পেতে ৩-৪ বার চালতে হয় কিন্তু সেপারেটর দিয়ে খুব সহজেই সারের আর্দ্রতাভেদে ১-২ বারেই কাঙ্ক্ষিত সার পাওয়া সম্ভব।

বৈশিষ্ট্য

- স্থানীয়ভাবে প্রাপ্ত লৌহ সামগ্রী দিয়ে তৈরি করা যায়
- সার থেকে কেঁচোকে সফলভাবে আলাদা করা যায়
- অল্প সময় ও স্বল্প খরচে বাণিজ্যিক ভিত্তিতে কেঁচো সার চালার জটিল ও ঝামেলাপূর্ণ কাজ সম্পন্ন করা যায়
- কেঁচোর কোন ক্ষতি হয় না
- ট্রাইকোকম্পোস্টকে সহজেই চালা যায়
- যন্ত্রটি চালাতে ৩ জন লোকের প্রয়োজন হয়
- যন্ত্রটি দ্বারা ৫ মিমি এর চেয়ে কম আকারের চা পাতার মত সার সহজেই পাওয়া যায়।
- কার্যক্ষমতা : ১,৫০০ কেজি/ঘণ্টা (ভার্মিকম্পোস্ট), ১,০০০ কেজি/ঘণ্টা (ট্রাইকোকম্পোস্ট)
- চালনা খরচ : ৭০ টাকা/টন (ভার্মিকম্পোস্ট), ১৫০ টাকা/টন (ট্রাইকোকম্পোস্ট)
- মূল্য : ৫৫,০০০.০০ টাকা (মোটরসহ)

চিত্রঃ বারি কম্পোস্ট সেপারেটর

কার্যপ্রণালী

যন্ত্রটি একটা ছায়াযুক্ত সমতল ও খোলা জায়গায় বসান। তারের সাহায্যে বৈদ্যুতিক লাইনে মোটরকে সংযোগ দিন। সুইচ অন করলে মোটর চালু হবে এবং সিলিন্ডারাকৃতির চালনি ঘুরতে আরম্ভ করবে। প্রবেশ হপারে পিট/চাড়ি থেকে সংগ্রহকৃত কম্পোষ্ট ঢালুন। হালকা আর্দ্রতা সম্পন্ন কম্পোস্ট সমান ভাবে চালনিতে প্রবেশ করান। মুহূর্তের মধ্যে কাঙ্ক্ষিত চা পাতার মতো সার চালনির নিচে সংগ্রহ ট্রেতে জমা হবে এবং কেঁচো ও বড় আকৃতির বর্জ্য নির্গমন পথ দিয়ে বের হবে। লক্ষণীয় যে, ভার্মিকম্পোস্টের বেলায় কেঁচোগুলো একদিকে জমা হবে এবং বর্জ্য কিঞ্চিত দূরে জমা হবে। কেঁচোগুলোকে সামান্য বর্জ্যসহ আলাদা করে নতুন পিটে বা চাড়িতে দেয়া যাবে। বড় আকৃতির বর্জ্য অন্যান্যের সাথে মিশিয়ে পুনরায় পিটে/চাড়িতে দেয়া যাবে। ট্রাইকোকম্পোস্টের আর্দ্রতা বেশি থাকলে বড় আকৃতি ও অচালা সার যা নির্গমন পথ দিয়ে বের হয় তাকে দ্বিতীয় বার চালতে হতে পারে। কিছুক্ষণ পর পর সার সংগ্রহ করে বস্তায় ভর্তি করতে হবে।

বারি সৌরচালিত কেবিনেট ড্রায়ার

আমাদের দেশে সবজির বীজ উৎপাদনের পর বিভিন্ন প্রতিকূল পরিবেশ যেমন বাতাসে উচ্চ আর্দ্রতা, টানা বৃষ্টিপাত বা কুয়াশা ইত্যাদি পরিস্থিতির কারণে বীজমান নষ্ট হয়। বীজ সংরক্ষণের প্রধান ধাপ বীজ সঠিকভাবে শুকানো। টমেটো বীজ মাঝারি গতিতে শুকায়, কপি ও মুলার বীজ ধীরে শুকায় আবার লাউয়ের বীজ তাড়াতাড়ি শুকায়। কাজেই সব বীজেই একই ভাবে একই সময় ধরে শুকানো ঠিক নয়। কম তাপমাত্রায় অনেক সময় ধরে বীজ শুকালে বীজের তেজ যেমন নষ্ট হয় তেমনি অধিক তাপমাত্রায় অল্প সময়ের মধ্যেই শুকালে সজীবতা নষ্ট হতে পারে। তবে যে বীজেই হোক না কেন বীজ ভালোভাবে শুকিয়ে রাখতে হবে। সবজি বীজের ক্ষেত্রে আর্দ্রতার উপর বীজের আয়ুষ্কাল নির্ভরশীল। পাকা ফসল থেকে সবজি বীজ সংগ্রহের সময় এতে সাধারণতঃ ৬০-৮০% আর্দ্রতা থাকে এবং বীজমান বজায় রেখে দীর্ঘ দিন সংরক্ষণের জন্য এর আর্দ্রতা ৭-৯% থাকা জরুরী। আমাদের দেশে প্রাচীনকাল থেকেই রোদে সব ধরনের বীজ শুকানো হয় কিন্তু এই পদ্ধতি ধীরগতির ও আবহাওয়ার উপর পুরোপুরি নির্ভরশীল হওয়ায় এতে পোকা মাকড় ও ছত্রাকের আক্রমণে বিপুল পরিমাণ বীজ নষ্ট হয়। বর্ষাকালে টানা মেঘলা আবহাওয়ায় বীজ শুকানো প্রলম্বিত হয় এবং হঠাৎ বৃষ্টিতে অনেকসময় বীজ ভিজে ক্ষয়ক্ষতির পরিমাণ বৃদ্ধি পায়। এ সকল সমস্যা ও তার আশু সমাধানের কথা চিন্তা করে সোলার কেবিনেট ড্রায়ার উদ্ভাবন করা হয়েছে যা বীজকে পরিষ্কার রেখে সুষম তাপমাত্রা ও আর্দ্রতায় নির্দিষ্ট সময়ের মধ্যে শুকাতে সক্ষম।

বৈশিষ্ট্য

- ✓ স্থানীয়ভাবে প্রাপ্ত সামগ্রী দিয়ে তৈরী করা যায়
- ✓ অল্প জায়গায়, অল্প সময়ে সবজি বা অন্যান্য বীজকে শুকাতে সক্ষম
- ✓ কেবিনেটের ভিতরের তাপমাত্রা বাইরের তাপমাত্রার চেয়ে ১০-১২ ডিগ্রী বেশী থাকে
- ✓ ড্রায়ারের তাপমাত্রা নিয়ন্ত্রণযোগ্য
- ✓ উপরের কেবিনেটের সাথে নীচের কেবিনেটে থাকা বীজের শুকানোর মানে তারতম্য খুবই নগণ্য
- ✓ বারি সোলার কেবিনেট ড্রায়ারে শুকানো বীজের বীজমান মানঘোষিত বীজের শর্ত পূরণ করে
- ✓ প্রতি ব্যাচ বীজ শুকানোর খরচ ১১৭ টাকা (বড় ড্রায়ার) ও ১৬৩ টাকা (ছোট ড্রায়ার) মাত্র
- ✓ কার্যকারী ক্ষমতাঃ বড় ড্রায়ারঃ ১০-১২ কেজি/ব্যাচ (বীজের আকার অনুযায়ী)

ছোট ড্রায়ার ২-৬ কেজি/ব্যাচ (বীজের আকার অনুযায়ী)

- ✓ বড় ও ছোট সাইজের ড্রায়ারে প্রতি ব্যাচ বীজ শুকানোর খরচ ঘন্টা প্রতি যথাক্রমে ১১৭ টাকা ও ১৬৩ টাকা।
- ✓ মূল্যঃ টাকা ৯০,০০০.০০ (বড়); টাকা ৬০,০০০.০০ (ছোট)

চিত্রঃ বারি সৌরচালিত কেবিনেট ড্রায়ার

কার্যপ্রণালী

ড্রায়ারটি একটি পরিষ্কার, সমতল ও রৌদ্রজ্জ্বল স্থানে স্থাপন করতে হবে। যন্ত্রের কালেক্টর অংশটিকে রৌদ্রের দিকে রেখে যন্ত্রের সাথে সংযোগ দিতে হবে। হিটার সুইচ চালু করলে সোলার প্যানেল চালিত ফ্যান দুটি চালু হবে। কালেক্টরে সর্বাধিক সৌরশক্তি শোষণ ও তাপ উৎপন্নের জন্য এটি ঢেউ খেলানো কালো রঙের হয়ে থাকে এবং মোটা স্বচ্ছ প্লাস্টিক শিট দিয়ে তাপ বিকিরণ প্রতিহত করে। ফলে কালেক্টরের অভ্যন্তরীণ বাতাসের তাপমাত্রা বৃদ্ধি পায় এবং বীজ ধারণ করা কেবিনেট ও কালেক্টরের মধ্যবর্তী অবস্থানে থাকা ফ্যান এই উত্তপ্ত বাতাসকে টেনে কেবিনেটের ভিতরে প্রবেশ করায়। এই উত্তপ্ত বাতাস কেবিনেটের ভিতরে থাকা হিটার দ্বারা আরো উত্তপ্ত হয়ে বীজ শুকানোর আদর্শ তাপমাত্রায় পৌছে। এই তাপমাত্রা তাপমাত্রা নিয়ন্ত্রকের মাধ্যমে নির্ধারণ করা হয়। কেবিনেটের ভিতরে থাকা ট্রে তে সবজির বীজ একক স্তরে ছড়ানো হয়। প্রতি ট্রেতে কমপক্ষে ১-৩ কেজি বীজ দেয়া হয়। বীজপূর্ণ ট্রে শুকানোর জন্য কেবিনেটে প্রবেশ করানো হয়। মাঝে মাঝে বীজ নেড়ে দিতে হয়।

বারি হাইব্রিড ড্রায়ার

সূর্যের তাপে বা রোদে শস্য শুকানোর গতি অনেক কম এবং শস্য শুকাতে অনেক জায়গার প্রয়োজন হয়। সূর্যের আলো কখনও কম থাকে আবার কখনও বেশি হয়, ফলে সুষমভাবে শুকনো হয় না । শস্য শুকানোর সময় ধূলিকণা, পোকা-মাকড়, পশু-পাখি ও অণুজীবের দ্বারা শস্য আক্রান্ত হয়। শস্য সংগ্রহকালীন সময়ে অনবরত কয়েক দিন বৃষ্টিপাত হলে শস্যের বিরাট অংশ নষ্ট হয়ে যায় এমনকি সমস্ত শস্যও নষ্ট হয়ে যায়। উচ্চ মুল্যের ফসল যেমন- বীজ, মসলা ইত্যাদির গুনগত মানের জন্য সুষমভাবে শুকনো খবই গুরুত্বপূর্ণ

বৈশিষ্ট্য

- সৌরশক্তি ও বৈদ্যুতিক শক্তির সমন্বয়ে এটি চালনা করা হয়। তাছাড়া রিফ্লেক্টর ব্যবহার করে সৌরশক্তির মাত্রাকে প্রায় ৫০% বৃদ্ধি করা হয়।
- নির্গত গরম বাতাসকে পুন:রায় ব্যবহার করে তাপশক্তির সাশ্রয় করা যায়
- চাকা থাকার দরুণ ড্রায়ারকে স্থানান্তর করা সহজ এবং ড্রায়ারকে ঘুরিয়ে এবং রিফ্লেক্টর উচু ও নিচু করে সর্বাধিক সৌররশ্মি ড্রায়ারে আপতিত করা যায়
- ড্রায়ারের ক্ষমতাঃ
  ফল (৮০-১০০ কেজি) ২০-২৫ ঘন্টা, সবজি (৪০-৬০ কেজি) ১২-১৫ ঘন্টা, আলুর চিপস (১০ কেজি) ৬ ঘন্টা
- ড্রায়ারের মূল্যঃ টাকা ১২০০০০

চিত্রঃ বারি হাইব্রিড ড্রায়ার

বারি হ্যান্ডি সোলার ড্রায়ার

বিবরণ

সূর্যের তাপে বা রোদে শস্য শুকাতে অনেক সময় লাগে এবং শস্য শুকাতে অনেক জায়গার প্রয়োজন হয়। সূর্যের আলো কখনও কম আবার কখনও বেশী থাকে, ফলে সুষমভাবে শস্য শুকায় না। শস্য শুকানোর সময় ধূলিকণা, পোকা-মাকড়, পশু-পাখি ও অণুজীব দ্বারা শস্য শুকানো হয়। কয়েক দিন অনবরত বৃষ্টিপাত হলে শস্য নষ্ট হয়ে যায় এমনকি অনেক সময় সমস্ত শস্য নষ্ট হয়ে যায়। উচ্চ মুল্যের ফসল যেমন- বীজ, মসলা ইত্যাদির গুনগত মানের জন্য সুষমভাবে শুকনো খবই গুরুত্বপূর্ণ। এই ড্রায়ার ব্যবহার করে স্বাস্থ্যসম্মত উপায়ে আলুর চিপস শুকিয়ে, আলুর ব্যবহার বৃদ্ধির সাথে সাথে গ্রামীন মহিলাদের কর্মসংস্থানের সুযোগ রয়েছে।

বৈশিষ্ট্য

- ✓ **আকারঃ** লম্বা ২০০ সেমি, চওড়া ৮০ সেমি, উচ্চতা পিছনে ১৩০ সেমি ও সামনে ১০০ সেমি (২৩.৫ ডিগ্রী ঢালু)
- ✓ ট্রের সংখ্যাঃ ২ টি, প্রতি ট্রের আকারঃ লম্বা ৮৭ সেমি, চওড়া ৭২ সেমি,
- ✓ সৌর প্যানেলের শক্তিঃ ১০ ওয়াট; তাপমাত্রাঃ ৪৫-৫০ ডিগ্রী সেলসিয়াস
- ✓ ওজনঃ ৪৫ কেজি; কার্যক্ষমতাঃ ২.৫ কেজি/ ১০ ঘন্টায়
- ✓ ড্রায়ারের মূল্যঃ ২৫,০০০ টাকা।

ছবিঃ বারি হ্যান্ডি সোলার ড্রায়ার

বারি কাঁচা কাঠাল ছিলানোর যন্ত্র

কাঁঠাল আমাদের দেশের জাতীয় ফল। এটি একটি গ্রীষ্মকালীন ফল। অনেকে পাকা কাঁঠালের গন্ধ সহ্য করতে পারে না। তাছাড়া বর্তমান প্রজন্ম পাকা কাঁঠাল পছন্দ করে না। কাঁচা কাঠাল সবজি হিসেবে খাওয়া যায়। কাঁচা কাঁঠাল এঁচোড় নামেও পরিচিত। এই এঁচোড় দিয়ে তৈরি করা যায় উপাদেয় অনেক খাবার। যেমন,কাঁচা কাঁঠাল প্রক্রিয়াজাত করে আচার, চাটনি, মোরব্বা ইত্যাদি তৈরি করা যায়। কিন্তু কাঁচা কাঁঠালে আঠা থাকায় এটি ছিলানো একটি কষ্টসাধ্য কাজ। কাঁচা কাঁঠাল সহজে ও দ্রুত ছিলানোর জন্য কাঁচা কাঁঠাল ছিলানো যন্ত্র উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- ➢ যন্ত্রটির সার্বিক আকার ১৬০০× ৫৬০× ৫১০ মিলিমিটার
- ➢ বৈদ্যুতিক মোটর শক্তিঃ ০.৫ অশ্বশক্তি
- ➢ যন্ত্রটি দিয়ে ৩-১০ মিমি কাঁচা কাঠালের ছাল ছিলানো যায়।
- ➢ ৯০% শ্রমিক ও ৮০% খরচ সাশ্রয় করে ।
- ➢ কাঁচা কাঠাল ছাড়াও মিষ্টি কুমড়া, কাঁচা পেঁপে, চালকুমরা ও অন্যান্য সবজি ছিলানোর কাজেও ব্যবহার করা যায়।
- ➢ ওজনঃ ৫০ কেজি (মাইল্ড স্টীলের); ৭০কেজি (স্টেইনলেস স্টীলের)
- ➢ কার্যক্ষমতাঃ প্রতি ঘন্টায় ৩০-৩৫ টি
- ➢ মূল্য: ৬৫,০০০.০০ টাকা (মাইল্ড স্টীলের) ১০০,০০০.০০ টাকা (স্টেইনলেস স্টীলের)

ছবিঃ বারি কাঁঠাল ছিলানো যন্ত্র

বারি ক্রীম সেপারেটর

সুস্থ ও স্বাভাবিক জীবন-যাপনের জন্য একজন প্রাপ্তবয়স্ক মানুষের দৈনিক ২৫০ মিলি দুধ খাওয়ার প্রয়োজনীয়তা রয়েছে। দুধ দিয়ে নানাবিধ খাবার তৈরি করা হয়। দুধ থেকেই হয় মাখন, ঘি, পনীর, ছানা ইত্যাদি। তরল দুধ থেকে এ সমস্ত বস্তু পৃথক করতে হয়। তাছাড়া দুধ থেকে মাখন পৃথক করার পর যে চর্বিবিহীন দুধ থাকে তা হৃদরোগী বা উচ্চ রক্তেচাপযুক্ত রোগীর পানের উপযোগী। প্রচলিত পদ্ধতিতে দুধ থেকে মাখন বা ক্রীম পৃথক করা কষ্টসাধ্য ও সময় সাপেক্ষ কাজ। দুধ থেকে সহজে ও দ্রুত সময় ক্রীম পৃথক করার জন্য ক্রীম সেপারেটর উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- যন্ত্রটি বৈদ্যুতিক মোটর চালিত তবে বিদ্যুৎ না থাকলে পা ও হস্ত দ্বারা চালানো যায়
- যন্ত্রটির সার্বিক পরিমাপঃ ১০৯০ মিমি × ৫১০ মিমি× ১০৭০ মিমি
- দুধ থেকে ক্রীম পৃথকীকরণ ক্ষমতাঃ ১৫০-১৬০ লিঃ/ঘন্টা
- ফ্যাট পৃথকীকরণ দক্ষতাঃ ৮৭.৫০%
- খামারী বা উদ্যোক্তাগণ বানিজ্যিকভাবে সহজে দুধ থেকে ক্রীমকে আলাদা করতে পারবেন।
- এই যন্ত্র ব্যবহারের ফলে সময় ও অর্থ সাশ্রয় হবে
- মূল্যঃ ১০০,০০০.০০ টাকা ।

চিত্র: বারি ক্রীম সেপারেটর

বারি কফি পাল্পার

বিশ্বে চা এর পরে সর্বোচ্চ জনপ্রিয় ও পানকৃত পানীয় হলো কফি। কফি একটি মাঝারী ঝোপ জাতীয় উদ্ভিদ যার বীজ থেকে কফি উৎপন্ন হয়। সমগ্র দক্ষিণ আমেরিকা, আফ্রিকা ও মধ্যপ্রাচ্যের কয়েকটি দেশে বিশ্বের প্রায় সম্পূর্ণ কফি উৎপাদিত হয়। বাংলাদেশের পাহাড়ী এলাকার জলবায়ু ও মাটি কফি চাষের জন্য খুবই উপযোগী। কফি প্রধানত দুই প্রকার- কফি এরাবিকা ও কফি রোবাস্টা। তন্মধ্যে কফি এরাবিকা খাগড়াছড়িতে এবং কফি রোবাস্টা বান্দরবানে। বিচ্ছিন্নভাবে চাষ হয়ে আসছে। বাংলাদেশে চায়ের পাশাপশি কফি পানকারী ভোক্তার সংখ্যা প্রচুর বৃদ্ধি পাচ্ছে। সঠিকভাবে চাষ ও প্রক্রিয়াজাত করতে পারলে বাংলাদেশে কফি উৎপাদনে বিপ্লব সৃষ্টি করা সম্ভব। কিছু সরকারি এবং স্থানীয় উপজাতি কৃষকদের উদ্যোগে খাগড়াছড়ি ও বান্দরবান জেলার পাহাড়ী এলাকায় বিচ্ছিন্নভাবে বিগত তিন দশক ধরে কফির চাষ হয়ে আসছে। উৎপাদিত কফির সঠিক প্রক্রিয়াজতাকরণ সম্পর্কিত জ্ঞান এবং ভাল বিপণন ব্যবস্থার অভাবে অত্যন্ত লাভজনক এ ফসলটির চাষ জনপ্রিয় হয়নি। কফি প্রক্রিয়াজাতকরণ একটি জটিল এবং যন্ত্রপাতি নির্ভর প্রক্রিয়া। উন্নতমানের কফি প্রস্তুতকরণের জন্য বিভিন্ন ধরনের আধুনিক যন্ত্রের প্রয়োজন হয়, যেগুলো অনেক ব্যয়বহুল এবং আমাদের দেশে সহজলভ্য নয়। কফি প্রক্রিয়াজাতকরণের সর্বপ্রথম ধাপ হচ্ছে তাজা কফির খোসা ছাড়ানো। এ কাজটি স্থানীয় কফি উৎপাদনকারীরা তাজা কফি ভিজিয়ে হাতে খোসা আলাদা করে। কাজটি যেমন শ্রম সাপেক্ষ তেমনি এভাবে উৎপাদিত কফির গুণগতমান বহুলাংশে কমে যায়। কফির গুণগতমান ঠিক রেখে তাজা কফিকে পাল্পিং করার কাজটি সহজে এবং দ্রুত করার জন্য বারি কফি পাল্পার যন্ত্রটি উদ্ভাবন করা হয়েছে।

