Project ID 728

Competitive Research Grant

Sub-Project Completion Report

on

Development of shelf stable value added products from onion, garlic and ginger

Project Duration

May 2016 to September 2018

Spices Research Center

Bangladesh Agricultural Research Institute, Shibganj, Bogura

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
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Acronyms

ALF	:	Aluminium Foil
ANOVA	:	Analysis of Variance
BARI	:	Bangladesh Agricultural Research Institute
BARC	:	Bangladesh Agricultural Research Council
BAU	:	Bangladesh Agricultural University
DMRT	:	Duncan's Multiple Range Test
PB	:	Poly Bag
PP	:	Plastic Pot
RFT	:	Refrigeration Temperature
RT	:	Room Temperature
PI	:	Principle Investigator
HDPE	:	High Density Polyethylene
$Na_2O_5S_2$	:	Sodium metabisulfite
WR	:	Water Ratio

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Executive Summary

Under this project, a survey to identify post-harvest practices and to determine the post-harvest losses of onion, garlic and ginger in farmer's field was performed. Procurement of this project has been completed through RFQ. Different dehydrated shelf stable products from onion, garlic and ginger have been developed by mechanical drying. Packaging and storage study have been conducted using different packaging material at different temperature. Different composition analysis has been completed. Sensory evaluation was done. Total received fund was Tk.18,16,298.00 and total expenditure was Tk.17,24,548.00.

The drying time to a specific moisture ratio was decreased with the increase in drying temperature at constant sample thickness. As a result drying rate constant increased with increasing temperature. It was also noticeable that for a specific moisture ratio, the least drying time was achieved at 68^o C, followed by 60°C, while the highest drying time was required at 52°C to dry onion, garlic and ginger slices. It was also observed that thickness had profound influence on drying time and as the thickness of the samples increased, the drying time to a specific moisture ratio also increased with resultant decrease in drying rate constant.

Studies on packaging materials showed that T_1 (ALF-0.08mm) and T_2 (PB-0.09mm) with almost similar thickness but T_1 gave quite low WR (1.0) indicating better performance of ALF compared to PB in all cases. It is also indicated that ALF 0.08 mm (T_1) give negligible weight gain and is followed by T_2 and T_4, while highest water uptake is given by T_3 for the storage period (i.e 180days) for onion, garlic and ginger. It is also observed that during refrigeration storage samples $T_{1,}$ $T_{2,}$ T_3 and T_4 show very little moisture gain (WR) for onion garlic and ginger.

The results of the chemical analysis showed that there are least losses of nutrients in treated and nontreated onion, garlic and ginger following dehydration except vitamin C. Final organoleptic taste tests carried out using three different samples showed that dehydrated onion, garlic and ginger may be used instead of fresh onion, garlic and ginger in curry with other spices The study thus showed that high quality shelf-stable onion, garlic and ginger products can be developed utilizing available low cost dehydration processes based on fossil fuel or renewable energy and thereby, post-harvest losses of summer onion, garlic and ginger can be reduced to an acceptable level.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Development of shelf stable value added products from onion, garlic and ginger

2. Implementing organization: Spices Research Centre, Bangladesh Agricultural Research Institute, Shibganj, Bogura

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

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4. Sub-project budget (Tk):

Total: Tk. 19,99,870.00 (Nineteen lakh ninety nine thousand eight hundred seventy taka only)

5. Duration of the sub-project:

   a. Start date (Based on LoA signed): 14 th May, 2017
   b. End date: 30 September, 2018

6. Justification of undertaking the sub-project:

Onion, garlic and ginger are the integral part of our daily food recipe. It is used to make our food palatable, attractive colour and to impart good flavour by reducing bad smell. Besides, these spices have medicinal values. Spices, which are used in different items of curry and other food that help cure or protect our body indirectly against various kinds of disease.

Onion, garlic and ginger are available in large quantity during the harvesting season. Huge supply during peak season is responsible for lower market price. Farmers are using traditional storage. So a significant amount of (20-30%) onion, garlic and ginger are rotten in the store. In some cases this losses is more than that. There is very negligible data are available on post-harvest losses of these spices. Lack of adequate processing and preservation technology, adequate transportation and marketing facilities further aggravated the situation. Bangladesh is not self-sufficient in onion, garlic and ginger production and a lot of money is used every year to import these spices. So the country needs to take all out measures to reduce the losses /spoilage to an acceptable level to meet the shortage. Thus there is no alternative but to process and preserve the above spices.

Normally onion is cultivated during the Robi season (October-February) in Bangladesh. But from 2001-02 it is also grown in summer season. There are three varieties developed by Spices Research Center (SRC) of Bangladesh Agriculture Research Institute (BARI) known as BARI piaz -2, BARI piaz -3 and BARI piaz -5 which are being grown in summer season. The yield of these varieties is 4-5 times higher than that of winter onion, but their shelf life is very poor.

In Bangladesh onion is mainly used as spices and occasionally used as salad to increase the palatability of meal. It is used in various ways in all curries, fried or baked. In developed countries it is also used in processed form eg. flakes, powder, paste, crush and pickles. In USA, Japan etc. about 45% of entire output of fresh onion is dehydrated and sold to the food processors for use in salad, tomato products, biryani and in several meal preparation (Pruthi, 1998). Further, raw onion is used for the manufacture of onion powder, onion chip, onion fry, onion bread, onion becon etc. which are being increasingly available in the American and Asian market. It is also being used in different food preparation notably in chutney, pickles, curried vegetables, meat preparation, tomato ketchup and the like (Pruthi, 1998).

Onions are available in large quantity during the harvesting season. As a result about 40-50 percent post-harvest loss is observed in winter onion during storage. The situation is even worse for the summer onion which can not be kept more than 15-30 days. The losses include decay or rotting, sprouting, physiological loss of weight, splitting of bulbs, discoloration, shrinkage, descaling and rooting (Bhonde, 2008).

Ginger is important cash and one of the principal spice crops all over the Bangladesh and world. India is its largest producer, consumer and exporter in the world (Pruthi, 1998). Ginger of commerce is the dried rhizome prepared from the fresh rhizomes. It plays a significant role in earning valuable foreign exchange. It is marketed in different forms such as raw ginger, dry ginger, bleached dry ginger, ginger powder, ginger oil, ginger oleoresin, gingerale, ginger candy, ginger beer, brined ginger, ginger wine, ginger squash, ginger flakes, etc. Chinese ginger is usually not exported as a dried spice, but preserved in sugar syrup or converted into 'ginger candy'.