কফি প্রক্রিয়াজাত পদ্ধতিসমূহ

বিশ্বে প্রধানত দুই পদ্ধতিতে কফি বীজ প্রক্রিয়াজাত করা হয়- ১. ওয়েট প্রসেসিং বা সিক্ত পদ্ধতি ও ২. ড্রাই প্রসেসিং বা শুষ্ক পদ্ধতি। এর মধ্যে ওয়েট প্রসেসিং বা সিক্ত পদ্ধতিতে উৎপন্ন কফির মান ভাল হয়।

প্রধান বৈশিষ্ট্য

- স্থানীয়ভাবে প্রাপ্ত লৌহ সামগ্রী দিয়ে তৈরি করা যায়
- এ যন্ত্রটি চালানোর জন্য অল্প জায়গার প্রয়োজন হয়
- হাতে বা পায়ে যন্ত্রটি চালানো হয়
- এ যন্ত্র ব্যবহারের ফলে উৎপাদন সময় ও খরচ কম লাগে
- এটি দিয়ে তাজা কফির খোসা ছাড়ানো হয়
- একজন মানুষ অতি সহজেই এ যন্ত্র চালাতে পারে
- কার্যক্ষমতা : ১২৬ কেজি/ঘন্টা
- খরচ: প্রতি কেজি ০.৮০ টাকা
- মূল্য : ৪৫,০০০ টাকা

বারি কফি পাল্পার

কফি ডিহালার

কফির ফল (চেরি) থেকে বীজ পৃথক করা একটি জটিল পদ্ধতি। কফি দুই পদ্ধতিতে প্রসেস করা হয় যেমন ভিজা পদ্ধতি এবং শুকনা পদ্ধতি। ভিজা পদ্ধতিতে কাচা পরিপক্ক কফি পাল্পিং করার পর শুকানো পার্চমেন্ট এর আবরণ আলাদাকরণের জন্য যেমন ডিহালিং প্রয়োজন তেমনি শুকনা পদ্ধতিতে পরিপক্ক কফি শুকানোর পর খোসা ছাড়ানোর জন্য পাল্পিং করা দরকার। বারি উদ্ভাবিত কফি ডিহালার দিয়ে উভয় কার্যাবলী সম্পন্ন করা সম্ভব।

বৈশিষ্ট্য

- যন্ত্রটি দিয়ে সহজে ও অল্প সময়ে কফির রূপালী কালারের আবরণ ও শুকনা কফির খোসা ছাড়ানো যায়
- স্থানীয় কাঁচামাল দিয়ে স্থানীয় কারখানায় তৈরি করা যায়
- যন্ত্রটির সাথে চালুনি থাকায় সহজে পরিষ্কার কার্য সম্পন্ন হয়
- যন্ত্রটি মোটর চালিত বা হাতেও চালানো যায়
- সার্বিক আকার : ১০২০ ×৮৫০× ১৩৫০ মিমি
- ড্রাম লম্বা ও ব্যাস:৫১০ ও ২৬০ মিমি
- চালুনির গতি:৩৬০ আরপিএম
- ড্রামের গতি: ১১০ আরপিএম
- রোলারের গতি:৪০ আরপিএম
- কার্যক্ষমতা: ৫০ কেজি/ঘন্টা
- খরচ: প্রতি কেজি ১.০০টাকা
- ওজন : ২৫ কেজি
- মূল্য: ৪৫,০০০.০০ টাকা

বারি কফি ডিহালার

বারি কফি রোস্টার

কফি প্রক্রিয়াজাতকরণের সবচেয়ে গুরুত্বপূর্ণ ধাপ হচ্ছে সবুজ কফিকে উচ্চ তাপে ভাজা বা রোস্টিং করা। এটি একটি তাপ রাসায়নিক প্রক্রিয়া যার মাধ্যমে সবুজ কফিতে অবস্থিত বিভিন্ন রাসায়ানিক পদার্থ পরিবর্তিত হয়ে সুগন্ধ, রং,ও স্বাদ প্রাপ্ত হয়। আমাদের দেশের কফি চাষীরা কফি রোস্টিং বা ভাজার কাজটি সাধারণ চুলায় খোলা পাত্রে বা কড়াইতে করে থাকেন। পর্যাপ্ত তাপমাত্রার অভাবে কফির সুষমভাবে ভাজা হয় না । ফলে স্বাদ, রং ঘ্রাণের দিক দিয়ে এ কফি খুবই নিম্নমানের হয়। উৎকৃষ্ট মানের কফি প্রস্তুত করার জন্য কফি রোস্টার মেশিনের কোন বিকল্প নেই। এ ধরণের মেশিন কফি উৎপাদকারী দেশগুলোতে সহজলভ্য হলে আমাদের দেশে এখনও সহজলভ্য নয়। বাণিজ্যিকভাবে কফি চাষকে উৎসাহিত করার জন্য এফএমপিই বিভাগ, বিএআরআই একটি কফি রোস্টার যন্ত্র উদ্ভাবন করেছে।

বারি কফি রোস্টার

বৈশিষ্ট্য

- স্থানীয়ভাবে প্রাপ্ত লৌহ সামগ্রী দিয়ে তৈরি করা যায়।
- এ যন্ত্রটি চালানোর জন্য খুব অল্প জায়গার প্রয়োজন হয়।
- মাত্র ০.২৪ অশ্বশক্তির (০.১৮ কিলোওয়াট) বৈদ্যুতিক মোটর দ্বারা চালানো সম্ভব।
- এ যন্ত্রটি প্রাকৃতিক গ্যাসচালিত হওয়ার ফলে উৎপাদন সময় ও খরচ কম লাগে।
- এর যন্ত্রাংশ তৈরি করা খুবই সহজ বলে যে কোন প্রকৌশল কারখানায় এটি তৈরি করা যায়।
- এটি তাপ নিয়ন্ত্রণযোগ্য হওয়ায় এটি দ্বারা যে কোন কাঙ্ক্ষিত মাত্রার ভাজা কফি পাওয়া যায়।
- একজন মানুষ অতি সহজেই এ যন্ত্রটি চালাতে পারেন।
- কার্যক্ষমতাঃ ৪.৫ কেজি/ঘন্টা
- মূল্যঃ ৭০,০০০ টাকা (মোটরসহ)

বারি কফি গ্রাইন্ডার

উৎপাদিত কফির সঠিক প্রক্রিয়াজতাকরণ সম্পর্কিত জ্ঞান এবং ভাল বিপণন ব্যবস্থার অভাবে অত্যন্ত লাভজনক এ ফসলটির চাষ জনপ্রিয় হয়নি। কফি প্রক্রিয়াজাতকরণ একটি জটিল এবং যন্ত্রপাতি নির্ভর প্রক্রিয়া। উন্নতমানের কফি প্রস্তুতকরণের জন্য বিভিন্ন ধরনের আধুনিক যন্ত্রের প্রয়োজন হয়, যেগুলো অনেক ব্যয়বহুল এবং আমাদের দেশে সহজলভ্য নয়। কফি প্রক্রিয়াজাতকরণের সর্বপ্রথম ধাপ হচ্ছে তাজা কফির খোসা ছাড়ানো এবং সর্বশেষ ধাপ হচ্ছে ভাজা (রোস্টেড) কফিকে গুঁড়া (গ্রাইন্ডিং) করা। কাজটি যেমন শ্রম সাপেক্ষ তেমনি এভাবে উৎপাদিত কফির গুণগতমান বহুলাংশে কমে যায়। কফির গুণগতমান ঠিক রেখে ভাজা কফিকে গুঁড়া করার কাজটি সহজে এবং দ্রুত করার জন্য বারি কফি গ্রাইন্ডার যন্ত্রটি উদ্ভাবন করা হয়েছে।

বৈশিষ্ট্য

- স্থানীয়ভাবে প্রাপ্ত লৌহ সামগ্রী দিয়ে তৈরি করা যায়
- এ যন্ত্রটি চালানোর জন্য অল্প জায়গার প্রয়োজন হয়
- মাত্র ০.৫ অশ্বশক্তির বৈদ্যুতিক মোটর দিয়ে চালানো হয়
- এ যন্ত্র ব্যবহারের ফলে উৎপাদন সময় ও খরচ কম লাগে
- এটি দিয়ে তাজা কফির খোসা ছাড়ানো হয়
- এটি নিয়ন্ত্রণযোগ্য হওয়ায় এটি দিয়ে যে কোন কাঙ্ক্ষিত ধরণের কফি গুঁড়ো করা যায়
- একজন মানুষ অতি সহজেই এ যন্ত্র চালাতে পারে
- কার্যক্ষমতা : ১১.৫ কেজি/ঘন্টা
- মূল্য: ৮০,০০০ টাকা (মোটরসহ)

বারি কফি গ্রাইন্ডার

বিএআরআই এর সাথে চুক্তিবদ্ধ কৃষি যন্ত্রপাতি প্রস্তুতকারকদের নাম ও ঠিকানা

ক্র. নং	প্রতিষ্ঠানের নাম ও ঠিকানা	ফোন ও মোবাইল নং
১	মাহবুব ইঞ্জিনিয়ারিং ওয়ার্কশপ,বিসিক শিল্প নগরী, জামালপুর	০১৭১১-২৩৭৭৮৫
২	আর কে মেটাল ,টেপাখোলা, ফরিদপুর	০১৭১০-৯২৮৯৭৭
৩	আলীম ইন্ডাষ্ট্রিজ লিঃ বিসিক শিল্প নগরী, গোটাটিকর কদমতলী, সিলেট	০১৭১৩-৩২৮৭৯৬, ০৮২১-৮৪০৬৬২ info@alimindustriesltd.com
৪	নিউ বর্ষা ইঞ্জিনিয়ারিং ওয়ার্কশপ, গোহাইল রোড, সূত্রাপুর, বগুড়া	০১৭১১১৮৪২৮২, ০৫১-৬৪০৭২
৫	উত্তরন ইঞ্জিনিয়ারিং ওয়ার্কস (প্রাঃ) লিঃ,কালিতলা, দিনাজপুর	০১৭২৭-২১৯৯৪৬, ০৫৩১-৫১৭০৮
৬	দি মেটাল (প্রাঃ) লিঃ,আতার্তুক এভিনিউ, গুলশান-২ ঢাকা-১২১২	০১৭১৩-১৬৪২৬৯, ৮৮৩৫০০৬ info@metalbd.biz
৭	মেসার্স কামাল মেশিন টুলস, ছিলিমপুর, বগুড়া	০১৭১১-০২৭২০৫, ০৫১-৬৪০০০
৮	এসি আই মটরস লিঃ.২৪৫, তেজগাঁও ইন্ডাষ্ট্রিয়াল এরিয়া, ঢাকা-১২০৮	০১৭৫৫৫৫১২০৩, ৮৮৭৮৬০৩
৯	আলম ইঞ্জিনিয়ারিং ওয়ার্কস, ২৫, ভজোহরি সাহা রোড, ওয়ারী, ঢাকা	০১৭১১-৩৫৬০৫৫
১১	জনতা ইঞ্জিনিয়ারিং, সরোজগঞ্জ বাজার, চুয়াডাঙ্গা	০১৭১১-৯৬০৮৬১ janataengineering786@gmail.com
১২	মন্নু জেনারেল এন্ড এগ্রিকালচারাল মেশিনরিজ লিমিটেড, ধামরাই, ঢাকা	০১৭৫৫-৫৫৯২২২
১৩	এক্সপার্ট ইঞ্জিনিয়ারিং, স্টেশন রোড, টংগী, ঢাকা	০১৮১৯-৮৯২১৬৫
১৪	মটস,মিরপুর এগ্রিকালচারাল স্কুল, ঢাকা	০১৭১৩-৩৮৪০৯০

Storage, Processing, Preservation, Packaging of Fresh Produce and Products: Technologies and Practices

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Fruits and vegetables are highly perishable for their metabolic process. Fresh produce generally contains a large amount of water. When they are harvested the metabolic process starts. Respiration and ethylene production occur as per their climacteric nature. If they are not controlled then physiological deterioration happens such as water loss, physical appearance, rotting, microbial infestation, nutrient loss etc. Postharvest treatments assist in controlling respiration and ethylene production as well as retain quality. It also adds value to fresh produce as well as processed products for increasing shelf life and maintaining quality.

Postharvest Management of Fruits and Vegetable

Harvesting of fruits and vegetables

Harvesting provides the first opportunity for physiological damage of fruits and vegetables, therefore, the choice of right stage of maturity and harvesting method should allow for maintenance of quality. Fruits and vegetables are harvested manually in the country. Most of the fruits and vegetables are harvested considering their size, shape and surface colour. Analytically established maturity indices are not yet established for most fruits and vegetables. To avail themselves of the high prices sometimes the farmers/producers harvest their fruits and vegetables very early when the nutritional quality is poor. Pre-cooling is not generally done. As a result, deterioration starts after harvesting.

Grading and standardization of fruits and vegetables

Grading and standardization of fresh produce in terms of size, variety, maturity and quality are important considerations for improvement of postharvest quality and reduction of postharvest losses. In the absence of grading, losses may be incurred because of contamination between mixed rotten items and good quality ones after some period. Thus, grades and standards are instrumental in making the market more transparent which is to the advantage of all producers, traders and consumers. It is not true to say that there is no standardization in developing countries. The criterion of edible versus inedible is the basic standard and whenever there is a glut of a particular produce in the market, prices fall most for the lower quality whilst for the best quality this fall is least.

Storage

Storage is important for agricultural commodities, particularly fresh produce to enhance shelf life and retain quality. Perishable commodities often require balancing day-to-day fluctuations between harvest and marketing products to the consumers. Storage slows down

biological activity of the product by maintaining the lowest temperature that will not cause freezing or chilling injury and by controlling atmospheric composition. It minimizes surface moisture on the product that results wilting and shrivel by reducing the difference between product and ambient temperatures and maintaining the high humidity in the storage room. The temperature in a storage facility normally should be kept within about ±1^{o}C of the desired temperature for the commodities being stored. Optimal range of temperature is an important consideration to avoid freezing or chilling injury. Above temperature can cause shorter storage life of that commodity.

Recommended temperature and humidity are vital issues for long time storage of horticultural produces that is needed to be in mind during storage or preservation of fresh produces and processed products. Specialized cold storage facility is required for storing fresh produce and processed products for a certain time. In glut season, a substantial amount of postharvest loss occurs due to inadequate storage facility and processing technology. Maintaining proper postharvest treatment may reduce loss and add value to crops. To fabricate a specialized cold storage facility (Figure 1 & 2), temperature, humidity, ethylene scrubber should be considered. Storage temperature, humidity and shelf life of some commodities are listed below in Table 1.

Table 1. Recommended temperature, relative humidity and storage life of some commodities

Name of the commodity	Temperature (^{o}C)	Relative humidity (%)	Storage life (week)
Mango	13	85-90	2-3
Mangosteen	13	85-90	2-4
Banana	13-15	90-95	1-4
Papaya	7-13	85-90	1-3
Pineapple	7-13	85-90	2-4
Apple (Chilling sensitive)	4	90-95	4-8
Avocado (Hass)	3-7	85-90	2-4
Cherry			
Bean, Faba Broad beans	0	90-95	1-2
Bean, Lima beans	5-6	95	>1
Long beans	4-7	90-95	1-2
Snap beans	4-7	95	1-2
Beet, bunched	0	98-100	1-2
Blueberry	-0.5-0	90-95	1-3
Blackberry	-0.5-0	90-95	>1
Strawberry	0	90-95	1-2
Bitter gourd	10-12	85-90	2-3
Broccoli	0	95-100	1-2
Cabbage, Chinese, Napa	0	95-100	8-12
Carambola, starfruit	9-10	85-90	3-4
Carrots, topped	0	98-100	24-32
Carrots, bunched, immature	0	98-100	2
Cashew apple	0-2	85-90	5
Cassava	0-5	85-90	4-8
Cauliflower	0	95-98	3-4
Chilies, hot chili	5-10	85-90	2-3

Name of the commodity	Temperature (ºC)	Relative humidity (%)	Storage life (week)
Citrus, Lemon	10-13	85-90	4-24
Pummelo	7-9	85-90	12
Mandarin	4-7	90-95	2-4
Coconut	0-2	80-85	4-8
Cucumber, slicing	10-12	85-90	>2
Pickling	4	95-100	1
Eggplant	10-12	90-95	1-2
Guava	5-10	90	2-3
Jackfruit	13	85-90	2-4
Jujube	2.5-10	85-90	4
Lettuce	0	98-100	2-3
Longan	4-7	90-95	2-4
Mushrooms	0	90	1-2
Honeydew orange flesh melon	5-10	85-90	3-4
Plum	-0.5-0	90-95	2-5
Pomegranate	5-7.2	90-95	8-12
Potato, early	10-15	90-95	>2
Potato, late	4-12	95-98	20-40
Sweet potato, yam	13-15	85-90	16-27
Pumpkin	12-15	50-70	8-12
Radish	0	95-100	4-8
Rambutan	12	90-95	1-3
Spinach	0	95-100	>2
Squash, soft rind	7-10	95	1-2
Tamarind	2-7	90-95	3-4
Tomato, mature green	10-13	90-95	2-5
Water chestnuts	1-2	85-90	8-16
Watermelon	10-15	90	2-3

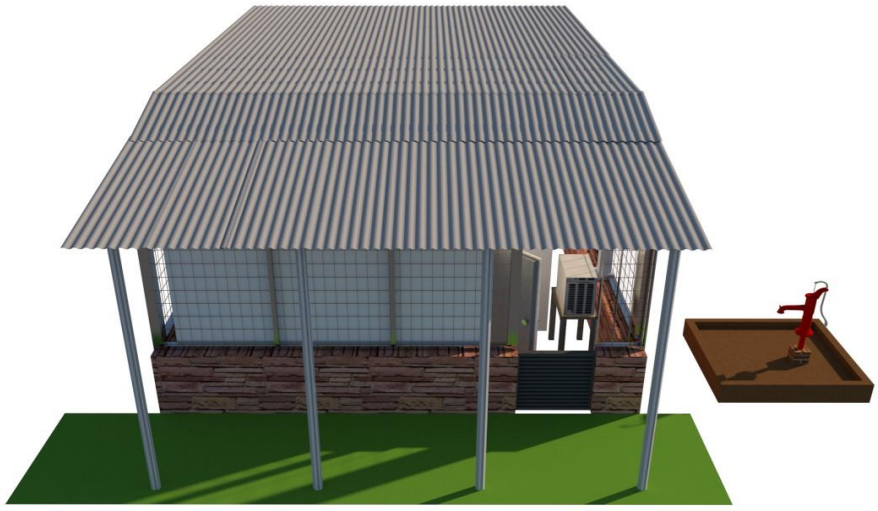

Figure 1. Pictorial view of a specialized cold room

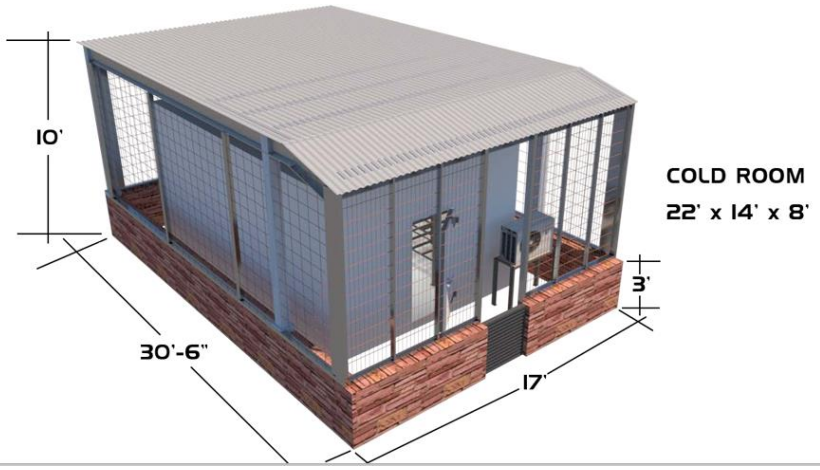

Figure 2. Schematic diagram of Specialized Cold Room

Zero Energy Cool Chamber

Zero energy cool chamber is made based on direct evaporative cooling. It is constructed using a single layer of bricks over which a double walled rectangular structure. The cavity between inner and outer walls is filled with river sand while the top is covered with a gunny cloth in a bamboo framed structure. It can be effective when the temperature is very high, especially in the summer. It can be constructed using bricks, sand, angle bar or bamboo.

Modified Atmospheric (MA) Storage

MA storage implies a lower degree of control of gas concentration in the atmosphere surrounding the commodity in package. An appropriate atmosphere can passively evolve within a sealed package as a result of consumption of O_2 and production of CO2 through respiration. Film must allow O_2 to enter the package at a rate offset by the consumption of O_2 by the commodity and CO_2 must be vented from the package to offset the production of CO2 by the commodity. This atmosphere must be established rapidly and without danger of the creation of injurious high levels of CO_2. Modified atmosphere packaging will provide a modified atmosphere for the products packed inside. The number and types of flexible plastic films for packaging having different gas permeability, water vapor transmission rates, anti-fogging properties, strength, stretch-shrink properties have proliferated in recent years and new types are constantly underdevelopment.