Ginger is seasonal in also nature and available in large quantities during the peak season in the local market. But due to higher water activity (a_w), ginger cannot be kept for longer time after harvesting. Ginger is normally stored in pit but within few days sprout and roots are found. In this situation the farmers do not sell them without removing sprout and rooting part from ginger. That's why additional labour cost is required. Sometime decay or rotting is found due to higher moisture in pit. But if ginger is kept out of pit it become shrivel within few days. In this case the farmers do not get good price. If spoilage/postharvest losses could be reduced to an acceptable level by proper processing/preservation; farmers would get proper price of their products and thus be encouraged to increase yield and production

Dehydrated garlic being very economical yields a powder of better colour, flavour and pharmaceutical value or antibacterial activity. About 20-25% of the fresh crop is wasted due to respiration, transpiration and micro-biological spoilage due to lack of proper storage and transport facilities (Pruthi, 2001). Thus, if the surplus crop could be conveniently and economically use into the production of garlic powder/garlic slices by improve technique, a considerable national waste could be reduced. Particularly in the glut season this will also assist in regulating the market price. All undersized or culled but healthy bulbs, which normally fetch a very low price in the market, could be conveniently utilized in the manufacture of dehydrated garlic slices. Dehydrated garlic slice/powder could also save the bothering of peeling garlic every day and thus save our valuable time. Given the necessary publicity, garlic powder/slice may prove very handy to the house wife for ready to use both as condiment and as folk medicine. It also has bright future possibilities for export purposes.

Onion/ginger/garlic can be preserved for long duration using chilling/freezing, drying and osmotic dehydration. However, chilling/freezing is a costly method and requires availability of cold storage. For long term preservation drying is considered to be the better option for developing countries like

Bangladesh. Such preservation would reduce wide fluctuation of prices in peak harvesting and in the off season. Drying would reduce the volume and minimize transportation cost so that consumer will get good quality product at better price.

Proper drying techniques as well as proper slice thickness of product are required for obtaining good quality dried products. Drying of onion/ginger/garlic is carried out by open sun drying, solar or mechanical drying. Thus, it is important to know the drying characteristics of this crop. The drying rate of these spices is closely associated with the drying air temperatures, relative humidity and air velocity. One of the most important criteria of food is colour. Undesirable changes in the colour of food may lead to a decrease in consumer's acceptance as well as market value. Hence, it is necessary to dry spices in a suitable environment to produce good quality stable dried products. The efficiency of drying system can be improved by the analysis of the drying process.

Onion, garlic and ginger are major spice which is regularly used in our daily food preparation at large amount. The total production of these spice was 14.6 lakh metric ton (BBS, 2012-13) and the demand is about 27.23 lakh metric ton on the basis of 44.5 g daily requirement per person per day. Due to increasing population, demand of cereal food increased largely. To mitigate this demand, the land of spices crop come to under cereal food crop cultivation. For this reason, the total demands of various spices are increasing in incremental rate. Due to decreasing production and increasing demand of spices a big gap was observed between production and demand now. To meet up this gap the country has to spend a huge amount of foreign currency (about 2000 crore taka) in every year for importing onion, garlic and ginger from abroad. On the other hand due to perishable nature of these spices a big portion of post-harvest losses observed in onion, garlic and ginger. Unfortunately, up till now there are no remarkable technologies to minimize these losses. Though different private food industries showed their efficiency for chilli, turmeric and some other minor spices processing.

So, we need to take all out measures to reduce the losses /spoilage to an acceptable level by processing and preservation of onion, garlic and ginger. Moreover, such measures would reduce spoilage of these spices to meet the shortfall. This will be paved the way for commercial production of processed onion, garlic and ginger from raw condition with its natural colour and flavour with a potential prolong shelf life. These processed products may find its extensive use in the home as well as in the catering centers such as hotels, restaurants, canteens, hospitals, nursing home, prisons and other establishment. Higher incomes and more active life styles in Bangladesh, in recent years, have resulted in consumers seeking high quality, convenient food items in the markets. The prepared processed products, for its anticipated widespread use, may help to fill the needs of consumers for convenient food ingredient. This study will open up further possibilities for the production of other food processing unit.

7. Sub-project goal:

Increase income of the stakeholders and to improve their livelihood through processed products as well as reducing post-harvest loss and import cost

8. Sub-project objective (s):

i) To identify post-harvest practices and to determine the post-harvest losses of onion, garlic and ginger in farmers field

ii) To study storage stability and determine organoleptic acceptability of developed products

iii) To minimize the post- harvest losses and optimize process parameter to obtain high quality process products of onion, garlic and ginger

9. Implementing location (s): Spices Research Center, BARI, Shibganj, Bogura

10. Methodology in brief:

Study-1: To investigate the post-harvest practice and determine the post-harvest loss of onion, garlc and ginger in farmers field

The project was conducted from Spices Research Center (SRC) of Bangladesh Agricultural Research Institute (BARI), Bogura. For survey work principle investigator (PI) has been visited some spices potential area. Due to short duration of project six districts have been selected among fifteen for survey work. These are Lalmonirhat (with *Chhitmohol*), Rajshahi, Pabna, Faridpur, Chittagong and Khagrachhari. The present study has under taken to determine the post-harvest losses by collecting data from the farmers of different onion, garlic and ginger growing areas using structural questionnaires. Before visit for survey a pretested questionnaire was prepared by PI. After interviewed of farmers many information were found regarding pre and post-harvest practices of onion, garlic and ginger. Among six districts Rajshahi, Pabna, Faridpur are famous for onion and garlic. On the other hand Lalmonirhat, Chittagong and Khagrachhari are famous for ginger. Through this study pre and post-harvest practices and post-harvest losses of onion garlic and ginger in farmer's field were identified.

Study-2: Value added products development from onion, garlic and ginger

Uniform size onion, garlic and ginger were first sorted to remove infested ones and then washed in running tap water thoroughly. The samples were peeled manually with stainless steel knife and sliced in cross-section wise using electric slicer. The sliced samples were divided into five parts. T_1- Soaking in 1500ppm NaMS for 6hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm NaMS for 6 hr and dried, T_5- Without pretreatment dried (Control). The treated and non treated samples were spread on trays and dried in a mechanical drier at 60^0C until 6-8% mc (wb). Thus optimize process products from onion, garlic and ginger were obtained.

Raw material receiving

↓

Cleaning

↓

Sorting/Grading

↓

Removal the skin, roots and tops

↓

Chopping/Slicing (3/5mm thick)

↓

Blanching 10 min in steam

↓

Sulphiting (with 1500ppm $K_2S_2O_5$ for 6hr.)

↓

Draining

↓

Keeping in salt solution for osmosis (10% salt solution, 6 hr.)

↓

Placing the slices to a perforated pot to remove water

↓

Spreading the slices on tray with polythene paper

↓

Drying (60-65^{0}C) in mechanical dryer up to 6-8% moisture content

↓

Grinding

↓

Cooling in room temperature

↓

Packaging (HDPE / Foil / Plastic pot /Tin container)

↓

Store in refrigerator (5-10^{0}C) or room temperature

Fig 1 Flow-sheet for processing of onion slice/powder

Raw material receiving

↓

Cleaning

↓

Sorting/Grading

↓

Peeling

↓

Chopping/Slicing
(Only ginger will be sliced 5mm thick)

↓

Blanching 10 min in steam in case of low pungent powder

↓

Sulphiting (1500ppm $K_2S_2O_5$ for 6hr.)

↓

Washing

↓

Placing the slices to a perforated pot to remove surface water

↓

Spreading the slices on tray with polythene paper

↓

Drying (60-65^{0}C) in mechanical dryer up to desire moisture (6- 8%)

↓

Grinding

↓

Sieving

↓

Cooling

↓

Packaging (HDPE/ Foil/Plastic pot)

↓

Store in refrigerator (5-10^{0}C) or room temperature

Fig.2 Flow-sheet for processing of garlic and ginger powder

Study-3: Drying kinetics of summer onion, garlic and ginger

Drying can be accomplished in a mechanical dryer, direct sunlight or solar dryer. In the mechanical dryer, desired temperature and airflow could be maintained. Compared to sun/solar drying higher airflow and temperature can be used in mechanical drying. This leads to high production rates and improved quality products due to shorter drying time and reduction of the risk of insect infestation and microbial spoilage. Since mechanical drying is not dependent on sunlight so it can be done as when necessary. The overall objective of this research work was to study drying kinetics of above treated and non treated spices using mechanical dryer in respect of thickness and temperature on drying time. Moisture content at each time interval will be determined gravimetrically on the basis of initial moisture content and weight loss will be used as a measure of the extent of drying. To analyze the experimental data, Fick's 2nd law of diffusion will be used (Brooker *et al*., 1974; Islam, 1980).

Ficks second law of diffusion is applied to describe mass transfer during drying since food dehydration is assumed to be a diffusion process. The expression is:

$$\frac{\delta M}{\delta t} = \Delta^2 D_e M \text{ ------------------------------------ } (1)$$

Where,

M= Moisture content (dry basis), t= Time (s) and

D_e= Effective diffusion co-efficient (cm^2/s)

To find a solution of the above unsteady state diffusion equation for one dimensional transport for the case of initial uniform moisture distribution in the sample and negligible external resistance, appropriate boundary conditions are assumed: The solution for an infinite slab (with thickness,l), when dried from one major face (Brooker *et al.*, 1974; Islam, 1980 and Crank, 1975) is:

$$MR = \frac{M_t - M_e}{M_o - M_e} = \frac{8}{\pi^2} \sum_{n=0}^{\alpha} \frac{1}{(2n+1)^2} Exp \frac{-(2n+1)^2 \pi^2 D_e t}{l^2} \text{ ------------ } (2)$$

Where, MR= Moisture ratio, M_t, M_o and M_e are the moisture content at the time t, initial moisture content and equilibrium moisture content respectively. For situation when product is dried from both major faces. l is replaced by $4L^2$ and L is defined as half thickness of the product.

Semi theoretical drying equations

For low M_e values and for moisture ratio, MR<0.6 equation (1) reduces to:

$$\frac{M_t}{M_o} = \frac{8}{\pi^2} e^{-\pi^2 D_e t / l^2} = \frac{8}{\pi^2} e^{-mt} \text{ ----------------------------(3)}$$

Where, m = $\frac{\pi^2 \; D_e}{l^2}$ = drying rate constant, s^{-1}-------------------------------------(4)

Re-arranging above equation gives:

$$In \frac{M_t}{M_0} = In(\frac{8}{\pi^2}) - mt \text{ -------- ----------------------(5)}$$

Consequently, a straight line should be obtained when plotting L_n MR versus time (t). The slope of the regression line is the drying rate constant, m for which the effective diffusion co-efficient, D_e is calculated.

Diffusion coefficient and activation energy

The diffusion co-efficient, D_e has an Arrhenius type of relationship with drying air dry bulb temperature (T_{abs}).

The relationship is as follows (Heldman, 1974):

$$\frac{dInD_e}{dT_{abs}} = \frac{E_a}{RT_{abs}}$$

Or,

$$\ln D_e = \ln D_0 - \frac{E_a}{RT_{abs}} \text{ ---------------------------------(6)}$$

Where, D_o is constant equivalent to the diffusivity at infinitively high temperature (m^2/s), E_a is the activation energy of diffusion of water (cal/g-mole), R is the universal gas constant (cal/g-mole ^{o}k) and T_{abs} is the absolute temperature, ^{o}k.

From equation (1), it is apparent that plotting diffusion co-efficient (D_e) versus the inverse absolute temperature on semi-logarithmic co-ordinates would lead to the evaluation of activation energy for diffusion of moisture during drying and activation energy could be calculated by non-linear regression analysis.

From the semi-theoretical equation, it may be noted that the drying rate constant, m is a function of the square of thickness of the product dehydrated, as, $m = \frac{\pi^2 D_e}{L^2}$

Symbolically, this may represented as:

$m = A(L)^{-n}$

Or log(m) = log A – n log (L)--(7)

Where, $A = \pi^2 D_e$, n = 2

The above relationship shows that if external resistance to mass transfer is negligible and if simultaneous heat and mass transfer effects are taken into account, the value of the exponent of the power law equation should be 2. But the above conditions are not always satisfied and experimentally determined 'n' value is found to be less than 2 (Islam, 1980).

Study-4: Effect of Packaging material on storage stability of dehydrated onion, garlic and ginger products

This study was conducted to select the best packaging material for dehydrated onion, garlic and ginger products in respect to weight ratio/moisture gain. The dehydrated onion slices were packed in Aluminum foil, ALF (0.08mm), Poly bag, PB (0.09mm), Poly bag, PB (0.03mm) and Plastic pot PP (1.75mm). This packets were stored at room temperature (RT) (10^0C) and refrigeration temperature (RFT) (5 ± 2^0C) at RH of 50-90% up to 360 days for storage study.