Controlled Atmospheric (CA) Storage

CA storage control ripening, firmness maintenance of flesh, maintenance of green colour, maintenance of organic acid. In CA system, O_2 is reduced inside an insulated chamber, CO_2 is increased, and ripening is slowed down. Respiratory rate is an important indicator of metabolic activity. The room should be adequate insulation and vapour barriers, enough cooling surface to ensure high humidity and air circulation to cool the produce. Excess CO_2 is removed from CA storage because high CO_2 is not tolerated by the commodities. Water scrubbing removes CO_2. High levels of CO_2 like the range of 10-15% CO_2 control grey mold in grapes but prolonged exposure with CO_2 can damage (> 2 weeks) the fruit.

Processing and preservation of horticultural crops

Fresh produce, especially fruits and vegetables, are important to the human diet because they provide the essential vitamins, minerals, fiber etc. required for maintaining our health. But they are highly perishable and postharvest loss of fruit and vegetable is very significant

amount (20-45%) which is lost before consumption due to inappropriate harvesting, handling, storage, transportation, and marketing facilities. Processing and preservation techniques are alternative ways to reduce loss and add value to fresh produce where producers and traders will be benefitted and encouraged to grow and handle the product to the consumers. Food demand is increasing in developing countries because of the increased population. Some processing and preservation technologies of horticultural commodities, both fresh and processed products have been illustrated below.

Postharvest handling of fruits and vegetables

Fruits

- Maturity indices for mango cultivars namely Gopalbogh, Khirshapat, Langra, Fazli, Bombai and Aswina have been standardized. The optimum maturity time for harvesting Gopalbogh, Khirshapat, Langra, Fazli, Bombai and Aswina were 87-91, 87-95, 97-105, 112-120, 97-105 and 139-146 days, respectively. The indicators applied were color, specific gravity and sinking and floating behavior of mangoes in salt solutions of different concentration. The mangoes harvested at above age were found to have 9-10 days shelf life at ambient temperature with good eating quality. All the methods are easily adoptable by the growers.
- Mangoes treated with hot water and transported through paper carton or plastic crates performed better in reducing transport losses.
- An evaporative cooler without use of refrigeration was designed and fabrication for short-term preservation of fruits and vegetables during dry season for use at farmers' level with maintaining relative humidity 90-99% and lowering temperature to an extent of 13^0C was attained. This cooler has excellent potential for village level storage of harvested fruits and vegetables for a short period.
- Physical injury of banana was minimum when transported through plastic crates.
- For local marketing, litchi bunches in perforated polyethylene bags which were put in plastic crates for transporting to distant places can be maintained the shelf life for 3-4 days.

Vegetables

Leafy vegetables viz. spinach, red amaranth and Indian spinach packed in perforated packages give longer shelf life.

Semi-processing technique for mango pulp

Mango is an important fruit in our country. It is highly perishable in fresh form and shelf life is extremely limited to about a week only. Preservation of pulp extracted from fresh mangoes in production season can be an alternative way to make available the mango pulp during the off-season. The semi-processed pulp may be used for processing into products like jam, drinks, squash, nectar etc. This type of processing may be adopted at home level and at level of the village cooperative system and the entrepreneur system since the technologies are inexpensive and do not need sophisticated equipment and machinery.

Mango pulp after extraction should be strained in net/sieves to remove the fibers and other coarse fractions. Heating of pulp should be done to attain temperature of 85-90^{0}C with addition of 100 ml water per kg pulp followed by 10 mins heating at this temperature and maintained the acidity 0.9% with the addition of citric acid. Sodium benzoate (1000ppm) or KMS (1000ppm) should be added to the pulp 2 mins of completion of heating. Sterilized glass bottles should be kept dipped in boiling water along with the lids. After heating is completed in the fruit pulp, it is filled hot into sterilized bottles followed by further processing of the filled bottles for 20 mins in boiling water. The processed bottles are sealed and kept inverted for 5 mins. When cool, the mouth of the filled bottles is dipped in molten wax and then the bottles should be stored in a dry, clean and cool place. Different food processing industries preserve these pulps by mechanized process and follow the HACCP requirements.

Semi-processing system for tomato pulp

Tomato is one of the most important vegetables in our country. It is extremely perishable and can not be preserved in fresh stage. Huge postharvest losses of the harvested tomatoes may occur due to inadequacies in transportation and storage facilities which brings substantial loss to the growers and hence to the national economy. Tomato pulp after extraction should be strained in net/sieves to remove the seeds and other coarse fractions. The pulp is concentrated with adequate cooking upto reached the pulp concentration at 10^{O}B from the initial TSS of 4^{O}B and added citric acid 0.2% and sodium benzoate (1000ppm). The pulp was filled hot into sterilized bottles followed by further processing of the filled bottles for 20 mins in boiling water. The processed bottles were sealed, kept inverted for 5 mins. After cooling, the filled bottles should be stored in a dry, clean and cool place.

Steeping preservation of fruits

Preservation by steeping in brine solution has been in practice from time immemorial. Sodium chloride acts as a preserving, conditioning, flavour enhancing and taste-improving agent in processed and preserved foods. The vegetables preserved by steeping can be used for pickling or home cooking after leaching out the salt and acid. The fruits like green mango, olive, golden apple, satkora etc and vegetables like tomatoes, carrot, cauliflower, cabbage, bitter gourd, peas, mushroom etc. could be preserved in an acidified sulphited brine solution.

Steeping preservation of green mango

Fresh, sound green mangoes are selected, washed and removed the stalk and cut into slices by hand cutter. After removing the seed and foreign particle again they are washed with clean water, branched for 2 mins at 90^{O}C and cooled immediately. The blanched slices were soaked in the solution containing 8-10% salt, 0.6% acetic acid, 0.02% turmeric powder and 1000ppm SO_2 in a clean plastic drum and closed airtight and stored in dry, clean and cool place at room temperature.

Fermentation of cabbage

Select mature heads of cabbage, washed and remove the outer leaves and the core. Heads will be cut into narrow shreds and mixed with 2.5% salt and packed firmly in a vat and covered with a plastic bag filled with water. The vat is placed at room temperature for 11-12 days for fermentation and acidity of the product reaches around 1.5%. This product is known as sauerkraut. The shelf life of the product is more than 1 year.

Pickling preservation

The process of food preservation in common salt or in vinegar or in both is called pickling. Pickles are prepared with a mixture of salt, oil, vinegar, and spices. Pickles are good appetizers and add to the palatability of a meal. They add digestion by stimulating the flow of gastric juice. The shelf life of pickles depends primarily on the salt and acid content in the product. The taste of the product also depends largely on the addition of various spills and processing.

Preservation of fruit juices by sugar concentration

Fruit juices are preserved and stored in bulk under ambient temperature till further utilization in the preparation of different food products ready to serve. Usually double dose of preservative (0.2%) and 1 to 3% citric acid are used for preservation. The following juices keep well for more than 6 months if preserved carefully.

Processing of preserves and candies

For preserves, fruits and vegetables washed thoroughly by potable water and peeled with a stainless-steel knife and cut into 2cm x 2 cm x 2 cm cubes. The cubes are immersed for 3 hours in 2% NaCl solution having 500 mg/kg and washed with water and steeped for 24 hours in a solution containing 2% calcium lactate and 1% potassium metabisulphite. After draining, the cubes are balanced in boiling water for 10 minutes and rinsed under tap water. The cubes are then pricked by a stainless-steel needle and the pricked cubes are dipped in 25^0 Brix sugar syrup and heated in the syrup until^0 Brix of the syrup reached 30 followed by keeping for in this syrup 24 hours. The ratio of fruit to syrup is maintained at 1:3. In the following 2^{nd}, 3^{rd}, and 4^{th} days, the materials are cooked so that the syrup attained 35, 40 and 45^0 Brix, respectively, followed by a keeping period of 24 hours every time. On the 5^{th} day, heating is continued until the syrup attained 50^0 Brix. At this stage, citric acid is added at the rate of 0.5% based on weight of cubes plus syrup. On the 6^{th} day, the material is cooked upto 60^0 Brix of the syrup. On the 7^{th} day, the material is heated until the syrup attained about 70^0 Brix. At this stage, the preserves along with the syrup are filled into sterile dry glass bottles and heat sealed.

Processing candies is ended by dipping the preserves in water to remove adhering syrup. The preserves are then dried in the cabinet dryer at 70 ^{0} C till the product reaches the moisture content of 17.52-20.44%. Moisture finally the temperature is brought down to ambient one. Candy pieces are then packed in polypropylene bags followed by their storage at room temperature (20-37 ^{0}C).

Processing of Fruits and Vegetables by drying and dehydration

The sulfited commodities (immature dropped mango, carrot, jackfruit, banana, pineapple, potato, bitter gourd, cabbage, cauliflower) were spread on trays and dehydrated in a mechanical and sun dryer. It can be easily processed in rural areas where modern facilities do not exist.

Preparation of fruits into juice and shelf stable Ready to Serve (RTS) beverage

Bael, pineapple, mango and lemon were different formulated for preparation of juice and beverage. The prepared juice and beverages were packed in glass bottles upto 6 months storage.

Processing of fruits into chips

Chips prepared from different fruits and vegetables using vacuum frying have been standardized and stored in ambient temperature in different packaging materials. Packing and packaging of fresh produces and their processed products This operation is needed for fruits and vegetables in order to protect during the marketing process, avoid individual handling and to unities and rationalize the produce. In Bangladesh, this important handling step is either non-existent or at best basic. The materials used for packaging fresh perishables are mostly bamboo, straw, banana leaves, wooden boxes, cardboard boxes, plastic bags, synthetic fibers, multi-layer paper sacks etc. (Figure 3). These materials must have the performance capabilities of preventing mechanical damage to the produce, provide enough strength to withstand wears and tears in handling, allow ventilation for the produce with maintenance of shapes and sizes of the packaged commodities and lastly and most importantly should be either disposable or returnable. Over and above, any forms of packaging most add value to the produce, sufficient to cover the additional capital outlay plus a margin of profit.

Figure 3. Existing packaging system of fruits and

Mode of Packaging

- Single Unit
- Semi Bulk Packaging
- Bulk Packaging
- Palletizing
- Volume Calculation

Packaging for Fruits

Packaging fresh fruits and vegetables is one of the more important steps in the long and complicated journey of growing to consumer. Gags, crates, hampers, baskets, cartons and palletized containers are convenient containers for handling, transportation and marketing fresh produce. It is important that packers, shippers, buyer and consumers have a clear understanding of the wide range of packaging options available.

Consideration during packaging

Recyclability/ Biodegradability

A growing number of US markets and many export markets have waste disposal and many export markets have waste disposal restrictions for packaging materials. In the near future, almost all produce packaging should be recyclable or biodegradable, or both. Many of the largest buyers of fresh produce are also those most concerned about environmental issues.

Packaging or packaging materials

The trend is toward greater use of bulk packages for processors and wholesale buyers and smaller packages for consumers. There are now more than 1,500 different sizes and styles of produce packages.

Sales Appeal

High quality graphics are increasingly being used to boost sales appeal. Multi-color printing, distinctive lettering, and loges are now common.

Shelf life

Modern produce packaging can be custom engineered for each commodity to extend shelf life and reduce waste.

Packaging Materials

Wood Pallets

Depending on the size of the product package, a single pallet may carry from 20 to over 100 individual packages. The pallets are built as inexpensively as possible and discarded after a single use.

Wire-Bound Boxes or Crates

It is used extensively for snap beans, sweet corn and several other commodities that require hydro cooling.

Wooden Boxes or Crates and Lugs

Wooden crates, once extensively used for apples, stone fruit, and potatoes have been almost totally replaced by other types of containers.

Wooden Baskets

Wire-reinforced wood veneer baskets of different sizes were once used for a wide variety of crops from strawberries to sweet potatoes. They are durable and may be nested for efficient transport when empty.

Corrugated Fiberboard Cartoon

It is manufactured in many different styles and weights. Because of its relatively low cost and versatility, it is the dominant produce container material. The strength and serviceability of corrugated fiberboard cartoons have been improved in the last few years.

Pulp Containers

Containers made from recycled paper pulp and starch binders are mainly used for small consumer packages for fresh produce. It can absorb surface moisture from the product, which is a benefit for small fruit and berries that are easily harmed by water. Pulp containers are also biodegradable, made from recycled materials and recyclable.

Paper and Mesh Bags

Consumer packs of potatoes and onions are about the only produce items now packed in paper bags. The sturdier mesh gags have much wider use. Mash has the advantage of uninhibited air flow. Good ventilation is particularly beneficial to onions. Supermarkets produce managers like small mash bags because they make attractive displays that stimulate purchases.

Plastics Bags

Plastic Bags (Polyethylene film) are the predominant material for fruit and vegetables consumer packaging. Besides their material costs are very low, have automated bagging machines further reduce packing costs. Film bags are clear, allowing for easy inspection of the contents, and readily accept high quality graphics. Plastic films are available in a wide range of thickness and grades.

Shrink Wrap

One of the newest in produce packaging is the shrink wrapping of individual produce items. Shrink wrapping has been used successfully to package potatoes, apples, onions, sweet corn and a variety of tropical fruit. Shrink wrapping with an engineered plastic wrap can reduce shrinkage, protect the produce from disease, and reduce mechanical damage.

Conclusion

In Bangladesh a significant portion of horticultural corps are lost. These losses can be reduced by processing those commodities into different products. The processing methods are very simple and low-cost technology. If practical training and demonstration are provided to the rural people, and if they adopt the technology, it will play a vital role in reducing the postharvest losses of the crops. Production of different products and their marketing will also create income generation for the rural people. It can also create job opportunities for the trainees in agro-processing industries.

Transportation, Distribution, Consumption and Quality Assurance of Fresh Produce and Products: Technologies and Practices

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Postharvest losses of fruits and vegetables during all stages of postharvest operations is one-third of the total production. Fresh fruits and vegetables are grown and harvested under a wide range of climatic and diverse geographical conditions, using various agricultural inputs and technologies, and on farms of varying sizes. Different hazards may vary significantly from one type of production to another. In each primary production area, it is necessary to consider the particular agricultural practices that promote the production of safe fresh fruits and vegetables, taking into account the conditions specific to the primary production area, type of products, and methods used. Procedures associated with primary production should be conducted under good agricultural practices, good handling, good hygienic conditions and should minimize potential hazards to health due to contamination of fresh fruits and vegetables.

Harvesting factors and quality

The ultimate quality of fresh or processed foods of plant origin depends on : a) harvesting factors, b) harvesting methods, and c) post-harvest handling procedures. Quality attributes of food and processed products usually differ in many ways. Consumers judge fresh products by a different set of criteria than they do processed foods.

Pre-harvest factors

Pre-harvest factors affect the nutritive value, post-harvest yield, and quality. These factors include genetic factors, climatic factors, biotic, chemical and other factors and the combined effects of these factors.

Genetic factors

Cultivars and rootstock selection are important due to differences in raw product composition, durability, and response to processing. In many cases, fruit cultivars grown for fresh market sale are not the optimal cultivar for processing, such as canning, drying, and freezing. New varieties have been developed to achieve higher yield, disease resistance, improved organoleptic properties, improved nutritional value, and reduced undesired toxic compounds.

Climatic factors

The growing region and environmental or climatic conditions specific to each region significantly affect the quality of the plant produce. These conditions include temperature, humidity, light, wind, soil texture, elevation, and rainfall. Light intensity significantly affects vitamin concentration, and temperature influences the transpiration rate, affecting mineral uptake and metabolism.

Environmental factors and cultural practices

Environmental factors and cultural practices include soil type, soil nutrient and water supply, pruning, thinning, pest control or chemical spray, and density of planting. Fertilizer application may significantly after the mineral content of fruit, while other cultural practices such as pruning and thinning may influence the nutritional composition by changing fruit crop load and size. The closer the planting the less sweet the fruits will be. Among leafy vegetables, leaves are larger and thinner under conditions of low light intensity.

Harvest at appropriate maturity

Maturity at harvest is one of the primary factors affecting fruit, vegetable, and other crop compositions, quality, and storage life. Achieving optimum harvest maturity is vital to ensure maximum postharvest life of the produce. Although most fruits reach peak eating quality when harvested fully ripe, they are usually picked manure, but not ripe to decrease mechanical injury during postharvest handling. Immature fruits are more subject to shriveling and mechanical damage and are of inferior quality when ripened. Overripe fruits are likely to become soft, mealy, and tasteless, soon after harvest. Fruits picked either too early or too late in the season are more susceptible to physiological disorders and have a shorter storage life than those picked at midseason.

Harvesting Methods

Harvesting provides the first opportunity for mechanical damage of plant produce; therefore, the choice of harvesting method should allow for maintenance of quality. Harvesting can be done by manually or mechanically. The advantages of manual harvesting are (a) accurate selection and grading according to maturity, (b) minimal damage to the product, (c) minimal capital investment; (d) mechanical devices can be used as aids. The disadvantages are the manual harvesting management of a labor force, and (b) is hereby slow.

Transpiration or water loss

Transpiration is a process of water loss from fresh produce, resulting in a loss of saleable weight, appearance (weight and shrivelling), textural quality (softening, flaccidity, limpness, crispness, and juiciness), and nutritional quality (vitamins, minerals, antioxidants, phenols etc.). It is generally occur in fresh produces. The signs of shrived become objectionable when weight loss reaches about 5% of the harvested weight. Most fruits and vegetables with 5-10% loss in moisture content is visibly shrived as a result of cellular plasmolysis.

Mechanical damage

The surface crack that may develop during growth or result from the mechanical handling of produce, such as abrasion, impact bruises, scratches, surface cuts, punctures, and other injuries that either remove or weaken the protective outer layers also cause water loss. At early stages of maturity, some fruits and vegetables have the ability to maintenance the damaged area. Mechanical damage causes a release of active enzymes, exposes internal

tissue to environmental condition, increase respiration, promotes chemical and enzymatic reactions, allows the spread of harmful microorganisms, and induces an overall quality decline.

Temperature, Relative humidity and Air movement

Temperature, relative humidity and air movement affect moisture loss. In general, higher surface temperature increases the rate of transpiration, and higher relative humidity of storage atmosphere reduces it. It is common to lower the temperature or raise the relative humidity during storage. One practical way of minimizing transpiration is to cool the produce quickly via hydro-cooling using anti-fungal chemicals which will perform both cool the fruits and control the adhering fungal growth. Surface condensation should be avoided to protect against mold growth. Air movement and atmospheric pressure also influence water loss. Air circulation or velocity increases evaporation of moisture from the surface.

Respiration

Respiration is an indication of metabolic activity of living produce. All living organisms convert matter into energy through a fundamental process called respiration. In plants, respiration primarily involves the enzymic oxidation of sugars to carbon-di-oxide and water, accompanied by release of energy. Changes in proteins, lipids and organic acids also take place through respiration. The rate of deterioration of fruits is generally proportional to their respiration rate. There are three phases of respiration: a) breaking down of polysaccharides into sugars, b) oxidation of sugars to pyruvic acids, and c) aerobic transformation of pyruvate and other organic acids into CO_2, water, and energy.

Non-climacteric fruits

Non-climacteric fruits ripen on tree and are not capable of continuing ripening process once removed from the plant. These produce very small quantities of ethylene and do not respond to ethylene treatment, except in terms of de-greening in citrus fruits and pineapples by degradation of chlorophyll.

Climacteric fruits

Climacteric fruits can be harvested mature and ripened off the plants. These produce much larger quantities of ethylene in association with their ripening and exposure to ethylene treatment will result in faster and more uniform ripening. The respiration rate is minimum at maturity and remains constant, even after harvest. The rate will rise abruptly to the climacteric peak only when ripening is about to take place, after which it will slowly decline.

Physiological disorders

Plants require a balance mineral intake from soil for proper development. Physiological disorders due to nutritional deficiencies may affect the skin, flesh or core region of the produce. Factors involved include maturity at harvest, cultural practices, climate during the growing season, produce size, harvesting and handling practices.

Postharvest diseases and infections

Postharvest diseases are initiated in produce in the following ways: a) at an early stage of development when attached to the plant, b) by direct penetration of certain fungi or bacteria through the intact cuticle or through wounds and/or natural openings in the surface, and c) through injuries and cut stems or damage to the surface. While most microorganisms can invade only damaged produce, a few are able to penetrate the skin of healthy tissue. Initially, only one or a few pathogens may invade and break down the tissues, followed by a broad-spectrum attack of several weak pathogens, resulting in complete loss of commodity due to the magnified damage.

Atmospheric Gas composition

Components of the atmosphere, such as oxygen, carbon dioxide and ethylene, can greatly affected respiration rate and storage life. In addition, some natural volatile components of the produce as well as added ones also affect the growth of microorganisms in produce. Reduction of oxygen and elevation of carbon dioxide may be intentional (modified or controlled atmosphere storage) or unintentional. Such changes can promote or retard deterioration. The magnitude of such changes depends upon the commodity, cultivar, physiological age, oxygen and carbon dioxide levels, temperature and duration of storage.

Chilling Injury

Chilling injury is a physical disorder induced by low, nonfreezing temperatures that occurs in certain susceptible plants or produce. The consequences are (a) change in internal color (spots or areas may become soft and tan, brown, or black), (b) external discoloration, (c) pitting of surface or skin (early symptom of chilling injury), (d) uneven ripening, (e) off-flavor development, (f) accelerated incidence of surface molds and decay, (g) loss of nutritive value (e.g., ß-carotene, pro-vitamin A and ascorbic acid) in some products and (h) loss of ripening and increase in susceptibility to fungal spoilage.