The weight of different dehydrated products were determined gravimetrically at different time interval and weight ratio (W_t/W_o) was calculated by dividing sample weight at any time (W_t) by the samples initial weight (W_o).

After getting dehydrated products it will packed using different type packing materials. The packed product will store for at least 6 months in different temperature.

Study-5: Nutritional study of fresh and dehydrated onion, garlic and ginger products

The experiment was conducted jointly in the laboratories of Spices Research Center, Bogura, Post-harvest laboratory and Soil Science laboratory of BARI, Gazipur, BCSIR laboratory, Dhaka. Moisture, fat, protein, fibre, vitamin C and ash/minerals of fresh and dehydrated onion, garlic and ginger were determined according to reported procedure of Rangana (1986). The main aim of this experiment was to determine and compare the nutrient content of fresh, dehydrated, osmosed and sulphited spices.

5.1 Moisture content

Procedure

At first, the weights of 3 empty dry crucibles will be taken and 5 g of samples will be taken in each dried crucible. Then the crucibles with samples will be dried in a hot air oven at 55^0C till constant weight obtained. The crucibles should be cooled in desiccators and weighed soon after reaching room temperature. The losses in weight will be taken as the moisture loss of the samples and the percent of moisture in the samples will be calculated as follows (AOAC, 2000):

$$\%\,\text{Moisture} = \frac{\text{Loss of weight}}{\text{Weight of samples}} \times 100 \qquad \text{-----------------------(1)}$$

5.2 Fat Content

Procedure

The dried sample remaining after moisture determination will be transferred to a thimble and plugged the top of the thimble with fat free cotton. The thimble will be dropped into the fat extraction tube of a Soxhlet apparatus. The bottom of the extraction tube should attached to a Soxhlet flask. Approximately 75 ml or more of anhydrous ether will be poured into the flask. The top of the fat extraction tube will be attached to the condenser. The sample might be extracted for 16 hours or longer on a water bath at 70 to 80^0C. The water bath will be regulated so that the ether which volatilized will be condensed and dropped continually upon the sample without any appreciable loss. At the end of the extraction period, the thimble will be removed from the apparatus and most of the ether may be distilled off by allowing it to collect in the Soxhlet tube. The ether will be poured off when the tube will nearly full. When the ether will be reached a small volume, it was poured into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask would be rinsed and filtered thoroughly using ether. The ether was evaporated on a steam bath at low heat. It will then be dried at 100^0C for 1 hour, cooled and weighed. The difference in the weights will be the ether-soluble material present in the sample. This process will be followed for the determination of fat content of all types of samples. The percent of crude fat may be expressed as follows(AOAC, 2000):

$$\%\,Crude\,fat = \frac{Weight\ of\ the\ ether - Soluble\ material}{Weight\ of\ sample} \times 100$$ -------------------------(2)

5.3 Protein Content

Reagent required :

1. Concentrated H_2SO_4 (Nitrogen free)
2. Digestion mixture. (Potassium Sulfate = 100g,Copper sulfate = 20g and Selenium di-oxide = 2.5g)
3. Boric acid solution= 2% solution in water.
4. Alkali Solution = 500g sodium hydroxide dissolved in water and diluted to 1 liter.
5. Mixed indicator solution = Bromocresol green 0.1 g and Methyl red 0.02 g dissolved in 100 ml ethyl alcohol.
6. Standard HC1= 0.01 N

Procedure

Two gm of sample will be taken in three 250 ml Kjeldahl flask. 2 g of digestion mixture and 25 ml of concentrated sulfuric acid (H_2SO_4) will be added in each flask. The flasks will be placed in inclined position on the stand in digestion chamber and might be heated continuously until frothing ceased and then simmered briskly. The solutions will be become clear in 15 to 20 min., continued heating for 45 min. After cooling, 100 ml water will be added in both flask. Enough NaOH solutions will be added gently down the side to form precipitates at cupric hydroxide and immediately connected to a stream-trap and condenser. In each of three 500 ml conical receiving flasks, 50 ml of boric acid solution, 50 ml distilled water and 5 drops of indicator solution will be added. Positioning the condenser, distillation will be carried out for 40-50 min. or until about 250 ml of distillate may be obtained for each sample. The contents of the receiving will be titrated against hydrochloric acid solution, the end points will be marked by a pink color and the readings for blank sample will also be determined and deducted from the titration.

A Protein conversion factor will be used to calculate the per cent protein from nitrogen determination. Percentage of nitrogen and protein may be calculated by the following equation (AOAC, 2000):

$$\% \, Nitrogen = \frac{(T_s - T_b) \times Normality \; of \; HC1 \times M_{eq} .of \; N_2}{Weight \; of \; Sample \, (in \, g)} \times 100$$ --------------------(3)

Where,

Ts = Titer volume of the sample (ml), T_b = Titer volume of the blank (ml), M_{eq}. of N_2 = 0.014

% Protein = % Nitrogen × Protein factor

5.4 Fibre

Procedure

Two gm weighed sample will be taken into a 1000 ml conical flask. 200ml boiling H_2SO_4 solution should be added and connected with a reflux condenser and heated. The volume of content of the flask will be marked with a glass pencil to observe any loss in volume and to recover this volume by adding water. The conical flask should heated to boil the content exactly for 30 minutes. At the expiration of 30 minutes, the flask will be removed and the content will be immediately filtered through a filter paper and washed with boiling water until the washing will be acid free. The residue will be transferred into the 1000 ml conical flask by making a hole in the filter paper and then washing the residue with 200ml of boiling NaOH solution. The flask will be connected with reflux condenser and the content boiled exactly for 30 minutes. Proper care should be taken so that there will be no loss of volume of the content. After the end of alkali digestion, the content of the flask will be immediately filtered through gooch crucible (using buchner funnel) with thin but close layer of asbestos. After thorough washing with boiling water, the residue should also washed with alcohol (3 times) and ether (2 times). The gooch crucible should heated in an oven at 100^0C for 4 hrs, cooled in desiccators and weighed. The material will be again heated at 55^0C for 4 hrs. and weighed. The drying and weighing process was continued until constant weight was achieved (AOAC, 2000).

$$\% \, Fibre = \frac{Loss \; in \; weight \; noted}{Weight \; of \; sample \; taken} \times 100$$ --(4)

5.5 Vitamin C

Procedure

Ten gm sample will be blended and homogenized in a blender with 3% metaphosporic acid solution. The homogenized liquid was transferred to a 100 ml volumeric flask and made to volume 100ml with metaphosphoric acid solution. Content of the flask should then thoroughly mixed and filtered. Then 5ml of the aliquot will be taken in a flask and titrated with 2-6 dichlorophenol indophenol dye. The dye will be standardized with vitamin C solution to find an equivalent dye factor. The ascorbic acid content of the samples will be calculated from the following formula (AOAC, 2000):

$$\text{mg vitamin C/ 100g} = \frac{TDV_1}{V_2 W} \times 100 \qquad \text{--(5)}$$

Where, T= Titre, D= Dye factor, V_1 = Volume made up, V_2 = Aliquot of extract taken for estimation, W = Weight of sample taken for estimation

5.6 Ash/Minerals Content

Procedure

Two gm of each sample will be taken in dry, clean porcelain dishes and weighed accurately. Moistures of each sample should be removed using hot air oven method. Then the samples will be burnt on an electrical heater. These will be done to avoid the loss of sample in the muffle furnace under higher temperature. Then the samples will be transferred into the muffle furnace and burnt at 550^0C temperature for 4-6 hours and ignited until light gray ash resulted (or to constant. weight). Then the samples should be cooled in desiccators and weighed. The ash contents will be expressed as (AOAC, 2000):

$$\%\,\text{Ash} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100 \qquad \text{---(6)}$$

5.6.1 Minerals analysis

Preparation of samples: One gm sample will be taken and then ground and poured in digestion tube. Five ml analytical grade H_2O_2 and 5ml HNO_3 should be added and the sample will be allowed to stand overnight. The following day, the tube will be placed on a heating block and heating should be continued for 2-4hr and the temperature will be slowly raised to 125^0C. In some cases more time is required for clear solution. Thereafter, the tube will be allowed to cool at room temperature. After cooling the volume will be made 100 ml with distilled water and then stored in plastic bottle.

Plant Properties	**Methods**
Na, K	Digesting the samples in di-acid mixture (HNO_3- $HCIO_4$) and determined directly by flame photometer (Yoshida *et al.*, 1976)
P	Digesting the samples in di-acid mixture (HNO_3- $HCIO_4$) and determined colorimetrically using molybdovanadate solution yellow colour method (Yoshida *et al.*, 1976)
Zn, Fe	Digesting the samples in di-acid mixture (HNO_3- $HCIO_4$) and determined directly by atomic absorption spectrophotometer (Yoshida *et al.*, 1976)
Ca, Mg	Ca, Mg concentration in the extract will be determined by flame photometer as outlined by Knudsen *et al.* (1982)

5.7 Total Carbohydrate Content

Total carbohydrate content of the samples will be determined as total carbohydrate by difference that is by subtracting the measured moisture, fat, protein, fibre and ash/minerals content from 100.

Study-6: Sensory Evaluation of dehydrated onion, garlic and ginger products

The aim of this investigation is to evaluate the sensory quality of dehydrated onion, garlic and ginger and their sensory response in beef curry compared to same fresh spices sample.

A panel of 25 judges evaluated the colour, smell/flavor, pungency, texture, taste and overall acceptability of the dehydrated spices with or without pretreatment. The evaluation was conducted after

12 months of storage since most of the samples remained in good condition during this period. The following samples were subjected to sensory evaluation at room temperature after 12 month of storage: T_1- Soaking in 1500ppm NaMS for 6hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm NaMS for 6 hr and dried, T_5- Without pretreatment dried (Control). All treated and untreated samples were dried at 60^0C to moisture content corresponding to 0.65 $a_{w.}$

Among the five samples (which were mentioned above) one sample (T_4- Steam blanching for 10 min + Soaking in 1500ppm NaMS for 6 hr and dried) was carried out to compare the sensory quality of the dehydrated spices in beef curry with the fresh spices sample of same variety.

The acceptability of developed products were evaluated by a 25 member taste-testing panel using 1-9 hedonic scale (Pawar *et al*., 2011). The panelists were selected from BARI scientist, Ph.D and M.S. student of BAU, Mymensingh. The members are experienced in such evaluation and additionally they were consulted in determining appropriate quality attributes as well as briefed before evaluation. Thus the panel may be termed as expert panel as used for organoleptic evaluation of dehydrated potato products (osmosed and nonosmosed) by Islam and Flink (1982b).

The scale was arranged such that:
9=Like extremely, 8=Like very much, 7=Like moderately, 6=like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much and 1=Dislike extremely

Each judge gave a score for the individual factor by the method described in and recorded his/her observation in the score sheet. The data obtained were analyzed as per analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) to ascertain whether there is significant difference (0.01) among samples (Gomez and Gomez, 1984).

The dehydrated products will use in curry for sensory evaluation. Normally onion, garlic, ginger are used in curry in fresh condition. Through using these dehydrated products if we get same score or near about same score from sensory evaluation in respect of fresh onion, garlic and ginger, the project study seem to be success.

11 Results and discussion:

Study-1 : To know the post-harvest practice and determine the post-harvest loss of onion, garlc and ginger in farmers field

A lot of farmer's field visited in Faridpur, Lalmonirhat, Rajshahi, Pabna, district to know the post-harvest practice and determine the post-harvest loss of onion, garlc and ginger in farmers field. A questionnaire was prepared on harvest and post-harvest practice of onion, garlic and ginger. The questionnaire was filled up through farmers opinion during visiting time. Normally onion and garlic are stored in celling of house. The ceiling is made of bamboo split. The thickness of onion and garlic storing on ceiling is about 4-18 inches. The thickness of onion storing varies on variety to variety. Most of farmers dry whole garlics with plant in sun before storing. After drying in sun they stored garlic making beni with garlic dry leaves and hang with ceiling. Normally ginger is stored in pit (earthen hole). Sometime it is stored in house floor covered with ginger leaves. Most of farmers reported that they stored ginger in pit but within few days sprout and roots are found. That's why additional labour is required when they want to sell ginger. But if ginger kept out of pit it become shrivel within few days. The farmers do not have the accurate data on the post-harvest losses of onion, garlic and ginger. But they assume that the losses become 20-40%. The post- harvest losses of onion, garlic and ginger include sprouting, decay or rotting, physiological loss of weight, splitting of bulbs, discoloration, shrinkage and rooting. In case of summer onion (which onion produce in our country in rainy/summer season) the losses become 70-80% or more than that.