Compatibility in mixed loads

Often it is necessary to transport or store several types of products at once. The problems created by shipping incompatible commodities together may be quite severe. The factors for determining the compatibility or products are (a) temperature, (b) relative humidity, (c) modification of the atmosphere, (d) release of volatile components harmful to other products, (e) products that produce or absorb objectionable odors or flavors and (f) difficulties in loading shipping containers or storage facilities of different size and shapes.

Curing

Curing is a postharvest healing process of the outer tissues via development of a wound periderm, which acts as an effective barrier against further infection and water loss. It is usually accomplished by holding the produce at high temperature and high relative humidity for several days while harvesting wounds heal and a new and protective layer of cells is formed. Thus, the purposes of curing are (a) to cure and heal wounds of tubers and bulbs that occurred during harvesting, (b) to strengthen the skin, (c) to dry superficial

leaves, (d) to develop skin color in case of onion, and (e) to reduce water loss during postharvest in plant products, such as potatoes, sweet potatoes.

Pre-cooling

Prompt pre-cooling conserves the weight of the product and reduces the rate of metabolic activity. Thus, rapid cooling produces acceptable appearance, texture, flavor, and nutritive value in strawberries. Pre-cooling is a means of removing field heat, and its aims are to quickly slow down respiration, minimize microbial growth, reduce transpiration rate and ease the load on cooling system. Common methods of pre-cooling are room cooling, forced air cooling, package icing, hydro-cooling, and vacuum cooling.

Cleaning, Disinfection and Rinsing

Additional steps, such as washing with disinfectants and application of waxes or other protective agents are also used in plant products. The main goals of cleaning are to (a) eliminate contamination such as insects, surface dirt, and soil particles, (b) separate pesticides, fertilizers and residues of other filed applied chemicals form the product, (c) reduce the microbial load of the incoming material and (d) enhance the appearance of the product. Washing may have beneficial or detrimental effects. Prolonged washing may produce a water-soaked appearance and moisture penetration may aid in pathogen access through the wounds.

Waxing

The purpose of waxing or applying another edible coating is to (a) reduce the rates of respiration and transpiration, (b) enhance product gloss, (c) generate modified atmosphere, (d) protect from fungus, (e) protect from insect or mechanical injury, and (f) cure tiny injuries and scratches on the surface. Wax coating is not always desirable. The coating may modify the inside atmosphere, leading, for example, to low oxygen levels that could encourage fermentation.

Packaging, Storage and Distribution

Postharvest handling systems involve the channels through which harvested fruits reach the processing facility or consumer. The quality of fresh produce is affected markedly by the length of time between picking and storage.

Packing, transportation, storage and retail distribution are also important for postharvest handling of plant materials. Physical and mechanical injuries can occur during the handling, grading and packaging operations before and after shipment. To avoid excessive physical damage, proper precautions are necessary during harvesting, loading, unloading, transportation, sporting, packaging and storage.

Broccoli Grading

Grading of Long beans

Packaging of French beans

Placement of cartoons in cooling chamber

Potato Loading

Reefer Truck

Present status of transportation

Generally, head loading or shoulder slings are common practice for transporting fruits and vegetables in the rural areas. But truck or pickups are used for long distance and tricycle or vans are used for short distance (Figure 1). Sometimes traditional fruits and vegetables packages are carried on the top of passenger buses. In the northern part of the country the farmers/traders use boat or launch for transporting fruits and vegetables. There is no cool chain system in transporting fruits and vegetables. The produce is loaded in ways which promotes major problems such as inadequate transport containers, inappropriate staking, inadequate packages, very rough loading method, poor and nonexistence of air circulation, heating, and mechanical injury to the produce etc. As a result a significant portion of fruits and vegetables is lost during transportation.

Figure 1. Existing transport system of fruits and vegetables

Present status of distribution for marketing of fresh fruits and vegetables

Local marketing

Most of the wholesale market and retail markets in the country are poorly managed. In the wholesale markets the 'Aratder' keep the produce in a heap haphazardly in an open area or in a shaded area. Generally, the 'Aratder' do not sort or grade the produce. As a result, deterioration starts quickly because of the presence of some damaged one which happened during transporting. The retailers buy these materials. Sometime the retailer sort or grade the materials to prevent the materials from contamination or deterioration. In most cases the retailers discard the damaged ones. That is why in most cases the retailer's demands high prices of the produce. The present status of local market is shown in figure 2.

Figure 2. Existing status of local market

Quality Assurance for Food Processing

Quality

The totality of its attributes and properties which bear upon its fitness for its intended use. Quality indicates the essential nature of a thing.

Quality Control

It is the essential part of Good Manufacturing Practice, which is concerned with Sampling, Specifications, Testing as well as the organization, documentation and release procedures which ensure that the necessary and relevant tests are carried out and that materials are not released for use, nor product released for sale, or supply, until their quality has been judged to be satisfactory. Quality Control is not only confined to laboratory operation. But the

involvement and commitment of all concerned at all stages are mandatory towards the achievement of Quality Objective.

Quality Assurance (QA)

Quality Assurance (QA) is a vital part of a food processing industry. It has a broad jurisdiction concerning quality of product individually or collectively. QA justify the quality of a product by using standard specification, sampling frequency and its specific parameters analysis. Therefore, R&D, quality audit, quality control, microbiology, toxicology, raw materials, processing development and packaging material testing department etc. department should be formed by to obtain an instant quality of the product of a food processing industry.

Good Manufacturing Practice (GMP)

Good Manufacturing Practice (GMP) in a food processing plant describe the methods, equipment facilities and control for producing safe and wholesome processed food. It is a daily practice guideline for a food processing industry in the corner of quality management, personnel & training, premises & equipment, documentation, production & its area, quality assurance, storage area and hygiene & sanitation. GMP always protects the quality of product as well as preserves the benefit of a food industry and its consumer satisfaction with minimum product loss to equate quality of product with survival and growth of the business.

Hazard Analysis Critical Control Point (HACCP)

It is any type of hazard like chemical, physical and biological are identified and its preventive measure are pointed out and made a solving system. HACCP is a safeguard of a food product as well a human consumption. Processing method evaluation, identification, and monitoring of critical control point (CCPs) are carried out by HACCP implementation and verification. Improvement of product quality is a natural aftermath of such activities.

GMP for processed food products

- To manufacture safe and wholesome food product.
- To maximize consumer satisfaction.
- To minimize product loss.
- Comply with regulatory and sanitary codes.
- To equate product quality with survival and growth of the business.

Objectives of GMP

To produce any food product must satisfy the following criteria-

- Safety
- Efficacy
- Acceptability
- Potency
- Stability
- Regulatory Compliance

Basic Requirement of GMP

- Quality Management
- Personnel and Training
- Premise and Equipment
- Documentation
- Production
- Quality Control
- Contract Manufacture and Analysis
- Complaints, Product Recall and Returned Products
- Self-inspection and Quality Audits and Validation

Quality Management in Food Plant

Basic elements of Quality Management in the Food Plant are:

- To establish a "Quality System" or appropriate infrastructure to GMP encompassing the organizational structure, procedure, processes and resources.
- To take systematic nations necessary to ensure adequate confidence that a product or service will satisfy a given requirements for quality.
- To set quality objectives.
- The attainment of quality objective is the responsibility of senior/top management and requires the participation and commitments by staff in all departments, by company's suppliers and by the distributors.

Quality Policy

- Overall intentions and directions of an organization as quality as formally expressed by top management. The quality policy will be relevant to the supplier's organizational goals and the expectation and needs of its customers.

Requirement to fulfil the Quality Objective

- Establish a comprehensively designed and correctly implemented system of Quality Assurance incorporating Good Manufacturing Practice and Quality Control.
- Document and monitor the effectiveness of Quality Objectives.
- Resource adequately all parts of Quality Assurance system with competent personnel, suitable and sufficient premiss, equipment and facilities.
- Ensure compliance with additional legal responsibilities by the holder of manufacturing Licenses and for the Quality Control.

Quality Assurance Functions

- Designing and developing the products as per requirements of Good Manufacturing Practice (GMP) and Good Laboratory Practice (GLP).
- Specifying production and control operations clearly and adopting GMP.
- Specifying clearly the key personnel (Managerial) responsibilities.
- Making necessary management for the manufacturing, supply and use of proper starting and packaging materials.

- Carrying out necessary controls on raw materials, intermediate products and other in process controls and validations.
- Correct processing of finished products and checking the quality according to defined procedures.
- Products are not sold or supplied before QA has certified that each production batch has been produced and controlled in accordance with the requirements of the Marketing Authorization as well as quality Standards.
- Making satisfactory arrangements to exist as far as possible that the products are stored, distributed and subsequently handled so that quality is maintained throughout their shelf life.
- Establishing a procedure of self-inspection or quality audit which regularly appraises the effectiveness and applicability of the Quality Assurance System.

GMP Guidelines for Quality Assurance:

- Quality Assurance should be designed to suit the operations to be carried out in them. Sufficient spaces should be given to avoid mix-ups and cross-contamination.
- There should be adequate space for sampling reference standards and records.
- Provision for sufficient ventilation, separate air handling units, AC facilities, prevention fumes, harmful gases etc should be available.
- A separate room may be needed for instruments to protect them against electrical interference, vibration, contact with excessive moisture and external factors.
- Laboratory must be AC.
- Microbiological room must be double door and hopa filter (0.2µ) must be used on the ventilators of the room.

Personnel requirements of GMP

The current GMP guide highlights code of practice for qualified persons and described their duties and responsibilities in greater detail. It also recommends about the adequacy of qualified persons for industry, their education, training, practical experience, professional code of conduct, delegation of duties and finally the disciplinary measures to deal with cases of misconduct.

The requirement spoll out that manufacturer must have an organization chart with written clearly understood job descriptions and adequate authority to carry out their responsibilities. There should be no gaps or unexpected overlaps in the responsibilities of those personnel concerned with the application of GMP.

The key personnel, being heads of production and quality control are the responsible for all production and quality control activities. They should be full time personnel.

GMP Guidelines for Training

Training and personnel development are in separable. Product quality depends a lot on engaging right people for the right job.

Benefits of Organized Training Program

- Better Understanding of Process, People and Equipment.
- Uniformity and Consistency in Manufacturing.
- Higher Quality Attainment.
- Increased Productivity and Faster Response

Guidelines for Training

A well written Training Program should contain the following:

- Give training for all new staff at recruitment appropriate to the duties assigned to them.
- Offer training to all personnel who work the manufacturing and quality control areas maintenance and clearing personnel on the basic principle of GMP.
- Conduct specific training of personnel working in sterile and clean areas or in areas where contamination is a hazard and where highly potent, toxic or sensitive materials are handled.
- Conduct training on GMP on a continuing basis and at frequent and regular intervals so that knowledge of GMP remains fresh in the memory of employees.
- aintain training record of personnel and make periodic assessment of the effectiveness of the training program.
- After training appraise the performance of the employees to determine whether they have proper knowledge for the jobs they are assigned to.
- Discuss the concept of Quality Control/Assurance and all measures capable of improving its understanding and implementation during the training session. So that trainees learn how noncompliance with standards and procedures can affect consumer, company and employee.

GMP Guidelines for Personal Hygiene and Sanitation

Shelf life of a product depends on three conditions:

1. Environment of the premises.
2. Space Hygiene.
3. Personal Hygiene.

Sanitation and Hygiene Programs are essential for following causes:

- Product might be adversely affected.
- Product might fail to function as expected to be.
- A contaminated product might lead to serious fatal consequences.

A chart of rules about cleanness, hygiene and prevention of contamination must be prepared and followed.

Requirements of GMP for Premises

General Requirements for suitable premises are:

- Ideal Layout and Design
- Weather Protection

- Segregation of activities
- Air Handling System
- Serious Block
- Utility Services
- Construction
- Sanitation
- Lighting and Ventilation
- Changing Room
- Toilets
- Canteen and Praying Room
- Safety Measures
- Engineering Backup
- Maintenance Facilities
- Security Services
- Quarantine Store
- Raw Material Store
- Finished Goods Store
- Intermediate Position Store (In process)
- Packaging Hall
- Quality Control Laboratory
- Humidity Control Facilities
- Air Conditioning Facilities
- Environmental Control Facilities

GMP Guidelines for Production Areas

- Provide adequate working space for the operation of equipment as applicable to the actual manufacturing operations required.
- Maintenance workshops should be located away from production areas.
- Production and storage areas should not directly connect to toilets.
- Premises should preferably be laid out in such a way as to allow the production to take place in areas connected in a logical order corresponding to the sequence of operations and to the requisite cleanliness level.
- The adequacy of working and in process storage space should permit the orderly and logical positioning of equipment and materials so as to minimize the risk of confusion between different products or their components to avoid cross contamination and to minimize the risk of omission or wrong application of any of the manufacturing and control steps.
- Pipe work, light fillings, ventilation points and other services should be designed and suited to avoid creation of recess that are difficult to clean.
- Drains should be of adequate size and equipped to prevent back-flow. Drains should be covered.

- Provision should be made for proper and safe storage of waste materials and their subsequent disposal in a sanitary manner at regular and frequent intervals.
- Production areas should be effectively ventilated with air control facilities appropriate to the products handled and to the operations undertaken.
- Rodenticides, insecticides, fumigating agents and sanitizing materials should be stored separately and should not be allowed to contaminate equipment materials and products.

GMP Guidelines for Storage Areas

- Storage areas should be of adequate space to allow orderly placement of various categories of materials and products.
- Storage areas should be suitable for effective separation of quarantined materials and products.
- Special and segregated areas should be available for storage of toxic substances and dangerous chemicals.
- Segregated storage should be provided for rejected recalled and returned materials and products.
- Safe and secure storage arrangements for different labels as well as other printed materials to avoid mix-up.

Requirement of GMP for Equipment

All dispensing, processing, packaging machinery and analytical equipment must be suitable for the operations.

Criteria for selecting manufacturing and control equipment are

- Safety
- GMP Guidelines
- Minimum failure risk
- Local maintenance facilities
- To available the parts in local
- Cost effectiveness

Equipment used for the manufacture of the food product should be

- Easy to clean and wash the equipment.
- Preserve and make operation & maintenance.
- Easy opera table as possible.
- Calibrate where necessary as per SOP at a regular interval and kept records.
- Locally available of spares.
- Separate and making the defective and out of calibrating equipment.
- Ensure clean and wash after processing.

GMP and Batch Documentation

Batch documentation constitutes an essential part of the quality control/assurance system. It serves as a legal record supporting the batch.

The WHO guides states that the "manufacturing records must provide a complete account of the manufacturing history of each batch of a product, showing that it has been manufactured, tested and analyzed in accordance with the manufacturing procedures and written instructions."

An ideal batch documentation must satisfy the following criteria:

1. Compliance
2. Accountability
3. Traceability
4. Control

A complete batch documentation should contain:

5. Batch Processing Records
6. Batch Packaging Records
7. In process Control Records
8. Quality Control Test Records
9. Finished Product Test Records

Every food industry must follow their prepared rules of documentations.

HACCP: Hazard Analysis Critical Control Point

HACCP Definition

CCP : A sequence of questions to determine whether a Control Point is a CCP.

Continuous Monitoring: Uninterrupted collection and recording of data such as temperature recording on a continuous strip chart.

Control

a) To manage the conditions of an operation to maintain compliance with established criteria

b) The state wherein correct procedures are being followed and criteria are being met.

Control point

Any point, step or procedure at which Biological, Physical or Chemical factors can be controlled.

Corrective Action

Procedures to be followed when a deviation occurs.

Criterion

A standard on which a judgment or decision can be based.

Critical Control Point (CCP)

A point, step or procedure in a food process at which control can be applied and as a result a food safety hazard can be prevented, eliminated or reduce to an accepted level.

Critical Limit
The maximum or minimum value to which a Physical, Biological or Chemical hazard must be controlled at a critical Control Point to prevent, eliminate or reduce to an acceptable level the occurrence of the identified food safety hazard.

Corrective Action
Procedures are to be followed when a deviation occurs.

Deviation
Failure to meet a critical limit.

Food Safety Hazard
Any Biological, Chemical or Physical property that may causes a food to be unsafe for human consumption.

HACCP Plan
1.Assemble the HACCP team.
2.Describle the food and its distribution.
3. List of Ingredients; Identify use and the consumers of the food.
4. Develop flow diagram.
5. Verify flow diagram.
6.Conduct Hazard Analysis.
If such activities are fulfilled, one is needy to begin developing HACCP plan through the seven principles of HACCP.

Seven Principles
1.Hazard Analysis.
2. CCP determination.
3. Critical Limit determination.
4. Development of Monitoring Procedure.
5. Development of Corrective Action.
6. Development of record keeping procedures.
7. Development of verification Procedures.

Explanation of seven Principles

Hazard Analysis: Potential hazard associated with a food and measures to control those hazards are identified. The hazard could be Biological like microbe, chemical like a toxin and physical like ground glass, particle of metal.

Identifying Critical Control Point: These are points in a food's production from its raw state through processing and shipping to consumption by the consumer at which the potential hazard can be controlled or eliminated. Example are cooking, Cooling, Packaging, and metal detection.

Establish Preventive measures with Critical limits or each control Point:

For a cooked food, for example, this might include setting the minimum cooking temperature and time required to ensure the elimination of any harmful microbes.

Establish Procedures to monitor the CCP: Such procedures might include determining how and by whom cooking time and temperature should be monitored.

Establish corrective action to be taken when monitoring shows that a critical limit has not been met: Reprocessing or disposing of food if the minimum cooking temperature is not met.

Establish procedures to verify that the system is working properly: Testing time and temperature recording devices to verify that a cooking unit is working properly.

Establish effective record keeping documenting the HACCP System: This would include record of hazards and their requirements and action taken to correct potential problems. Each of these principles must be backed by sound scientific knowledge. Example published microbiological studies on time and temperature factors for controlling food borne pathogens.

A food safety hazard might arise from

Biological contamination: microbiological, parasites.
Chemical contamination: Pesticides, natural toxin, drug residues, Chemical un approver use of direct or indirect food or colour additives.
Physical Hazard: Ground glass, metal particle.

HACCP Documents should be maintained for each product of a food Industry with following documents.

Product description.
Ingredients list.
HACCP related process flow diagram.
Hazard identification questionnaire.
Hazard identification and preventive measures.
Cleaning related documents.

Constraints in Processing, Preservation and Marketing of fruits and vegetables

The food processors face a growing number of constraints. The market for processed product is becoming fiercely competitive. Some of the constraints are as follows:

- Lack of improved infrastructure and Equip laboratory facilities for conducting research activities on Postharvest technology of crops.
- Improper packaging system
- In sufficiency of the scope for manpower development.
- Lack of dissemination of appropriate technologies.

- Most of the processing industries are lacking storage facilities prior to process the food crops as a result, due to higher perishable nature, Postharvest loss of the commodities are occurred to a great extent.
- Non availability of raw materials round the year.

Recommendation and suggestions for meeting future needs

To meet the challenges on global safety requirements. Bangladesh should gradually take necessary measures throughout the food chain from farm to table for improving quality of domestically produced agricultural food and stay competitive both at home and export market. For this, the following recommendation and suggestions may be followed:

- Creation and strengthening of necessary infra-structure for research, education, extension, training, input supply, marketing, processing, storage and credit etc. to sustain the growth of food processing industry.
- Postharvest technologies in developed countries should be exchanged among different connectivity and the network.
- Training programs should be organized to exchange Postharvest technologies among the network countries.
- Manpower development programme for researchers and extension workers should be undertaken among the developed countries where technological exchange of developed processing technologies should be given more emphasis.
- Marketing system of fresh and processed food is not properly developed in Bangladesh. Hence, there is an urgent need to develop the systems. Existing or developed marketing systems among the SAARC countries should be exchanged for the system development.
- Technology for manufacture of cottage and small-scale industry level food processing machines should be exchanged among the network countries.
- Giving priority towards development and expansion of processing technologies and facilities suitable for export of processed food products.
- Supporting and facilitating local small machinery manufacturers for the production of processing equipment and machinery for the processing of food crops.
- Giving necessary support services viz. feasibility studies, market intelligence, business advice, capital procurement and financial, etc., to the entrepreneurs on priority basis.
- Providing necessary financial-technical supports for the development of packaging industries.
- Develop industries for diversified use of agricultural products.

Postharvest Processing Technologies of Vegetables, Pulses and Oilseeds

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Introduction

Postharvest technology of crops implies activities from the stage of harvesting of a crop to its utilization. It provides the scientific basis for protection of agricultural commodities from quantitative and qualitative damages to process them into shelf-stable, nutritious and palatable products and other value-added for better economic dividend and employment to the farmers, entrepreneurs and the rural landless.

The postharvest technological scenario in cereals, grain legumes, oilseeds, fruits, vegetables, tubers, aroids etc. of this country present a dismal picture and mostly comprise of traditional techniques practiced by the growers, traders and the processors, owing to which considerable deterioration in physical and nutritional qualities of harvested crops occur. It has been reported that the average shortfall of food grain in the country is about 8-10% of our total production, but the average losses of food grains during different stages of postharvest handling operations is about 12-15% of total production. On the other hand, the average postharvest losses of horticultural crops are about 25-40%. It is better to give thrust on reduction of postharvest losses instead of increasing the yield of different crops. Therefore, improvement of the age-old practices and development of new technologies through organized research efforts has become obligatory to prevent the huge postharvest losses of grain and horticultural crops. The postharvest technology division of BARI has started to work on postharvest handling, storage, processing and preservation of BARI mandated crops since 1984 with the creation of separate Postharvest Technology Division (PHTD). The Division is now mainly working on the postharvest handling, storage, processing, preservation, and nutrition and quality determination of both fresh and processed products. So far, the division has developed more than 54 technologies and some of those have been described below.

Novel technique to fortify lentil using hot extrusion technology (HET):

Extrusion is a thermal processing that involves the application of high heat, high pressure, and shear forces to an uncooked mass, such as cereal foods. Residence time, temperature, pressure, and shear history characterize the extrusion cooking of food materials. It is an emerging technology for the food industries to process and market a large number of products of varying size, shape, texture, and taste. It is becoming popular over other common processing methods due to its low capital cost, feasible process to produce non-fried (without oil) products, automated control, high capacity and high productivity. During extrusion, proper ratio, mixing ingredients, conditioning, high temperature and large shearing forces cause disintegration of the product. Mixing ratio of the sample, shear and

thermal fields in a single screw extruder affect the fragmentation of the product at higher temperatures and lower moisture level. PHTD, BARI has developed manufacturing technique of lentil chips with fortification of multiple vitamins and minerals using single screw extruder.

Fig. Pictorial view of extruded lentil chips

Low Cost Small Scale Vacuum Fryer With De-Oiling Machine:

PHTD, BARI designed and developed a low cost small scale vacuum fryer with de-oiling machine for fruits and vegetables chips frying with a view to prepare quality fried chips product which will be safe for human health. The fabricated vacuum frying machine comprised three basic parts such as frying chamber, condenser and vacuum pump. Frying chamber belongs frying basket (304 × 304) mm and heating coil (4 kw, 220V, AC). Temperature sensor are connected with the thermocouple system to control the frying temperature. Condenser is added to exchange heat of stem from produced frying chips. Two stage oil type vacuum pump (1 HP) is used to create low pressure in the frying chamber during chips frying. De-oiling machine consists of perforated chips basket and control panel fabricated with stainless steel. To release excess oil from the fried chips surface, 1.5 HP motor is used for rotating the fried chips basket at 1400 rpm. To prepare and evaluate the fried chips quality sweet potato and jackfruit were used with the vacuum fryer with de-oiling machine. It was observed that 700 – 800 g processed raw samples is used for one batch frying and 500 - 600 g fried chips is de-oiled for one batch. The machine is affordable (1,40,000 – 1,60,000 Tk.) especially for SME (small and medium entrepreneurs) level to produce quality fruits and vegetables chips products.

Fresh-Cut Tender Jackfruit:

Jackfruit in its tender form is consumed as a vegetable and popular for its flavour, colour and meat like texture. In south Asian countries the tender jackfruit market has a huge market potential. To make available the tender jackfruit in the market, PHTD, BARI optimized the fresh-cut processing treatments of tender jackfruit to extend its shelf life and edibility. For this, fresh-cut jackfruit slices were pretreated by dipping into potassium metabisulphite (KMS) and calcium chloride ($CaCl_2$) solution followed by blanching in boiling water. The blanched jackfruit slices were instantly cooled and surface dried and then wrapped with

cling paper. Fresh-cut jackfruit stored at 3-6 ºC maintaining the relative humidity of 85±5% suitable to retain the nutritional quality and edibility up to 3 days.

Ready To Cook Jackfruit:

PHTD, BARI developed ready to cook (RTC) jackfruit and evaluate their nutritional and sensory quality. In this study, green tender jack fruits were harvested after 60 to 70 days after synthesis (DAS). Then the fruits were washed, peeled and sliced. Then the slices were treated with salt, citric acid and potassium metabisulphite (KMS). Then the treated sliced was steam blanched for 6 min. The blanched sliced were mixed with roasted beef spices. Then the roasted slices were dried at 60 °C. The cost of the product was found to be Tk. 25/kg.

Preservation of Vegetables by Steeping method:

Fresh vegetables like green peas, carrots sliced in finger stripes, sliced cauliflower, etc. can be preserved for 6 to 8 months steeping method. Fresh vegetables should be sorted, graded and washed. To retain the color into the vegetables, these could be blanched (heating with water at 55 – 70 ºC for 3 – 5 minutes) by deactivating the particular enzymes.

Steeping solution should be prepared using 5 - 10% salt, 0.30% glacial acetic acid and 0.10% potassium metabisulphite (KMS) solution. Then the solution should be boiled for 10-15 minutes at mild heat and the heated solution should be filtered through muslin cloth. The selected vegetables then poured into pre-sterilized glass/plastic container/drum, and

Cauliflower in steeping | Cauliflower parts in | Carrots in steeping

Fig. Vegetables preservation by steeping method

Drying, Milling and Storage Technologies of Rice Grain

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Introduction

The Farm Machinery and Postharvest Technology (FMPHT) Division is one of the major R&D Divisions of BRRI. The FMPHT Division started its journey in 1973 as "Agricultural Engineering" Division with two engineers and in 1990 the Division was renamed as Farm Machinery and Postharvest Technology Division. Initially, the main responsibility of this division was to support the work of BRRI's support service (Farm development, installation of deep tube wells, development of irrigation and drainage system, repair of vehicle's and agricultural machinery etc.). Research began when more manpower was recruited in the late 1970's and early 1980's. The mandates of the Division are, a) design, development and adaptation of appropriate agricultural machinery for various operations of rice cultivation, b) development and adaptation of modern technologies for post-harvest processing and grain storage, c) development and adaptation of technology for proper utilization of rice by-products, d) testing and evaluation of agricultural machinery and optimizing them for different land types and e) research on renewable energy.

Threshing

The demand of mechanical thresher has been increased remarkably due to increase in cropping intensity and migration of labor from farm to off farm sector. Most of the farmers want to thresh their crop using mechanical thresher. Recently various makes and models of the mechanical thresher are widely used by the farmers. BRRI developed open drum thresher (ODT) and close drum power threshers (TH-7, TH-8 and model-3). Open drum thresher is known as hold-on type thresher and suitable to operate by both male and female labours and keep the straw intact. The threshing capacity of ODT is around 350-400 kg/h and can save Tk 1200/ha over traditional method. However, the close drum thresher is also known as throw-in type threshers and suitable to thresh and clean simultaneously of paddy, wheat and other cereal grain. Threshing capacity of close drum threshers ranged from 700 -800 kg/h for paddy and 400 -600 kg/h for wheat. It can save about Tk.1875/ha over traditional methods. Using BRRI developed mechanical threshers (ODT, CDT), threshing loss can be minimized to 0.75% out of 0.85% that can save 0.36 million ton of rice annually.

Most farmers want to keep the straw intact. Straw in the open drum thresher remains intact but there is no facility of cleaning. On the other hand, closed drum threshers have the facility to clean the paddy but the straw gets crushed so that farmers cannot use the straw for their desired purposes. BRRI fabricated a thresher machine using local materials like MS seat, flat bar, angle bar, shaft, GI pipe, nut-bolt, gear, belt pulley, etc. Loop type teeth are attached to the drum of the threshing machine. The thresher has a head feed mechanism which keeps the straw intact and there is a whole feed mechanism where the straw does not

remain intact. The machine is operated by an 8 hp. diesel engine. Its threshing capacity is 350-400 kg/hr. Bundles of crop can be threshed by this machine and straw remains intact.

Cleaning

Farmers of Bangladesh clean their dried grain in natural wind blowing with the help of Kula (indigenous cleaning device) and electrically operated fan. The efficiency of this system is not suitable in inclement weather. BRRI developed a power winnower to overcome the existing problems of winnowing. It is suitable to operate in room conditions. Weed seeds and foreign materials are also separated during cleaning operations. The cleaning percentage of the winnower is about 95-98%. Both male and female can operate the machine with minimum drudgery. Winnowing capacity of the winnower is about 500 kg/h and can save about Tk.350/ton of grain. The winnowing loss (0.46%) can be minimized using BRRI power winnower that can save about 0.24 million ton of paddy annually.

Drying

Appropriate solar and mechanical dryer will be suitable for drying of agricultural products. Major rainfall occurs from May to October in Bangladesh. Boro and Aus paddy and summer maize are harvested, threshed and dried during this period. As a result the farmers face a lot of difficulties to dry their grain properly. Post-harvest losses of grain are attributed to a number of factors, most of which are related to excess moisture or improper drying. Grain with moisture content of 18 percent or more will start to deteriorate if drying is not commenced within 24 hours after harvesting, either before or after threshing. If losses are to be minimized, drying should be started as quick as possible after harvesting. Grains of insufficient drying are subjected to breaking during husking in rice huller and if stored, pest infestation, mould growth would occur reducing the quality of grains and thereby affecting market value. BRRI dryer can dry 100-250 kg of paddy in 8-10 hours depending upon the moisture content. Drying loss of paddy in Bangladesh is about 2.19%.

Storage

Underground storage study was undertaken in the open field located at BRRI, Gazipur to investigate the potentiality of seed storage in the cyclone/sidor prone areas. Eighteen kilogram of BRRI dhan28 was put inside a burnt clay “motka” and its mouth was sealed with lid and tape. Outside of clay motka was painted with black enamel paint to prevent moisture migration. The motka was placed inside a 3.5 feet deep underground pit covered with a thick polyethylene sheet. After seven months of storage, the seed viability was very good (in the range of 94 to 96%). This technology will be helpful for flood and cyclone affected area of the country where above ground storage is a problem. IRRI super bag is a low-cost storage technology that can store the dried paddy in hermetic condition where almost no exchange of air and moisture between the bag and the store environment was prevailed during the storage period. Moisture content of the stored seed also remained unchanged and nearly to the initial condition. Therefore, a limited number of insects can survived in the bag. Seed germination was also found satisfactory level (85%) after eight months of storage. To prevent rodent attack in the stacked bags, the space around the stack

should be kept clean and maintain a clear space of one meter minimum between the stacks and wall. Farmers can use this technology to store their farm products.

Milling

Automatic rice mills equipped with rubber roll sheller, emery stone polisher and related components in Bangladesh have been processing only locally available short grain (3-4mm) aromatic rice as unparboiled condition. The milling yield of those varieties is low (50-54%). BRRI scientists have developed long grain paddy drying and milling technology to reduce breakage and increasing head rice yield. It is a low-cost sun drying process of long grain aromatic paddy followed by milling in rubber roll sheller and emery stone polisher in automatic rice mills. Three to four days of mill yard drying give maximum milling yield for long grain paddy. Maintain drying temperature at 24-38^{0}C. Everyday, paddy will be dried for 4 hr and followed by 20 h stacking for tempering. The paddy stirred every 25 minutes interval for uniform drying. Repeat the process for 3-4 days to obtain the maximum removal of white belly in the rice (Manually hulled paddy). Milling yield of long grain rice (BRRI dhan37 and BRRI dhan38) is about 60%, which is 5% higher than the existing practice. Moreover, export quality rice should be produced to meet the demand of international market. Bangladesh can earn substantial amount of foreign currency by exporting quality rice to foreign and ethnic markets. The Engelberg huller mill still dominates the rice milling sector with a usage of >50% of the total paddy produced in Bangaldesh. However, the traditional Engelberg huller requires 2-3 passes for cleaning rice and, thus, needs excess electricity and labor. The milling recovery is also low. BRRI developed an air blow type Engelberg huller where clean rice can be obtained with a single pass operation saving more than 50% electricity. The milling capacity of the blow type rice mill is about 350-400 kg/hr and 1-2% more head rice can be obtained with the air blow type huller mill.

Renewable Energy

About 70% paddy is processed in different rice mills in the country. Out of total processed paddy about 90% is parboiled and rest is unparboiled. A huge amount of thermal energy is needed for parboiling of paddy. Rice husk is a by product of rice mill amounting 20% of paddy weight is used to meet up the thermal energy for parboiling. Traditional rice parboiling system is very dangerous and many operators died due to accident which is reported in the news papers. It also pollutes the environment by emitting smoke and spreading ashes. Recently BRRI developed a complete rice parboiling system which is very energy efficient and environment friendly. The efficiency of the improved rice parboiling system was higher (50%) than that of conventional (20%) system. The emission of CO gas was drastically lowered from >10000 to 100-500 ppm. Moreover, BRRI improved rice parboiling system is safe (fitted with pressure meter), comfortable and environment friendly. The parboiling time can be reduced by half (3-4 minutes) compared to traditional system (7-8 minutes). It consumes about the half amount (49 kg/ton of paddy) of rice husk compared to the traditional one (103 kg/ton of paddy). As a result about 3.12 million tons of rice husks will be saved per year (Tk.6431 million/year). Saved rice husk will be available for other purposes like briquette production, power generation, animal feed. More

employment will be created in rice husk briquette making and marketing. Scope for husk based production of electric power in rural industries will be increased. Pressure on forest for cooking fuel will considerably be reduced and less green house gases will be emitted. Flue gas temperature was reduced from 750-800 to 350-500^{o}C in the BRRI developed improved furnace. The small and medium rice mills will become more profitable.

Postharvest Processing Technology of Rice Products

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Grain quality is a complex relationship of physicochemical properties of rice. It is important in variety development program. Actually, grain quality influences the commercial success of a newly developed variety. Farmers prefer high yield, millers prefer superior milling performance and consumers prefer good eating and cooking qualities. On the other hand, rice contains nutrients such as energy, protein, macro and micro minerals and vitamins. The level of these nutrients and their absorption and utilization are important avenue for variety development process. Thus assessment of rice depends on parboiling, milling, physical and chemical quality and nutritional properties of rice. The quality indicators are as follows:

A. Processing of rough rice (paddy)
    1. Parboiling process
    2. Unparboiling process
    3. Milling process
B. Physical properties
    1. Milling yield
    2. Head rice yield
    3. Grain size and shape
    4. Chalkiness in the grain
    5. Appearance of milled rice
C. Chemical properties
    1. Amylose content
    2. Gelatinization temperature
    3. Gelconsistency
    4. Protein content
D. Cooking qualities
    1. Cooking time
    2. Tenderness
    3. Elongation ratio
    4. Imbibition ratio
    5. Aroma
E. Nutritional properties
    1. Energy content
    2. Protein content
    3. Mineral content
    4. Vitamin content

Parboiling process: Parboiling is a hydrothermal process that involves partially precooking rice within husk using steam before subsequent drying and milling. This technique induces the gelatinization of starch within the rice grain, causing starch and protein molecules to expand and fill internal air space, fostering strong cohesion. The process seals fissures and cracks in the endosperm, making the rice tough enough to withstand milling stresses, ultimately increasing the yield of finished edible rice and reducing broken rice quality. The parboiling process begins with soaking rough rice in water for several hours, followed by parboiling in cylindrical bins using steam for few minutes.

Unparboiling process: Harvested rough rice is dried manually on the floor under open sunshine or using the mechanical dryer to bring the moisture content down to a suitable level (~10%) and then milled to produce the final finished rice. Low moisture content makes the grain hard and cohesive enough to withstand milling stresses keeping the breakage reduced. But the longevity and taste of final unparboiled cooked rice is less compared to that of parboiled rice.

Milling process: Milling is done in the several types of rice mills. Such as;

Engleburg huller/Husking mills: Husking rice mills have drying floor, godowns, drum / MS sheet boilers for steaming, boiling houses. The process involves cleaning of paddy, steaming, steeping, sun drying, milling with engelburg huller, aerating and bagging. Boiler in husking mills is not standard. There is no system of measuring steam pressure and consequently, over and under steaming often affects the quality of rice. Steeping in this system consumes much time. Drying is not uniform as it is done on yard by sun. Engleburg huller produces more broken and under polished rice. Bran and husk are also mixed together. Rice produced in this system has less storage value and vulnerable to insect-pests and microorganism, and off-coloured within a year.

Semi-automatic rice mills: Semi-automatic rice mills are those in which processing operations of rice are done with either improved or modern boiler, Sun drying/dryer and milling device. The process involves cleaning of paddy, steaming, drying, milling with rubber-roll huller, polishing, aerating, bagging and weighing. Rice produced in semi-automatic rice mill is well polished and less broken. Husk and bran are obtained separately, and have better use in Briquetting and edible oil extraction.

Automatic rice mills: Automatic rice mills perform mechanically all operations such as cleaning, steaming, drying, milling, polishing and grading. Unlike other rice mills, these mills do not require any drying floor. The process involves cleaning of paddy, steaming, mechanical drying, milling with rubber-roll huller, polishing, paddy separator, stone separator, black rice sorter, cracked and discolored grain sorter, sieving for broken rice, aerating, bagging and weighing. Automatic rice mills produce best quality properly graded rice. Similar to semi-automatic rice mills husk and bran are obtained separately, and have better use in Briquetting of rice husk and edible oil extraction from bran.

Milling yield*:* Milling yield is a measure of rough rice performance during milling. It is the total quantity of head rice and broken grains recovered from unit quantity of rough rice.

Various components such as hull, bran, broken and whole grains are weighed to determine the total milled rice yield and head rice yield. They are expressed in percentage. The head rice yield is the proportion of the whole grain in the total milled rice. Rough rice contains around 20% hull and 10% commercial bran including embryo. The milling yields of high yielding varieties are grouped as high (>70%), intermediate (68-70%) and low (<68%).

Calculations: The percentage of hulls of rough rice is calculated as follows:

$$\text{Brown rice (\%)} = \frac{\text{weight of brown rice}}{\textit{weight}\text{ of rough rice}} \times 100$$

$$\text{Hull (\%)} = \frac{\text{weight of hull}}{\textit{weight}\text{ of rough rice}} \times 100$$

$$\text{Head rice (\%)} = \frac{\text{weight of head rice}}{\text{weight of rough rice}} \times 100$$

$$\text{Total milled rice (\%)} = \frac{\text{weight of total milled rice}}{\textit{weight}\text{ of rough rice}} \times 100$$

$$\text{Degree of milling (\%)} = \frac{\text{weight of total milled rice}}{\textit{weight}\text{ of brown rice}} \times 100$$

Head rice yield: It is the quantity of unbroken (whole) milled rice from a unit quantity paddy or milled rice and expresses as percentage. It is a varietal character. It depends on grain size and shape as well as physical appearance. In general, long slender or long bold kernels with white belly or white center produces comparatively low head rice yield. Post harvest grain drying is also known to influence grain breakage giving low head rice recovery. Thus, the milling quality of rice generally depends on variety, degree of maturity and moisture content. Other factors such as conditions under which it was grown, temparature and humidity during maturity and post harvest operations are also known to influence it.

Grain size and shape: Grain size and shape are important quality factors influencing the consumers. The size and shape of milled rice are classified as follows:

Size category	**Length in mm**
Extra long	Over 7.5
Long (L)	6.0 to 7.5
Medium (M)	5.0 to 6.0
Short (S)	Less than 5.0
Shape	**Length/Breadth ratio**
Slender (S)	Over 3.0
Bold (B)	2.0 to 3.0
Round (R)	Less than 2.0

Broadly, long slender, medium slender and short bold rice are known as fine grain rice. Medium bold and short round grains are known as coarse grain. In our country, long slender kernels are preferred.

Chalkiness: Chalkiness in kernel influences milling yield and consumers' preference. It may be present either on the dorsal side of the grain (white belly) or in the center (white center). Chalkines of kernel lowers market value. The chalky portion of the grain is not hard and the varieties with chalkiness in the grain tend to break more frequently during milling. The following scale is used to classify the endosperm chalkiness of milled rice.

Scale	% area with chalkiness
0	None
1	Less than 10%
5	10 to 20%
9	More than 20%

Grain appearance: Grain appearance is largely determined by endosperm opacity, the amount of chalkiness either on the dorsal side of the grain or in the center and the condition of the eye or pit left after germ. Grain brightness or cleanliness, grain length to breadth ratio and degree of milling also influence the grain appearance.

Gelatinization temperature: Gelatinization temperature of rice influences its cooking time. Final gelatinization temperature of rice ranges from 55^{o} to 79^{o}C. The gelatinization temperature of rice may be low (55 to 69^{o}C), intermediate (70 to 74^{o}C) and high (>74^{o}C). Gelatinization temperature is determined by the alkali spreading value of grain. The following classification of alkali spreading value corresponds to the gelatinization temperature.

Scale	Gelatinization temperature
1.0-3.0	High
3.1-5.9	Intermediate
6.0-7.0	Low

The gelatinization temperature of local and high yielding varieties is either low or intermediate.

Gel consistency: GC correlates negatively with test panel sources for cohesiveness and tenderness of the boiled rice. GC measures viscosity of pastes or gels made from milled rice flour and is a good determining factor of cooked rice texture, especially among rice varieties having a high amylose contents. GC of rice with less than 24% amylose may be soft, medium, or hard. Cooked rice with hard gel consistency hardens faster than those with soft gel consistency. The later also remains tender and soft even upon cooling (Juliano, 1979). Consumer therefore prefers rice with soft to medium gel consistency (Tang *et al*., 1991). The gel consistency test separates the high-amylose rice into three categories:

a. Very flaky rice with hard gel consistency (length of gel = 40 mm or less)
b. Flaky rice with medium gel consistency (length of gel = 41 to 60 mm)
c. Soft rice with medium gel consistency (length of gel > 61 mm).

Amylose content: Starch has two fractions-amylose and amylopectin. Amylose content in rice determines many of the cooking and eating qualities of milled rice. Amylose is almost absent or contains (0-2%) in the waxy or glutinous rice. Such rice does not expand in volume, is glossy and sticky, and remains firm when cooked. Non-waxy (non-glutinous) rice may have high (>25%), intermediate (20-25%), low (10-19%) or very low (3-9%) amylose content. The most of the BRRI rice varieties had high amylose content. This rice showed high volume expansion and high degree of flakiness. They cook dry, were less tender and became hard upon cooling.