Study-2: Value added products development from onion, garlic and ginger

The onion and ginger slices and garlic cloves were treated in five ways. i) T_1- Soaking in 1500ppm NaMS for 6hr and dried; ii) T_2- Soaking in 10% salt solution for 6 hr and dried; iii) T_3- Steam blanching for 10 min and dried; iv) T_4- Steam blanching for 10 min + Soaking in 1500ppm NaMS for 6 hr and dried and v) T_5- Without pretreatment dried (Control). After final drying and crushing steam blanched onion, garlic and ginger followed by soaking in NaMS solution (T_4) was more acceptable than others. Later T_4 was used for drying kinetics with different temperature and thickness, packed in different type packaging materials and finally used for sensory evaluation in beef curry.

Study-3: Drying kinetics of summer onion, garlic and ginger

3.1 Effect of thickness on drying time of onion slice

To determine the influence of thickness on drying behavior 3, 5 and 7 mm of onion slices were dried at a constant air dry bulb temperature (60^0C) and at constant air velocity in a cabinet dryer. The results were analyzed by using equation 1 and moisture ratio (MR) versus drying time (hr) was plotted on a semi-log graph paper and regression lines were drawn (Fig.1). For the three different thickness of samples, the following regression equations were developed:

$MR= 1.0888e^{-0.8584t}$ (for 3 mm, t=hr)-------------------------------------- (8)
$MR = 1.0631e^{-0.5084t}$ (for 5mm, t=hr)---(9)
$MR= 1.0026e^{-0.2885t}$ (for 7 mm,t=hr)-------------------------------------- (10)

The effect of different slice thicknesses on drying time is shown in Fig. 1 for onion. The drying process took place in the falling rate period and no constant rate period was observed from the drying curves. From Fig.1 it was also observed that thickness had profound influence on drying time and as the thickness of the samples increased, the drying time to a specific moisture ratio also increased with resultant decrease in drying rate constant.