Cooking quality: Grain quality of rice is reported to be influenced by various physicochemical characteristics that determine the cooking behavior (Bocevska *et al*., 2009 and Moongngarm *et al*., 2010). Cooking characters are the grain elongation, gelatinization temperature and aroma (Khush *et al*., 1979). Similarly, Little *et al*., (1958) stated that the gelatinization temperature is a major rice trait, which is directly related to its cooking and eating quality. On the other hand, amylose and amylopectin structure as well as protein composition explained the difference in cooking quality of rice (Lisle *et al*., 2000). Cooking and eating properties of rice are strongly influenced by grain shape and width of rice (Mc Kenzie *et al*., 1983). Various studies showed that Ghanaian consumers have a higher preference for imported rice because of its perceived higher cooking quality (Tomlins *et al*., 2005 and Diako *et al*., 2011).

Cooking time: Cooking time of the rice depends on coarseness, protein content, amylose content and finally on its starch gelatinization temperature. Moreover, small and slender grains cook faster than big and round grains. Yadav and Jindal, (2007) reported that high protein rice requires longer cooking time than low protein rice of their selected lines of rice samples. Longer cooking duration resulted in greater moisture content of cooked rice producing softer rice. As a result, high protein or high gelatinization temperature of rice was thought to need a longer cooking time and more amount of water to cook satisfactorily. Brown rice takes longer cooking time than the milled rice during cooking. The rice varieties which had higher amylose content required a shorter cooking time (Thomas *et al*., 2013). Pre-soaking of Basmati rice before cooking in excess water reduced the time of cooking from 20 minutes to 10 minutes and increased the dimensional changes due to cooking (Hirannaiah *et al*., 2001). Cooking time is classified as high (>20.0 min), intermediate (15.0-20.0 min) and low (<15.0 min).

Elongation ratio: Elongation ratio is the ratio of the length of cooked rice over the length of uncooked rice. Some varieties show extreme elongation along the long axis on cooking of cooked rice. Arrangement of cell may be a factor for such expansion characteristics. These cells in the grain may produce many fissures that form during presoaking, which increase grain elongation along the long axis on cooking. They observed that the rice grain developed transverse cracks upon soaking. The cracks formed within several minutes in raw milled rice but required up to 1-2 hours in the case of parboiled rice (Desikachar and Subrahmanyan, 1961). Grains elongated considerably more when cooked after presoaking compared with direct cooking. A relatively high kernel elongation during cooking is

considered an important desirable characteristic of the Basmati group of rice (Kamath *et al*., 2008).

Elongation of rice can be influenced by both the L/B ratio and amylose contents (Singh *et al*., 2005 and Danbana *et al*., 2011). During cooking elongation of rice might be dependent on variety and duration of storage of rice (Madan and Bhat, 1984). Additionally, Yadav *et al*., (2007) reported that the elongation ratio of rice kernels was observed to show highly significant and positive correlation with amylose content. The elongation ratio of cooked kernels showed a highly significant and positive correlation with L/B ratio of raw kernels. Earlier, a strong positive correlation has also been reported between amylose content and elongation of rice (Nayak *et al*., 2003). Elongation ratio is classified as high (>1.5), intermediate (1.3-1.5) and low (<1.3).

Imbibition ratio: It is the increase in volume of cooked rice over non cooked rice. Cooked rice of high amylose rice shows high volume expansion having non glossy but white in color. On the other hand, *Waxy* rice expanded less during cooking but cooked *Waxy* rice is very glossy with least white color (Juliano *et al*., 1965). Volume expansion influences many of the starch properties of rice (Juliano, 1979). Additionally, volume expansion was correlated directly with amylose content (Juliano, 1985b). Working class people who do not care whether the expansion is lengthwise or breadthwise but urban people who prefer the varieties that expand more in lengthwise than in breadthwise (Choudhury, 1979). Imbibition ratio is classified as high (>4.0), Intermediate (3.5-4.0) and low (<3.5).

Aroma: Farmers cultivate aromatic rice not only for home consumption as special dishes but also for commercial purposes. Non-aromatic rice varieties give a significantly higher yield compared to aromatic varieties, in most cases profit of aromatic varieties are much higher than that of aroma free rice (Baqui *et al*., 1997). Aroma of scented rice is a major character which increases the value of rice in international market (Nayak *et al*., 2002). The demand for special purpose of aromatic rice has dramatically increased over the past two decades. Most of the trade in aromatic rice is from India, Pakistan and Thailand. Bulk of aromatic rice from India and Pakistan consists of Basmati types, while Thailand is the supplier of Jasmine rice. In Bangladesh, the area of planted aromatic rice varieties is much lower than that of regular rice varieties which is about 23% of total rice area (Baqui *et al*., 1997). Aromatic rice varieties are low yielding due to its traditional plant type which has lodging tendency and low thousand grain weight in Bangladesh. In Bangladesh, aromatic varieties of rice are usually cultivated in Aman season. Some varieties invariably possess a strong aroma, which is a unique intrinsic quality of all aromatic varieties of Bangladesh. Among them three popular varieties, Chinigura, Kalijira and Kataribhog were widely cultivated and marketed. Both Kalijira and Chinigura mainly were grown in the Rajshahi region, whereas Kataribhog in the Dinajpur region.

The main aromatic compound, 2-acetyl-1- pyrroline (2AP) was detected in one of the famous aromatic rice Khaw Dawk Mali-105. It is volatile compound. After that, 2-acetyl-1- pyrroline (2AP) content of aromatic rice is 15 times greater than that of non-aromatic

rice was established by Weber *et al.*, in 2000. Retention of the volatile compound is affected by temperature during grain development, drying and storage reported by Itani and Fushimi, (1996).

Nutritional properties of rice

Energy content: Human body needs energy to function. The unit of energy is Calorie. The Calorie used in nutrition is usually the kilocalorie or large Calorie. One Calorie or kilocalorie is the amount of energy required to raise one kilogram of water to one degree centigrade. The body converts certain food into energy. Carbohydrate foods are the most important source of energy in our diet. Rice is carbohydrate food occupying about 60% of our daily diets. Milled rice contains 77.0-78.0% carbohydrate and 0.3-0.5% fat.

Protein content: Proteins are important for growth and replacement of damaged tissue and for production of enzymes, hormones, antibodies and secretion. Protein is made up of about 20 different amino acids. Some of them are synthesized in the body cells and others must be obtained from foods. The amino acids which are not synthesized in the body are called essential amino acids. There are 8 essential amino acids for man. Thus quality of protein depends on the presence of quantity of essential amino acids. Rice protein is superior to other cereal protein because it has high lysine content compared to other cereals. But lysine is the limiting amino acid in rice. The protein content of BRRI released varieties varied from 7.0-10.0 percent. Protein is the second highest component of rice. So, rice is the main source of protein for most of the rice consuming people. It supplies 55% of the total protein consumed in Bangladesh reported by Bhuiyan *et al*., (2002). Aleuronic and sub-aleuronic parts of rice kernel are rich in protein.

Mineral elements: Our body contains many mineral elements. They occur as simple compounds or complex materials. Many of the mineral elements such as calcium, phosphorus, potassium, magnesium, iron, sulfur, iodine, zinc, copper, manganese and sodium perform essential function in the body. Some of the elements are the vital part of cells, bone, teeth and blood while others are important part of hormones and secretion products of cells. Thus the importance of the mineral elements can not be ignored. In Bangladesh, mineral deficiency disease is very common. People suffer from nutritional anemia, calcium and zinc deficiency disease. Rice contains mineral elements but their level varied from variety to variety.

Vitamins: Vitamins are group of important compound. They are needed in small quantity for proper functioning of the body. Actually vitamins help controlling the chemical reaction in the cells but are not incorporated themselves into the reaction products. Thus, vitamins are known as co enzyme. Vitamins are not synthesized directly in the body. Hence vitamins are to be obtained from foods. Rice contains a few vitamins. Of them, thiamin (vitamin B_1) is the major one. Thiamin content in BRRI released varieties varied from 0.27 to 0.52 mg/100g rice powder in brown rice and from 0.08 to 0.14 mg/100g in milled rice. Milling had much effect on the thiamin content. In general, riboflavin (Vitamin B_2) and niacin content in milled rice were 0.02 to 0.06 mg/100g and 1.3 to 2.4 mg/100g respectively.

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Standards, Testing, and Certification of Food and Beverages in Bangladesh: A Comprehensive Overview

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Introduction

The food and beverage industry is one of the most significant sectors in Bangladesh's economy, providing not only nutritional sustenance to the population but also a crucial export avenue for the country. As the industry continues to expand, maintaining rigorous standards for product safety, quality, and consistency becomes essential. The **Bangladesh Standards and Testing Institution (BSTI)**, established under the Ministry of Industries in 1985, plays a vital role in regulating, testing, and certifying food and beverage products. This institution ensures that food products available in the market are safe for consumption, meet nutritional claims, and comply with national and international standards.

This lecture note aims to provide a comprehensive overview of the role of BSTI in food and beverage standards, testing, and certification processes, emphasizing its importance in ensuring public health, fostering economic growth, and facilitating international trade.

1. Overview of BSTI

BSTI is a national institution responsible for ensuring the quality and safety of products across multiple sectors, including food and beverages. It operates under the Ministry of Industries and has a wide-ranging mandate that includes developing standards, conducting testing, and providing certifications.

Key Functions of BSTI in Food and Beverage Sector:

- **Standardization**: BSTI develops national standards for food safety, quality, and packaging to ensure that food and beverage products are safe for consumption.
- **Testing and Quality Control**: The institution tests food products for a range of parameters including microbiological safety, chemical contaminants, and nutritional content.
- **Certification**: BSTI certifies food and beverage products that meet its standards, ensuring their quality and safety for both domestic and international markets.
- **Consumer Protection**: By enforcing strict standards, BSTI helps protect the public from unsafe or substandard food products.

BSTI's role is particularly important as it helps create a reliable framework for quality assurance, especially as the country increases its participation in global trade.

2. Standards for Food and Beverages in Bangladesh

BSTI has developed a comprehensive set of standards for various categories of food and beverage products. These standards are designed to maintain the safety, quality, and nutritional value of products while also ensuring that they meet consumer expectations.

Types of Standards:

- **Food Safety Standards**: These are designed to ensure that food products are safe for consumption and free from contamination. They cover microbiological safety, pesticide residue limits, and permissible levels of additives and preservatives.
- **Nutritional Standards**: These standards focus on the nutritional content of food products. They are essential for products that carry nutritional claims such as "low-

fat," "high-protein," or "sugar-free." BSTI ensures that these claims are accurate and that the products meet specific nutritional guidelines.

- **Packaging and Labeling Standards**: Food packaging must meet certain safety standards to prevent contamination during transportation and storage. BSTI also sets labeling standards to ensure that consumers are properly informed about product ingredients, nutritional content, and shelf life.
- **Quality Standards**: Quality standards ensure that food products have the expected taste, texture, color, and overall presentation. These standards are crucial for maintaining consistency across products and ensuring that manufacturers deliver a product that meets consumer expectations.

BSTI standards align with global best practices, including the standards set by the **Codex Alimentarius**, a food safety and quality standard system developed by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO).

3. Testing Processes for Food and Beverages

Testing is an integral part of BSTI's role in maintaining product quality and safety. It involves assessing food and beverage products against established standards to ensure compliance. BSTI operates a network of laboratories equipped to perform a variety of tests on food products.

Types of Testing Conducted by BSTI:

1. **Microbiological Testing**: Microbiological testing is critical for ensuring that food products are free from harmful microorganisms that can cause foodborne illnesses. Common tests include detecting pathogens such as **Salmonella**, **E. coli**, and **Listeria**.
2. **Chemical Testing**: This testing focuses on detecting harmful chemicals in food and beverages, such as pesticides, heavy metals (like lead and mercury), and preservatives. BSTI ensures that products comply with permissible levels to prevent health risks to consumers.
3. **Physical Testing**: Physical tests assess properties such as texture, color, and appearance. These tests help ensure that food products maintain consistency in their sensory attributes. For instance, beverages are tested for clarity and carbonation, while processed foods are tested for texture and shape.
4. **Nutritional Testing**: Nutritional testing ensures that the product's nutritional content matches the claims on the label. BSTI tests for the presence of essential nutrients like vitamins, minerals, protein, fats, and carbohydrates. This process is especially important for products that make specific health claims.
5. **Sensory Testing**: Sensory testing involves evaluating a food product's taste, aroma, and mouthfeel. A trained panel of testers assesses the sensory qualities to ensure that the product meets the desired standards for consumer enjoyment.

4. Certification Process

Once the food product meets the required standards through testing, it can apply for BSTI certification. Certification is a formal process that assures consumers that a product complies with national safety and quality standards.

Steps in the Certification Process:

1. **Application Submission**: The manufacturer submits an application to BSTI, providing detailed information about the product, including its ingredients, production process, and packaging.

2. **Inspection and Testing**: BSTI conducts an inspection of the manufacturing facility to ensure compliance with safety and hygiene standards. At this stage, BSTI may also perform tests on product samples.
3. **Approval and Certification**: If the product passes the testing and meets BSTI's standards, the manufacturer is granted certification. The product is then authorized to use the **BSTI Standard Mark** on packaging, signaling its compliance with safety and quality standards.
4. **Post-Certification Monitoring**: After certification, BSTI continues to monitor the products to ensure ongoing compliance with the standards. This may involve periodic re-testing and factory inspections.
5. **Certification Renewal**: Certification is valid for a specified period, after which it must be renewed. This ensures that products continue to meet the required standards and that manufacturers are up-to-date with any changes in regulations or standards.

5. Role of BSTI in Facilitating International Trade

BSTI's certification plays a vital role in expanding Bangladesh's food and beverage exports. As food products must meet international standards to be accepted in foreign markets, BSTI helps bridge the gap by aligning local food standards with international norms. The certification of food products by BSTI serves as a **quality assurance tool** that builds trust with international buyers and regulators.

Benefits for Exporters:

- **International Market Access**: Products certified by BSTI are more likely to meet the quality standards required by foreign markets.
- **Enhanced Credibility**: Certification provides an additional layer of credibility, enhancing the reputation of Bangladeshi products globally.
- **Consumer Confidence**: With certification, consumers in international markets can be confident that the products are safe and of high quality.

6. Challenges and Future Directions

Despite the progress made in standardization, testing, and certification, there are several challenges faced by BSTI and the food and beverage sector in Bangladesh.

Challenges:

- **Counterfeit Products**: The presence of counterfeit or substandard food products in the market remains a significant challenge.
- **Awareness Gaps**: Many small-scale manufacturers lack awareness of food safety standards, which can lead to non-compliance.
- **Resource Limitations**: BSTI's resources, including testing facilities and trained personnel, are often limited, especially in dealing with the increasing number of food products in the market.

Future Directions:

- **Training and Awareness Programs**: Expanding awareness programs for manufacturers, especially small-scale ones, will help ensure compliance with food safety standards.
- **Enhanced Testing Infrastructure**: BSTI can invest in modernizing laboratories and testing facilities to keep pace with growing demands.
- **Regional and Global Collaboration**: Strengthening ties with international regulatory bodies and organizations such as Codex Alimentarius will help Bangladesh integrate more effectively into global trade.

Conclusion

BSTI plays a pivotal role in ensuring that food and beverage products in Bangladesh meet safety, quality, and nutritional standards. Through its comprehensive approach to standardization, testing, and certification, BSTI helps protect consumers, ensures consistent product quality, and facilitates international trade. As the global food market continues to evolve, BSTI's role will remain essential in maintaining Bangladesh's reputation as a producer of safe, high-quality food and beverages.

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Supply Chain of Fresh Produce and Processed Products: Context of Pran Agro-Food Industry

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Introduction

The supply chain of fresh produce and processed products is critical in ensuring the availability of high-quality food items to consumers. In the context of Pran Agro-Food Industry, one of Bangladesh's leading agro-processors, the supply chain begins with sourcing raw materials directly from farmers. Pran emphasizes sustainable farming practices, efficient logistics, and modern storage facilities to maintain freshness and reduce wastage. The integration of advanced processing technologies ensures that raw produce is transformed into diverse, value-added products while retaining nutritional quality. With a well-organized distribution network, Pran effectively delivers both fresh and processed goods, meeting domestic demand and expanding global reach.

A. Supply Chain of Fresh Produce and Processed Products

PRAN Agro-Food Industry is one of Bangladesh's largest agro-processing companies, with a comprehensive supply chain dedicated to ensuring the freshness and quality of its fruits and vegetables products. PRAN's supply chain is crucial in maintaining product quality, which is central to consumer trust. This section explores how PRAN's supply chain for Fresh Produce and Processed Products is structured and the various stages involved, from sourcing to distribution.

1. Sourcing Raw Materials: Contract Farming and Local Partnerships

PRAN relies heavily on its vast network of local farmers for the sourcing of fruits and vegetables. Over 100,000 contract farmers in various regions of Bangladesh partner with PRAN to ensure a continuous supply of high-quality produce. PRAN provides farmers with training, necessary inputs, and technology to enhance yield and quality. This relationship also ensures that the company is able to maintain a stable and cost-effective supply of raw materials.

The company sources a variety of fruits and vegetables, including seasonal produce, which require careful coordination to match supply with demand. PRAN maintains strict standards for the selection of raw materials, ensuring that the products are free from contaminants and meet safety regulations.

2. Harvesting and Post-Harvest Handling

Once the fruits and vegetables are harvested, they undergo careful post-harvest handling processes to ensure their freshness and minimize spoilage. PRAN's post-harvest procedures

include sorting, cleaning, grading, and packaging to prepare the produce for transportation to processing units. The post-harvest handling is designed to preserve the quality of the produce, protect it from damage, and ensure compliance with food safety standards.

Advanced technologies are employed to reduce food loss and to optimize freshness. Packaging materials are designed to minimize physical damage to the produce during transit while maintaining hygiene.

3. Processing and Preservation

After the raw materials arrive at the processing facilities, they undergo various treatment processes, including washing, sorting, cutting, and blanching, depending on the final product. PRAN employs both conventional and modern techniques to ensure that the nutritional value, taste, and texture of the fruits and vegetables are preserved.

For preservation, PRAN uses methods such as canning, freezing, and pasteurization. Each method is selected based on the type of fruit or vegetable and the desired shelf life. Freezing, for example, helps retain the color, taste, and nutritional content of the vegetables, while canning offers extended shelf life for fruits and other products.

4. Cold Chain Logistics

Maintaining the cold chain is a crucial part of the fruits and vegetables supply chain. PRAN ensures that the products are stored and transported at the appropriate temperature to avoid spoilage and preserve freshness. Cold storage facilities are used at multiple points in the supply chain, from the point of harvest to the final distribution centers.

Cold chain management is not only important for raw produce but also for processed items like frozen vegetables and fruits. By maintaining temperature controls during storage and transportation, PRAN ensures that the produce retains its quality and is safe for consumption.

5. Quality Control and Safety Standards

Quality control is integrated throughout the supply chain, from farm to final distribution. At the farm level, PRAN ensures that the raw materials meet the company's standards for quality and safety. This includes monitoring pesticide use, soil quality, and water sources to minimize contamination risks.

At the processing level, PRAN conducts extensive checks for product consistency, flavor, and appearance. The company adheres to food safety regulations, such as HACCP (Hazard Analysis Critical Control Point) and ISO standards, to ensure that all fruits and vegetables meet the necessary safety requirements.

6. Distribution and Retail Network

PRAN’s extensive distribution network ensures that fruits and vegetable products are available across the country and in international markets. The products are distributed

through a combination of retail outlets, supermarkets, wholesalers, and export channels. Efficient logistics help ensure the products are delivered fresh and in a timely manner.

PRAN's distribution also uses refrigerated transport, ensuring that temperature-sensitive items like frozen vegetables remain intact until they reach the consumer.

Conclusion

PRAN's supply chain for fruits and vegetables products is characterized by efficient sourcing, state-of-the-art processing, cold chain management, and a robust distribution network. These efforts ensure that consumers receive fresh, safe, and high-quality produce that adheres to strict safety standards.

B. Supply Chain of Biscuit Bakery and Culinary Foods

The supply chain for biscuit, bakery, and culinary foods is crucial in ensuring that these products meet consumer expectations for taste, texture, and safety. PRAN Agro-Food Industry has a highly efficient and scalable supply chain in place to handle the production of these products, leveraging modern technology, efficient logistics, and strong supplier relationships.

1. Raw Material Sourcing and Procurement

The first step in the supply chain of biscuit and bakery products involves the procurement of high-quality raw materials such as flour, sugar, oils, and other essential ingredients. PRAN partners with both local and international suppliers to ensure the best quality of ingredients for its production lines. The company maintains a strict selection process, considering factors such as quality consistency, price, and supply reliability.

2. Manufacturing and Production

PRAN operates modern production facilities equipped with automated baking and mixing machinery. Automation helps streamline production processes and ensures that products are consistent in quality and taste. For biscuits, the production process includes mixing dough, baking, and cooling before packaging. For bakery items, similar processes of dough preparation, baking, and finishing take place, with some items requiring additional steps such as glazing or decoration.

Culinary foods, which can range from sauces to ready-to-eat meals, undergo a different process involving cooking, seasoning, and packaging. PRAN uses specialized equipment to ensure precision and quality in every step of production.