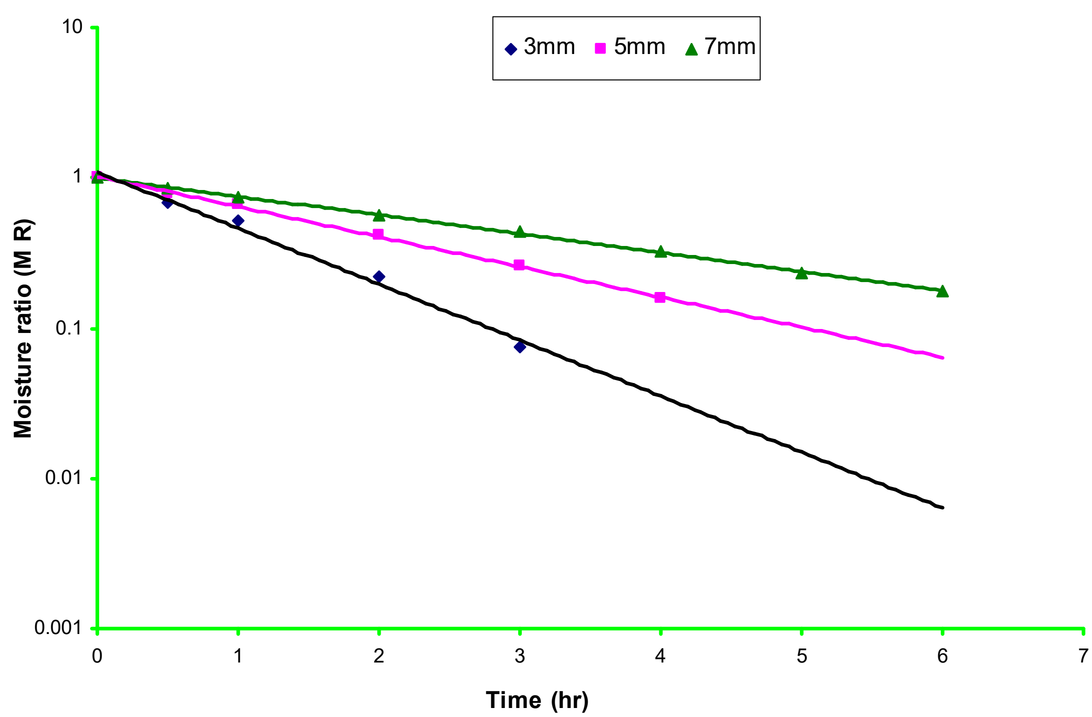

Fig.1 Influence of thickness on drying rate of onion slice

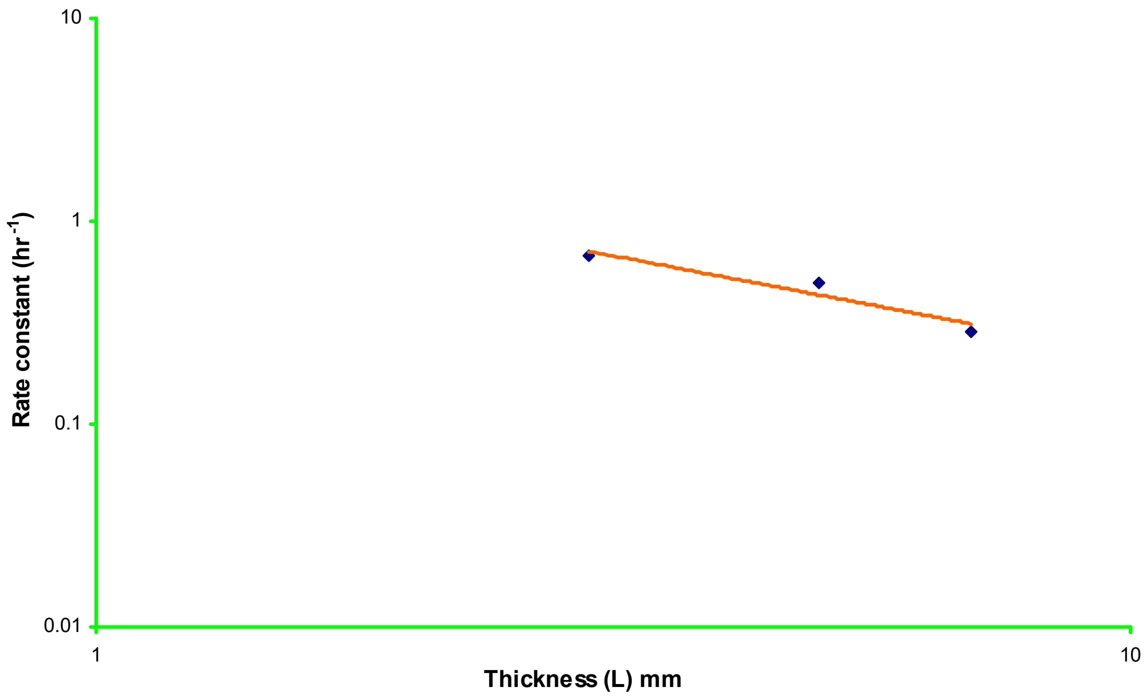

Fig. 2 Influence of thickness on drying rate constant of onion slice

It was also noticed that for a specific moisture ratio (MR = 0.1) 3 mm thick slice required the least time (3.78 hr), followed by 5 mm thick slice (4.7hr), while the highest time (8.0 hr) was required to dry 7 mm thick onion slice. From the developed equations (8 to 10), it is clearly seen that the rate constant decreases with the increase in slice thickness. The decrease in rate constant, however, does not maintain linear proportionality with slice thickness.

The drying rate constants obtained from equation 8 to 10 for each sample thickness were plotted (Fig.2) against sample thickness on log-log co-ordinates as per equation (2) to determine the thickness dependence of rate constants.

The relationship is represented by a power law (regression) equation which follows as;

$m = 3.6037L^{-1.277}$--(11)

Where,

m= drying rate constant (hr^{-1})

L= sample thickness (mm)

From equation 11 it is seen that value of index ‘n’ of the power low equation is 1.277. This value is quite lower than 2 as predicted by Fick’s unsteady state equation (3) indicating that the external resistance to mass transfer was highly significant and internal resistance to mass transfer did not control the drying process under the given conditions. This conditions resulted primarily due to low airflow rate (<1 m/s), since similar samples did not indicate the presence of external mass transfer resistance under conditions of high air velocity (>2 m/s) as noted by Islam and Flink (1982 b). Islam (2003) found an n value of 1.57 for mechanical drying of indigenous varitey of onion and Hai (2002) found 0.49 for banana using similar air velocity (0.6m/s). Kamruzzaman (2005) dried aroids under similar conditions and found ‘n’ value of 1.15. Islam (1980) found an ‘n’ value of 1.70 while drying potato using significantly higher airflow rates (2.5 m/s). The above discrepancy of ‘n’ values is primarily due to airflow rate and thickness range used and indicates the relative importance of external or internal mass transfer resistance. Internal mass transfer resistance is affected by product thickness, structure and composition. Simultaneous heat and mass transfer effects also play an important role in this regard. Islam (1980) while working with potato, showed that by taking into account of the simultaneous heat and mass transfer effect value of ‘n’ could be corrected to 2 from 1.7. Alzamora *et al.* (1978) using significantly high air velocity (13 m/s) to greatly reduce external mass transfer resistance, found the dependence of drying rate constant to be somewhat lower than the second power of sample thickness and lower value was attributed to simultaneous heat and mass transfer effects.

3.2 Effect of temperature on drying time of onion slice

To determine the influence of temperature on drying time 5 mm thick onion slices were dried in mechanical drier using three different air dry bulb temperatures (52^0C, 60^0C, and 68^0 C). The experimental data were analyzed by using equation (5) and plots of moisture ratio versus drying time were made on semi-log co-ordinate and regression lines were drawn (Fig.3). Accordingly, the following equations were developed:

$MR= 1.0359e^{-0.3367t}$ (for 52^0 C t in hr)---(11)
$MR = 1.0199e^{-0.4611t}$ (for 60^0C t in hr)--- (12)
$MR= 1.0399e^{-0.513t}$ (for 68^0 C t in hr)---(13)

From Fig (3) and the developed equation (11 to 13) it is clearly seen that when temperature is increased, drying rate constant is also increased. The drying time to a specific moisture ratio was decreased with the increase in drying temperature at constant sample thickness. As a result drying rate constant increased with increasing temperature. It was also noticeable that for a specific moisture ratio, the least drying time was achieved at 68° C, followed by 60°C, while the highest drying time was required at 52°C to dry 5 mm onion slice. The results are in agreement with Islam (1980), Tulek(2011) and Olawale and Omole (2012).

From the drying rate constant, the diffusion co-effcients were calculated. By plotting diffusion co-efficient (D_e) versus inverse absolute temperature ($1/T_{abs}$) in a semi-log scale (as per equation 6) a regression line was drawn (Fig 4). The equation of the straight line can be represented as (Fig. 4).

From the slope of the resultant straight line, activation energy (E_a) for diffusion of water was calculated and found to be 5.91 kcal/g mole. This finding is in agreements with the results of Islam (2003). He stated that the activation energy (E_a) for diffusion of water for Bangladeshi and Indian onion slices were found to be 5.44 and 6.81 kcal/g mole respectively. Kamruzzaman and Islam (2006) found similar E_a value (5.12 kcal/g mole) for aroids. Tulek (2011) also reported that the activation energy (E_a) for diffusion of water from oyster mushroom (an important vegetable) was found to be 5.32 kcal mol^{-1} while Rahman *et al.* (2008) and Rahman *et al.* (2009) found E_a for tomato to be 23.74kcal/g-mole and for cabbage to be 16.24 kcal/g-mole respectively. The differences in activation energy value from product to product are attributed product characteristics and process parameters as noted by Villota and Hawkes (1992) and Kamruzaman and Islam (2006).