3. Packaging and Shelf Life Management

After production, all products are carefully packaged using modern packaging materials designed to preserve the products' freshness, protect them from contamination, and extend

their shelf life. PRAN uses vacuum sealing, air-tight containers, and protective packaging for its biscuits and bakery items to prevent them from going stale.

For culinary foods, packaging is designed to keep food fresh and ensure that it remains easy to transport and store. Packaging innovations are also employed to make the products convenient for the end consumer, such as single-serve packs and microwaveable containers.

4. Quality Control and Safety Standards

Quality assurance is a major focus in the production of biscuit, bakery, and culinary foods. PRAN has stringent quality control procedures in place to ensure that all products meet established standards. The company's in-house quality control team conducts regular inspections throughout the production process, testing for consistency, safety, and flavor.

PRAN also complies with international food safety certifications such as HACCP and ISO to ensure that all products meet global food safety standards. The raw materials and finished products undergo microbiological testing, chemical analysis, and sensory evaluation to ensure that they are safe for consumption.

5. Distribution Network and Logistics

PRAN's distribution system for its biscuit, bakery, and culinary food products is extensive, covering local markets and international exports. The company uses an integrated logistics network to deliver products quickly and efficiently. The products are transported through a combination of refrigerated and non-refrigerated methods, depending on the product type.

The company has a large fleet of delivery trucks and a network of regional distribution centers that ensure timely and reliable deliveries to retail outlets, wholesalers, and direct consumers.

Conclusion

PRAN's supply chain for biscuit, bakery, and culinary foods is designed to ensure the consistent delivery of high-quality products. Through strategic sourcing, efficient production, stringent quality control, and robust distribution networks, PRAN continues to meet the demands of consumers while maintaining the highest standards of food safety and product excellence.

C. Supply Chain of Frozen Foods & Snacks

Introduction

Frozen foods and snacks have become an integral part of the modern food industry due to their convenience, long shelf life, and preserved nutritional value. PRAN Agro-Food Industry has established a comprehensive supply chain for frozen foods and snacks that ensures these products reach consumers in top-notch condition, preserving taste, texture,

and nutritional quality. This section examines the various stages involved in PRAN's supply chain for frozen foods and snacks, from raw material sourcing to final distribution.

1. Sourcing Raw Materials for Frozen Foods & Snacks

The foundation of PRAN's frozen food and snack supply chain starts with sourcing high-quality raw materials. These raw materials can range from vegetables, meats, spices, and fruits, to pre-cooked meals that are then frozen for preservation. PRAN has established partnerships with local and international suppliers to ensure the best quality ingredients are sourced consistently. For vegetables and fruits, PRAN often relies on contract farmers who grow produce according to the company's standards, ensuring uniformity in size, quality, and safety. For meats and seafood, the company adheres to strict quality guidelines, ensuring the procurement of fresh, high-quality products free from contaminants. The sourcing process includes regular inspections of raw materials to verify that they meet PRAN's safety and quality specifications.

2. Processing and Freezing Technology

Once raw materials are received at the processing facility, they undergo a series of steps, including washing, cutting, blanching, seasoning (for snacks), or marinating (for certain frozen foods). Blanching, a process where vegetables are briefly submerged in hot water or steam, is used to preserve color, flavor, and nutritional content before freezing. After blanching, the vegetables are rapidly cooled and ready for freezing. The freezing process itself is one of the most critical steps in the supply chain. PRAN employs state-of-the-art technology in its freezing process, ensuring that the food items are frozen quickly to lock in freshness, texture, and flavor. This rapid freezing process prevents the formation of large ice crystals, which can damage cell structure and affect the food's texture upon thawing. The freezing technology PRAN uses also extends shelf life while keeping the food's nutritional value intact. After freezing, the food is stored in temperature-controlled environments to maintain its integrity.

3. Cold Chain Management

A well-established cold chain is crucial to the preservation of frozen foods. PRAN's cold chain system is integrated at every step from the processing facility to the distribution points. This system uses refrigerated trucks, storage facilities, and transport containers to ensure that the temperature remains consistently low throughout the entire journey. Cold chain management is particularly important for frozen foods, as temperature fluctuations can lead to thawing and refreezing, which deteriorates product quality. To avoid this, PRAN maintains strict temperature monitoring systems that track and record temperatures during transportation, storage, and distribution. This ensures that all products are delivered in optimal condition to retailers and consumers.

4. Quality Control and Packaging

Quality assurance is a central component of PRAN's frozen food supply chain. The company has dedicated quality control teams that perform regular checks on the raw materials, during production, and post-production to ensure food safety and quality standards are consistently met. These checks involve testing for contaminants such as pesticides, microorganisms, and harmful chemicals. Once products pass the quality checks, they are packaged in materials specifically designed for frozen food items. The packaging is not only protective but also designed to maximize shelf life by preventing moisture loss, freezer burn, and contamination. PRAN uses vacuum-sealed bags, modified atmosphere packaging (MAP), and airtight containers to ensure that frozen foods retain their taste, nutritional value, and safety.

5. Distribution and Logistics

The distribution of frozen foods requires careful attention to timing and logistics. PRAN's distribution network is built to handle the specific challenges of frozen food transportation. It includes a fleet of refrigerated trucks that deliver products to a network of wholesalers, retailers, and export markets. These vehicles are equipped with temperature-control systems to ensure that the products remain frozen during transportation. The company also maintains refrigerated warehouses and distribution centers, where products are stored at low temperatures before being shipped to stores. This ensures that products are always available in retail outlets, supermarkets, and other locations without compromising on quality.

6. Export and International Markets

In addition to domestic distribution, PRAN has expanded its frozen food and snack offerings to international markets. The company's export supply chain includes additional logistics considerations, such as compliance with international food safety standards and ensuring that products remain within the required temperature ranges throughout the shipping process. PRAN ensures that its frozen food products are packaged according to international regulations, including labeling for allergens, nutritional content, and origin of production. This attention to detail helps the company maintain trust with consumers in export markets and ensures compliance with various international food safety standards.

Conclusion

PRAN's supply chain for frozen foods and snacks is designed to ensure that products reach consumers in optimal condition, retaining their taste, texture, and nutritional value. Through careful sourcing, advanced freezing technology, rigorous quality control, and efficient cold chain management, PRAN delivers high-quality frozen foods and snacks that meet both domestic and international demand.

Safety and Quality Assurance of Food Products and Beverages: Context of Pran Agro-Food Industry

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Introduction

Food safety and quality assurance are fundamental components of PRAN Agro-Food Industry's operations. The company takes proactive measures to ensure that its products are not only safe for consumption but also meet the highest quality standards. This section explores the steps PRAN takes to guarantee food safety, its commitment to quality assurance, and the certifications and processes that uphold these standards.

1. Commitment to Food Safety and Hygiene

PRAN's commitment to food safety begins with the selection of raw materials and extends through the production, processing, packaging, and distribution stages. The company recognizes that food safety is vital to consumer trust, and as such, it adheres to strict hygiene protocols at every step of the supply chain. At the farm level, PRAN ensures that raw materials are sourced from farms that follow sanitary and safe agricultural practices. These practices include using safe water sources, controlling the use of pesticides, and ensuring that food is handled properly from the point of harvest. In its production facilities, PRAN maintains high hygiene standards. The facilities are regularly sanitized, and employees undergo rigorous training on food safety practices. Equipment is cleaned regularly, and production lines are designed to prevent contamination.

2. Hazard Analysis Critical Control Point (HACCP) and ISO Certifications

PRAN follows internationally recognized food safety management systems such as Hazard Analysis Critical Control Point (HACCP). HACCP is a systematic approach to identifying and managing food safety hazards, ensuring that risks are eliminated or minimized during production. PRAN's HACCP-certified facilities conduct regular risk assessments and identify critical control points where intervention is required to prevent contamination. In addition to HACCP, PRAN has earned several ISO certifications, including ISO 9001 (Quality Management Systems) and ISO 22000 (Food Safety Management Systems). These certifications reflect the company's dedication to maintaining high standards in both food safety and quality management.

3. Quality Assurance at Every Stage

PRAN's quality assurance system is integrated at each stage of the production process. This includes raw material inspection, in-process quality control, and post-production testing. The company ensures that all raw materials meet its stringent safety and quality standards before they are used in production. During the production process, various quality control measures are in place. These measures include the monitoring of temperature, humidity,

and other environmental factors to prevent contamination. Routine microbiological testing is also conducted to detect the presence of harmful microorganisms that could impact food safety.

4. Product Testing and Sensory Evaluation

PRAN employs an extensive product testing system to ensure that every product meets both food safety and quality expectations. Each batch of product is tested for physical, chemical, and microbiological properties before it is approved for distribution. Sensory evaluation, which includes taste, smell, appearance, and texture, is another key component of PRAN's quality assurance process. Panels of trained tasters assess new products and ongoing production runs to ensure they meet the company's high standards for consumer satisfaction.

5. Packaging and Labeling

Packaging plays a crucial role in food safety. PRAN uses packaging that is designed to protect the product from contamination, preserve freshness, and ensure that the product remains safe for consumption throughout its shelf life. Packaging materials are selected based on their ability to safeguard the product and provide tamper-evident features. Labeling is another important aspect of food safety. PRAN ensures that all packaging includes clear, accurate information about the product, including nutritional facts, ingredients, storage instructions, and expiry dates. For products that may contain allergens, clear labeling is provided to protect consumers.

6. Continuous Improvement and Compliance with International Standards

PRAN is committed to continuous improvement in its food safety and quality management systems. The company regularly audits its processes, reviews feedback from consumers, and implements changes as necessary to address any issues or inefficiencies. PRAN also stays up-to-date with global food safety regulations and adapts its processes to remain in compliance with these evolving standards.

Conclusion

Safety and quality assurance are at the heart of PRAN Agro-Food Industry's operations. Through rigorous adherence to international standards such as HACCP and ISO, alongside comprehensive quality control measures at every stage of production, PRAN ensures that its food products and beverages are both safe and of the highest quality. The company's ongoing commitment to food safety not only protects consumers but also fosters long-term trust in its brand.

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Frontier Digital Technologies: Shaping the Future of Agri-Food Processing Sectors in Bangladesh

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Background

The agri-food industry is a complex, integrated production chain that spans from primary agriculture to the mature food and beverage sectors. This approach, known as "farm to fork" (F2F), is considered one of the world's most important sectors, contributing significantly to the economic progress of nations and having a major social impact. This industry is strong and complex, presenting a wide range of process and operational challenges (Panetto et al., 2020). To improve agricultural production and product quality, and to satisfy the market demands of an ever-growing population, the agri-food industry must develop innovative and sustainable solutions. As with all industries, technology plays a key role in agri-food operations and decision-making.

The agricultural sector is undergoing a digital revolution. Computers are now used in all agriculture-related processes, from machinery to decision-making systems, through the use of robots, sensors and cyber- physical systems technologies. By using integrated decision-support systems in conjunction with advanced internet networks and services,

the agri-food sector has great potential for radical improvement in terms of intelligence, efficiency, sustainability and performance. This potential is particularly relevant when considering the digital agri-food approach, which accelerates and supports agriculture in terms of sustainability, land management, quality of life and competitiveness (Panetto et al., 2020).

The agri-food sector presents numerous opportunities for designing the Internet of the Future, from the physical layer to the service layer, transforming data into first-class entities (Panetto et al., 2020). The use of digital technologies, such as the Internet of Things (IoT), Big Data, artificial intelligence (AI) and blockchain technologies, offers new opportunities to address challenges in the industry. These technologies are changing the way companies do business, as they affect operational routines and create new ways of networking with customers, suppliers and stakeholders (Cheng & Wang, 2021). In simpler terms, the use of digital technologies in agri-food aims to address sustainable challenges by increasing revenues and reducing the pressure on agri-food supply chain actors. These actors face complex, external factors beyond their control (like weather conditions, market behaviors, and policies), but digital technologies can help them react in time by visualizing current trends in needs. The agri-food industries of Bangladesh need to adopt these frontier technologies to visualize current needs, increase revenues as well as reduce the pressure on agri-food supply chain.

Frontier digital technologies in agri-food processing

Digital technologies are electronic tools, systems, devices, and resources capable of generating, storing, or processing data. This includes software applications, hardware devices, and communication networks that enable data to be processed, stored and transferred. In agriculture, terms like "digital agriculture", "agriculture 4.0" and "digital agricultural revolution" are used to describe an approach aimed at making food production more efficient. All these names refer to an approach aimed at making food production more efficient. This efficiency is achieved through streamlined communication of high-quality data and the use of current technologies (e.g. Internet of Things, Big Data, artificial intelligence, cloud computing, remote sensing, etc.). Optimization of food systems can achieve social, environmental, and economic goals, such as increased production yields, improved nutritional quality of food products, greater transparency, improved animal welfare, and greener production. While all definitions focus on the potential of digital tools to increase agronomic/production efficiency, many emphasize the impact on value chains, including e-commerce technology. This technology improves market access, restructures value chains and directly connects consumers and producers (Bahn et al., 2021; Glaros et al., 2023).

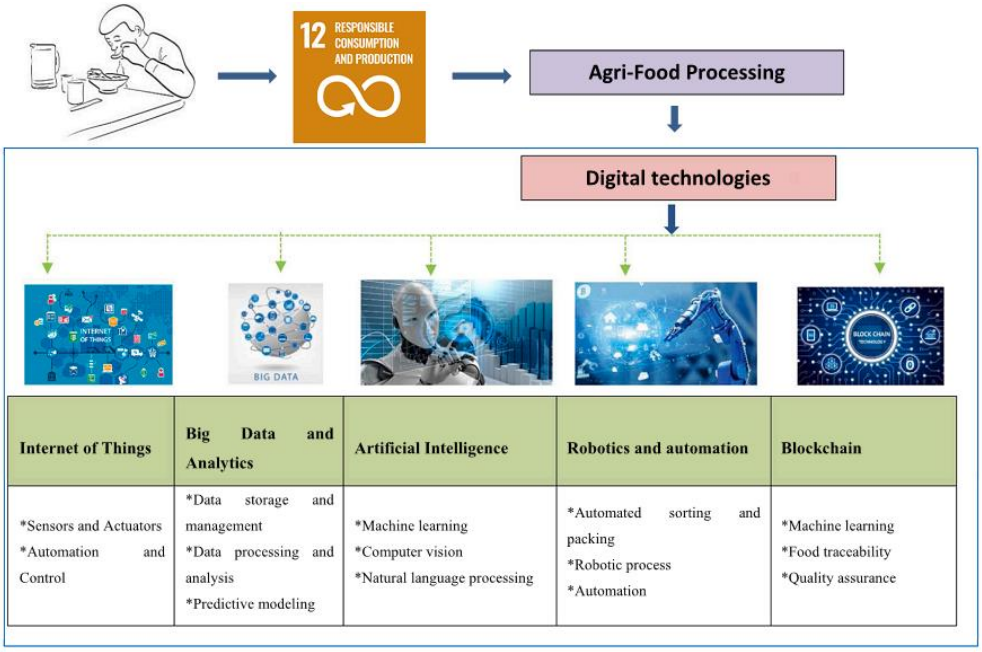
Different types of frontier digital technologies used in agri-food processing

There are several types of digital technology used in agri-food processing, such as artificial intelligence, the Internet of Things, blockchain, Big Data, robotics and smart sensors (refer to Fig. 1). These technologies can be used by the entire supply chain, from farm or field to the fork (F2F). The main objective of these technologies is to improve productivity, reduce food safety risks, and enhance the sustainability of the entire supply chain.

1. Artificial intelligence (AI)

AI refers to the ability of machines to acquire knowledge and make informed decisions by processing data. It encompasses a set of technologies based on electronic devices, computer systems, and robots that enhance and improve the acuity, speed, accuracy and efficiency of the user's activity. The primary goal of AI is to make computers, machines or robots intelligent, akin to human thought. In the realm of technology, AI should be able to easily identify things, recognize objects, analyze profiles, find solutions, make decisions, order actions, predict anomalies and learn and remember the next steps in the supply chain (Hassoun et al., 2022).

In agri-food processing, AI can be used to automate tasks such as sorting, grading and packaging produce, forecasting crop yields and detecting food safety risks. It can also be employed to mitigate risk factors, improve food security and achieve self-sufficiency, while reducing poverty, minimizing hunger, and preserving natural resources. Emerging technologies based on artificial intelligence can help increase the productivity and efficiency in the food supply chain while enhancing agriculture and preserving biodiversity.



Internet of Things	Big Data and Analytics	Artificial Intelligence	Robotics and automation	Blockchain
*Sensors and Actuators *Automation and Control	*Data storage and management *Data processing and analysis *Predictive modeling	*Machine learning *Computer vision *Natural language processing	*Automated sorting and packing *Robotic process *Automation	*Machine learning *Food traceability *Quality assurance

Figure 1. Overview of various digital technologies used in agri-food processing**.**

2. Internet of Things (IoT)

IoT refers to the integration of sensors and actuators within physical objects, enabling their connection through wired and wireless networks, often utilizing the same Internet Protocol used by the Internet. In 2021, the IoT market stood at $385 billion and is forecast to reach over $2.4 trillion by 2029 (Insights, 2021). The concept is to connect devices and sensors to the Internet to collect data and automate processes (Ben Ayed et al., 2022). The integration of IoT platforms in agriculture, also known as "precision agriculture" or "smart agriculture", provides additional data sources describing agricultural features, such as water, soil, humans and animals, with more data. Incorporating IoT platforms into agricultural practices presents notable research challenges, particularly regarding the interoperability of data storage and utilization in the cloud (protocols, security, etc.), performance monitoring, etc.. Moreover, the end user must participate in training sessions to learn and understand the use and applicability of the technology (Ben Ayed et al., 2022).

Most IoT applications of digital technologies in the agri-food industry focus on monitoring temperature, traceability, humidity, color, and improving sustainability performance. Applications of this nature hold significant importance within the vegetable supply chain, specifically during the agricultural phase. IoT systems have proven instrumental in optimizing operational parameters, including pesticide and water usage (Hassoun et al., 2022). Other parameters can be monitored via IoT, such as soil composition, humidity, temperature, and crop physiology, which can provide information for more accurate crop monitoring (Hassoun et al., 2022).

3. Blockchain

Blockchain is a transparent digital ledger technology that records transactions and stores data in a secure and decentralized way. It was developed in 2009 and has three different

types: open blockchain, private blockchain, and hybrid blockchain (Ben Ayed et al., 2022). The application of this technology in the agri-food supply chain has gradually extended due to its benefits in ensuring food traceability, transparency, safety, and security (Ben Ayed et al., 2022). It provides an innovative solution for these issues in the sector.

4. Big data (BD) technologies

BD refers to large, fast-moving and complex data that cannot be processed and managed by conventional and traditional techniques (Hassoun et al., 2022). It applies to data that is so vast, diverse and rapidly changing that conventional technologies, tools, and systems are unable to handle it effectively. The technology is characterized by its five "Vs" (volume, velocity, variety, veracity and value), which make it a vast enterprise. These five "Vs" refer to the large volumes of low-density unstructured data, the rapid speed at which data is received and exploited, the variety of availability of many types of data, the level of confidence and quality of the data, and finally, the detection of exploited values from the DB to support decision-making (Ben Ayed et al., 2022).

The integration of BD technologies in agri-food projects holds significant importance in three key areas: i) the extension of farmers' data to generate new knowledge; ii) the creation of innovative services and processes by IT providers and software developers and iii) the extension and adaptation of BD models linked to ICT and Factories of the Future (FoF) for agriculture. Numerous Big Data Repositories presently exist that ensure accessibility and utilization of Agri-Food data. For example, the "National Climatic Data centre" (around 2.9 GB per day); satellite imagery and metrological information from Google and NASAEarth Exchange; soil, water, and geospatial data from the National Resources Conservation Service (USA); OpenCorporates, etc. (Ben Ayed et al., 2022).

5. Knowledge model approaches

The objective of developing valuable knowledge models in agriculture is to utilize diverse data repositories and transform them into profitable services that aid in decision-making for various stakeholders. Recent research topics address precise data collection and engineering to serve knowledge creation of new farming models, technology application in farming, resource allocation, assessment frameworks for risk, policy definition and quality management. Additionally, researchers are focusing on qualifying decision models and identifying decision parameters such as region, land, climate, plant, time, and process (Lezochea et al., 2020).

2.8. Automation and robotization

Digital technologies have enabled machines and robots to perform tasks that were previously done by humans. Automation and robotization are driving the development of smart agriculture and accelerating the transition to smart factories in the food industry (Hassoun et al.,2022). In agri-food processing, robotics can automate tasks such as seeding, planting, weeding, picking, handling, harvesting, cutting, slicing, and packaging, thereby

improving efficiency and reducing labor costs. Fig. 2 provides a summary of the sectors in which technologies are used in the food industry.

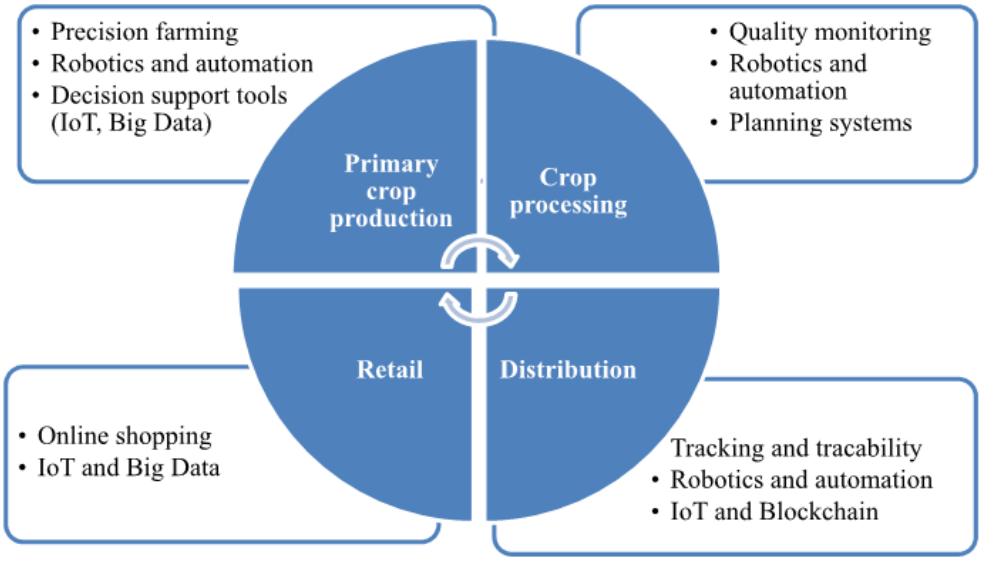


Figure 2. Concept of digitalization in the agri-food supply chain.

Digital technologies for improving efficiency and sustainability in agri-food processing

Agriculture and food processing face many challenges, including the need to improve efficiency and sustainability to meet the increasing demand for food while minimizing environmental impacts (Bahn et al., 2021). Digital technologies have the potential to transform agri-food processing by improving productivity, reducing waste, and optimizing resource use. Digital technologies can optimize energy use in agri-food processing facilities. For example, smart lighting and heating systems can automatically adjust energy use based on occupancy and weather conditions, reducing energy waste and costs (Abbate et al., 2023). Fig. 3 showcases the various stages of agri-food processing and the digital technologies that can be used to improve efficiency and sustainability in each stage.

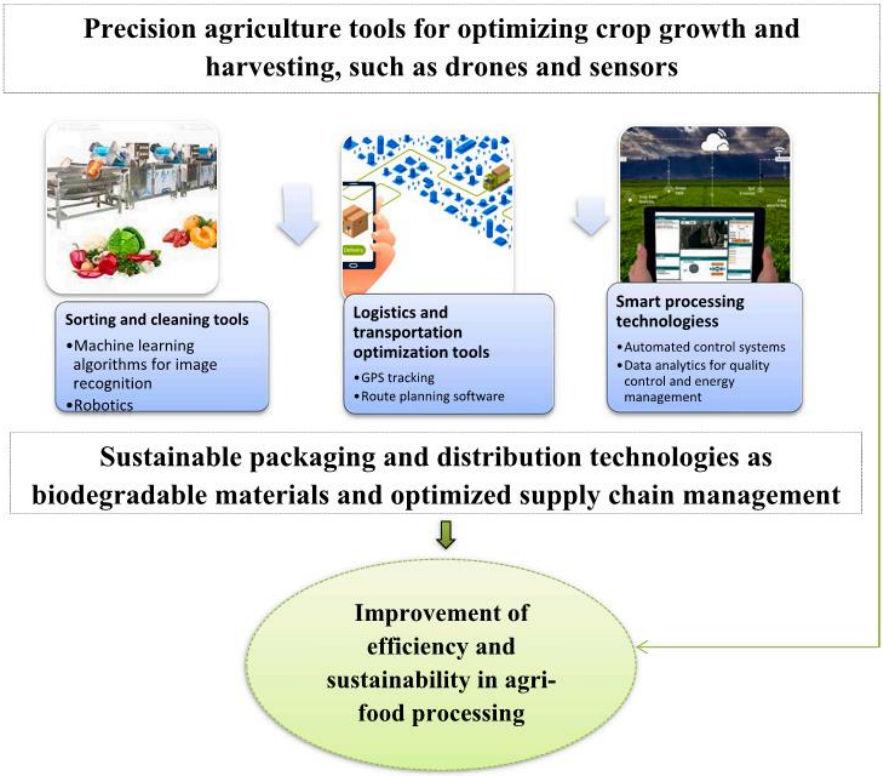


Figure 3. Flowchart presenting various stages of agri-food processing and the digital technologies that can be used to optimize each stage for improving efficiency and sustainability.

Conclusion

Frontier digital technologies present a transformative opportunity for the agri-food industry, offering significant advantages in efficiency, food safety, sustainability, and transparency in Bangladesh. The increasing integration of IoT, AI, blockchain, and robotics in agri-food processing showcases successful implementations and foreshadows a promising future. However, to realize the full potential of these technologies, addressing key challenges is imperative. Cost, technological accessibility, technical expertise, and resistance to change pose critical barriers that demand concerted efforts from all stakeholders in the agri-food sector. In perspective, targeted advancements in specific digital technology domains, such as big data and analytics, autonomous systems, 3D printing, virtual and augmented reality, and blockchain, hold immense promise for the industry. Through continuous innovation and collaboration, the agri-food sector has the opportunity to cultivate sustainability, efficiency, and transparency for the benefit of farmers, food processors, and consumers.

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Sustainable Supply Chains: Linking Producers, Markets, and Consumers for Agricultural Growth

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Introduction

Sustainable supply chains are essential for agricultural growth, ensuring efficient and equitable delivery of agricultural products from producers to consumers. In Bangladesh, agriculture is a key sector, and addressing challenges such as climate change, food security, and rural livelihoods through sustainable practices is critical. This write-up explores the importance of transforming agro-processing, fortification, biofortification, and applying technologies like e-radiation to create a sustainable agricultural supply chain. These strategies are crucial for improving food security, public health, reducing post-harvest losses, and increasing agricultural resilience.

Sustainable Agricultural Supply Chain

A sustainable supply chain integrates economic viability, environmental protection, and social responsibility. Key components include:

- Producers: Farmers and agricultural workers.
- Markets: Local, regional, and global marketplaces.
- Consumers: Individuals and organizations purchasing agricultural products.

A functional supply chain ensures efficient delivery of agricultural products from farms to consumers. In Bangladesh, challenges like inadequate infrastructure, fragmented markets, and poor access to financial services hinder supply chain efficiency. Addressing these challenges requires:

1. Logistics and Transportation: Modernizing transportation networks—roads, railways, and ports—will reduce costs and improve market access for farmers.
2. Market Access and Linkages: Direct linkages between farmers and markets reduce intermediaries, ensuring fair prices. This can be achieved through cooperatives, farmer organizations, and digital platforms connecting producers with buyers. Value Chain Development through support processing, packaging, and branding initiatives. Improvement of Market Information Systems through Providing real-time data on prices, demand, and trends. Promote producer organization and cooperatives to aggregating products for bulk sales, to negotiate better terms with buyers and to share resources. Traceability and Transparency should be ensured through implementing systems to track product origins and production methods. Building Trust through Certification and labeling schemes, regular engagement through marketing and communication and feedback mechanisms to address consumer concerns.
3. E-Commerce Platforms: Digital marketplaces or mobile apps help farmers reach broader customer bases, selling directly to consumers or retailers, bypassing traditional intermediaries.
4. Financial Inclusion: Providing access to credit, insurance, and financial services helps farmers invest in better farming practices, inputs, and technology, reducing risks from climate change and market fluctuations.

Role of Technology in Supply Chain Enhancement

1. IoT and Big Data: The Internet of Things (IoT) and big data can optimize supply chain operations in real-time, ensuring optimal storage and transportation conditions for products.
2. Mobile Applications: Mobile apps provide farmers with market prices, weather forecasts, and crop management information, enabling better decision-making and increased productivity.
3. Artificial Intelligence (AI): AI can optimize logistics, inventory management, and demand forecasting, ensuring supply matches demand and reducing waste.

By leveraging these technologies, Bangladesh can enhance agricultural supply chains, reduce food losses, improve market access, and ensure fair prices for both producers and consumers.

Fortification and Biofortification

Fortification and biofortification are strategies to improve food nutrition and address micronutrient deficiencies. In Bangladesh, where malnutrition remains a significant issue, these strategies are critical for improving public health and food security.

Fortification of Staple Foods

Fortification involves adding essential micronutrients to staple foods during processing. In Bangladesh, several fortification initiatives aim to combat malnutrition:

1. Rice Fortification: Rice is a staple food, but it lacks essential nutrients like iron, zinc, and vitamins. Fortifying rice with these nutrients helps address anemia and stunting. The World Food Programme (WFP) has promoted rice fortification in Bangladesh, improving public health.
2. Wheat Fortification: Fortifying wheat flour with iron, zinc, and folic acid prevents anemia and improves health. Government programs and public-private partnerships have supported this initiative.
3. Oil Fortification: Fortifying edible oils with vitamins A and D prevents vitamin A deficiency, a major health concern in Bangladesh. Oil fortification is widely practiced and contributes to improved public health.
4. Salt Fortification: Iodizing salt prevents iodine deficiency disorders, such as goiter and mental retardation. Salt iodization is common in Bangladesh and has contributed to public health improvements.

Biofortification

Biofortification improves the nutritional content of crops through breeding or genetic engineering. This sustainable approach addresses micronutrient deficiencies, particularly in areas with limited access to fortified foods.

1. Biofortified Rice: High-zinc rice varieties are being developed to combat zinc deficiency, which affects many people in Bangladesh. These varieties like BRRIdhan74, BRRIdhan100, BRRIdhan102 improves nutritional quality of rice.
2. Biofortified Lentils: Biofortified lentils, such as BARI Masur-8, are rich in iron, zinc, and other essential nutrients, addressing micronutrient deficiencies and improving nutrition.

Impact on Public Health

Fortification and biofortification provide significant public health benefits:

- Reduced Malnutrition: These strategies help address micronutrient deficiencies, especially among children and women.

- Improved Productivity: Healthier populations are more productive, contributing to economic growth.
- Cost-Effectiveness: Fortification and biofortification are affordable ways to improve nutrition without altering dietary habits.

E-Radiation for Crop Preservation

E-radiation, or electron beam radiation, extends the shelf life of crops by preventing sprouting, reducing microbial load, and enhancing preservation. In Bangladesh, e-radiation could be applied to crops like potatoes and onions to reduce post-harvest losses and improve food safety.

Benefits of E-Radiation

- Extended Shelf Life: E-radiation prevents sprouting in potatoes and onions, allowing longer storage without deterioration.
- Improved Quality: The technology maintains the nutritional and sensory qualities of crops, ensuring they reach consumers in optimal condition.
- Food Safety: E-radiation eliminates pathogens and contaminants, improving food safety and reducing foodborne illness risks.

Challenges and Adoption

Challenges to adopting e-radiation include infrastructure gaps, lack of awareness, and regulatory hurdles. Establishing irradiation facilities and educating stakeholders on its benefits will be essential for widespread adoption.

Measuring and Monitoring Progress for Supply Chain Enhancement

Key Performance Indicators (KPIs)

- Production and Consumption: Fresh produce and products' quality, safety and price
- Economic: Income growth for producers, Market share expansion.
- Environmental: Reduction in greenhouse gas emissions.
- Social: Improved livelihoods for rural communities, enhanced access to education, healthcare.

Tools and Methods

- Conduct regular surveys and audits, use frontier technologies for tracking physiological and environmental changes, collect and analyze consumer feedback.

Continuous Improvement

- Identify and address gaps in the supply chain, promote innovation and scaling of successful model, strengthen collaboration among stakeholders.

Conclusion

Sustainable supply chain practices are critical for agricultural growth, food security, and public health in Bangladesh. By transforming agro-processing, enhancing supply chains, and adopting fortification, biofortification, and e-radiation, Bangladesh can address challenges such as malnutrition, post-harvest losses, and climate resilience. Collaborative efforts among the government, private sector, researchers, and farmers will be crucial for building a resilient agricultural sector that meets the needs of the population and contributes to global sustainability goals.

Transforming Agro-Processing: Future Strategies, R&D, and Supply Chain Enhancement

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Agro-processing plays a pivotal role in adding value to raw agricultural products, reducing post-harvest losses, and contributing to economic development. For Bangladesh, modernizing agro-processing is essential to enhance supply chain sustainability, improve food security, and boost rural economies. This document explores key areas for transformation, outlines strategies for the future, and emphasizes the importance of research and development (R&D) to strengthen supply chain systems.

Key Areas for Transformation

1. Enhancing Processing Efficiency

The adoption of modern machinery and innovative techniques can revolutionize agro-processing. Mechanizing operations such as milling, packaging, and preservation can:

- Improve yield and quality.
- Reduce labor costs.
- Ensure product consistency and hygiene.

For instance, automated rice mills can process grains more efficiently than traditional methods, while vacuum packaging systems extend shelf life and maintain product freshness. By adopting these technologies, agricultural outputs are utilized more effectively, reducing waste and increasing profitability.

2. Promoting Value-Added Products

Agro-processing provides opportunities to diversify agricultural outputs into high-value products. Transforming raw materials into ready-to-eat meals, processed snacks, or export-quality items not only adds economic value but also opens new markets. For example:

- **Ready-to-Eat Meals**: Convenient products cater to urban and export markets.
- **Organic and Specialty Foods**: Target niche markets domestically and abroad.
- **Processed Fruits and Vegetables**: Canned or frozen items reduce spoilage and ensure year-round availability.

Value-added products offer better returns to both farmers and processors, incentivizing higher productivity and innovation.

3. Strengthening Cold Chain Infrastructure

Refrigerated storage and transportation systems are critical for maintaining the quality of perishable goods, particularly in a tropical climate prone to high spoilage rates. Developing robust cold chains can:

- Reduce post-harvest losses.
- Maintain nutritional value and freshness.
- Enhance export potential for perishables like seafood, dairy, and fruits.

Investing in cold chain infrastructure, including refrigerated trucks and cold storage facilities, is vital to minimize the impact of climate-related disruptions on agricultural supply chains.

4. Public-Private Partnerships (PPPs)
Collaborations between public and private sectors can drive innovation, investment, and efficiency in agro-processing. PPPs can:

- Fund research and development projects.
- Build shared infrastructure such as processing plants and storage units.
- Facilitate knowledge exchange between stakeholders.

For example, joint ventures between government bodies and agribusiness firms can enhance capacity building and introduce advanced technologies to smallholder farmers.

Future Strategies in Agro-Processing
1. Digital Integration
The integration of digital tools and technologies can transform agro-processing into a more efficient and transparent industry. Key innovations include:

- **Blockchain Technology**: Ensures traceability of products from farm to table, enhancing consumer trust.
- **IoT Devices**: Monitor storage conditions in real-time to prevent spoilage.
- **Data Analytics**: Analyze market trends and optimize production schedules.

By embracing digital integration, agro-processing businesses can streamline operations, reduce costs, and meet the evolving demands of global markets.

2. Green Technologies
Sustainability is increasingly becoming a priority in agro-processing. Adopting green technologies can:

- Reduce the environmental footprint of processing activities.
- Conserve resources through energy-efficient machinery and water-saving methods.
- Support circular economies by repurposing byproducts.

Examples include solar-powered drying systems for fruits and vegetables or biogas plants that utilize agricultural waste. These practices align with global sustainability goals and enhance the sector's resilience to climate change.

3. Capacity Building
Empowering farmers and agro-processors through training and education is critical for long-term success. Capacity building initiatives should focus on:

- **Modern Practices**: Teaching advanced farming and processing techniques.
- **Compliance**: Ensuring adherence to international quality and safety standards.
- **Entrepreneurship**: Encouraging innovation and business development.

Workshops, on-site demonstrations, and digital learning platforms can bridge knowledge gaps and enable stakeholders to adopt best practices effectively.

The Role of Research and Development in Agro-Processing
Research and Development (R&D) is essential for the growth and sustainability of the agro-processing sector. Investments in R&D can:

- Drive innovation in processing methods and product development.
- Improve storage techniques to reduce post-harvest losses.
- Develop environmentally friendly technologies.

R&D also enables the introduction of region-specific solutions that cater to the unique needs of farmers and processors in Bangladesh, such as drought-resistant crop varieties and energy-efficient processing equipment.

Enhancing Supply Chain Efficiency
Efficient supply chains are critical to the success of agro-processing. Key areas for improvement include:

- **Streamlined Logistics**: Ensuring timely transportation of raw materials and finished goods to reduce delays and spoilage.
- **Transparent Operations**: Utilizing digital tools for real-time tracking and management.
- **Collaboration**: Encouraging cooperation between farmers, processors, and distributors to align goals and improve efficiency.

By addressing these areas, supply chains can become more resilient, ensuring that high-quality products reach consumers while minimizing losses.

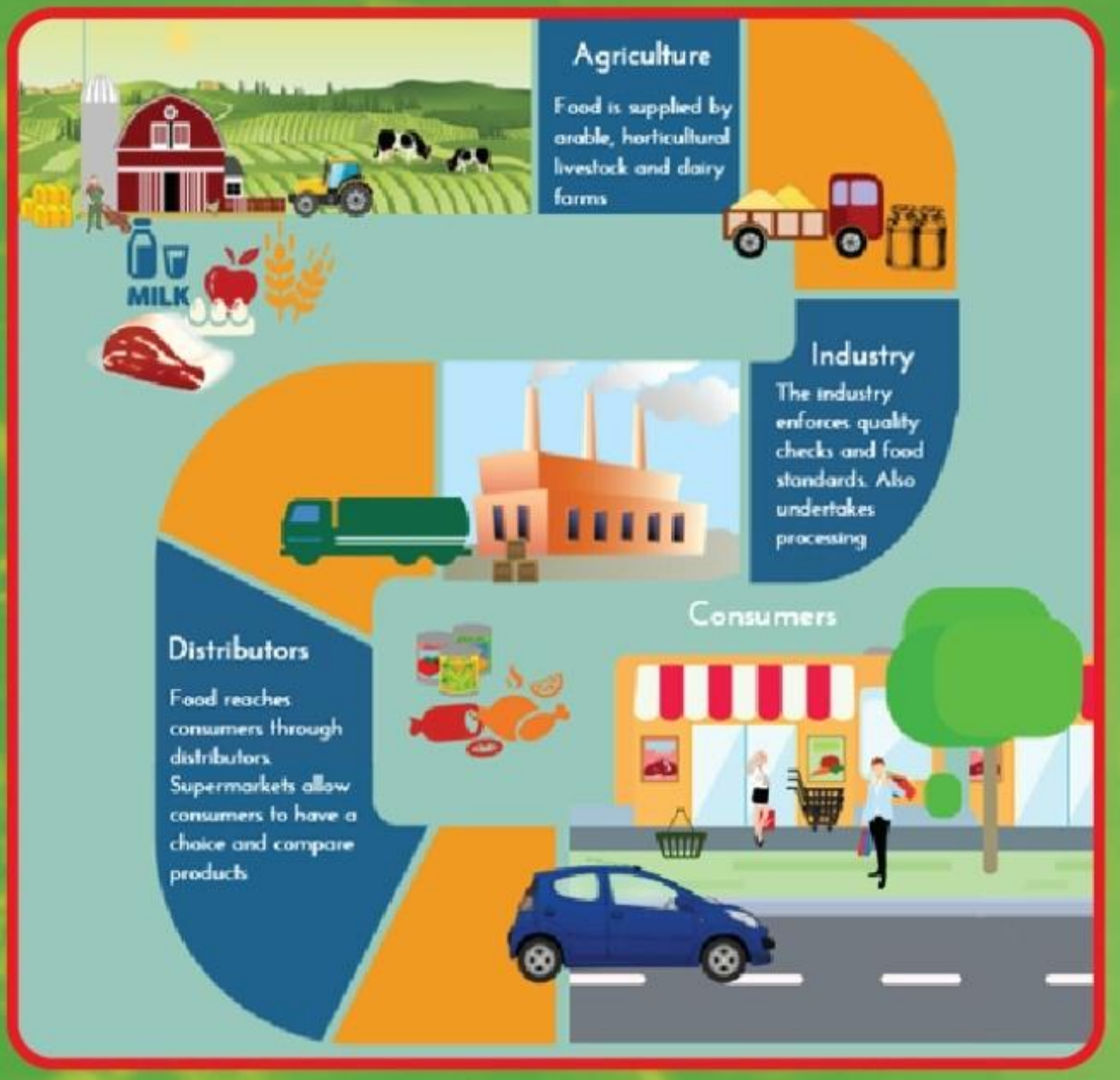
Benefits of Transforming Agro-Processing
Economic Growth
Modern agro-processing drives economic growth by:

- Generating employment in rural and urban areas.
- Increasing export earnings through high-quality products.
- Boosting farmer incomes by reducing waste and enhancing value.

Food Security
Improved processing and storage ensure a steady supply of nutritious food, even during off-seasons or adverse weather conditions. This reduces dependency on imports and strengthens national food security.

Rural Development
Investments in agro-processing infrastructure create opportunities for rural communities, reducing poverty and migration to urban areas. Empowered farmers and small businesses contribute to vibrant rural economies.

Conclusion
By adopting advanced strategies, leveraging R&D, and enhancing supply chains, Bangladesh can transform its agro-processing sector into a competitive and sustainable industry. Investments in modern machinery, value addition, cold chain infrastructure, and green technologies will drive efficiency, reduce waste, and enhance the quality of agricultural products. Additionally, fostering public-private partnerships and building the capacities of stakeholders will ensure a resilient supply chain that contributes to economic growth, food security, and rural development. The future of agro-processing in Bangladesh lies in innovation, sustainability, and collaboration.



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