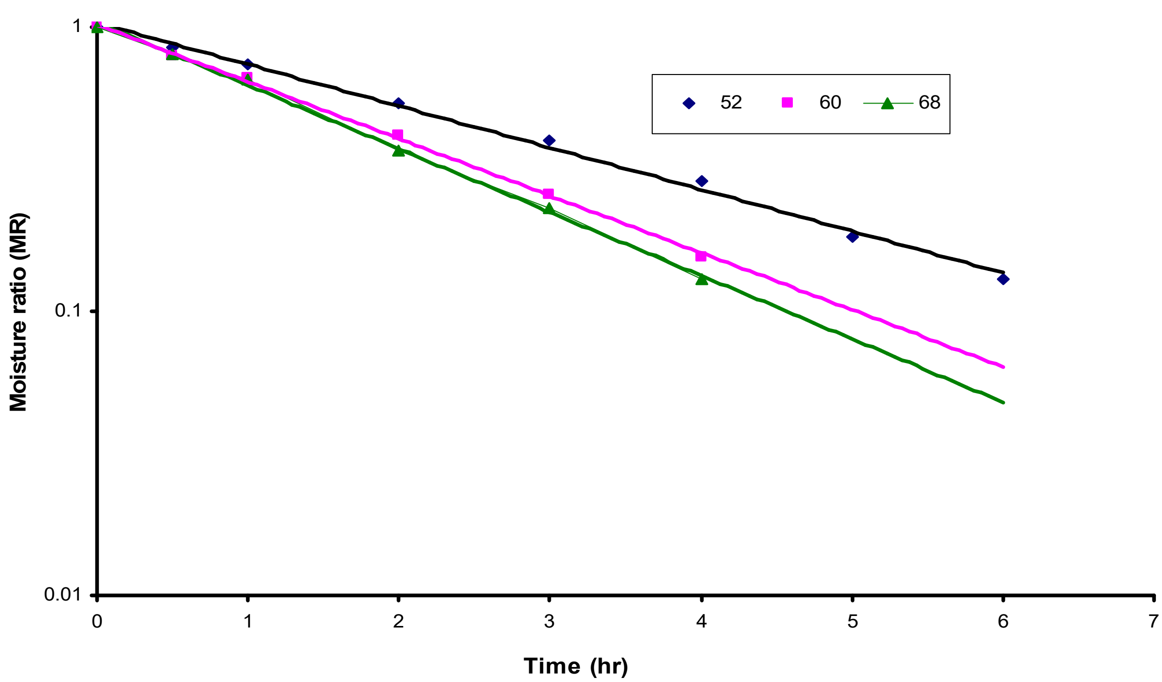

Fig. 3 Influence of temperature on drying rate of onion slice

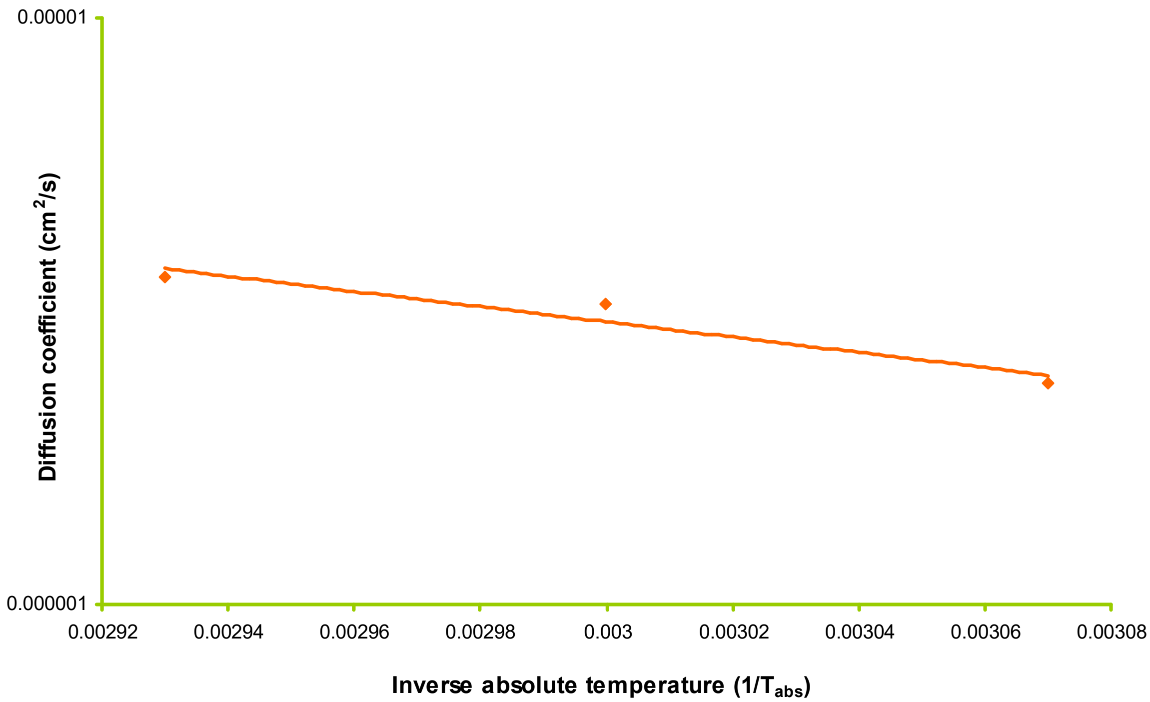

Fig. 4 Influence of temperature on diffusion coefficient of onion slice

$De = 0.0235e^{-2985.81/T_{abs}}$ --(14)

Where,

De = Diffusion co –efficient (cm^2/s)

T_{abs} = Absolute temperature ^0K

3.3 Effect of thickness and temperature on drying time of garlic cloves

To determine the influence of thickness on drying behavior 3, 5 and 7 mm of garlic slices were dried at a constant air dry bulb temperature (60^0C) and at constant air velocity in a cabinet dryer And to determine the influence of temperature on drying time 5 mm thick garlic slices were dried in mechanical drier using three different air dry bulb temperatures (52^0C, 60^0C, and 68^0 C). The results were analyzed by using equation 1 and moisture ratio (MR) versus drying time (hr) was plotted on a semi-log graph paper and regression lines were drawn. For the three different thickness of samples and different temperature the following regression equations were developed:

$MR = 1.0135e^{-0.2885t}$ (for 3 mm, t=hr)-- (15)

$MR = 1.0178e^{-0.2345t}$ (for 5mm, t=hr)--(16)

$MR = 1.0215e^{-0.1902t}$ (for 7 mm,t=hr)--(17)

To determine the thickness dependence of rate constants the relationship is represented by a power law (regression) equation which follows as;

$m = 0.0033L^{-0.48}$--(18)

$MR = 1.0162e^{-0.3734t}$ (for 52^0 C t in hr)--(19)

$MR = 1.0178e^{-.2345t}$ (for 60^0C t in hr)---(20)

$MR = 1.0086e^{-.186t}$ (for 68^0 C t in hr)--(21)

From the rate constants of the above equations, diffusion coefficients were calculated as before. The dependence of diffusion co-efficient on absolute temperature as per equation can be represented as:

$D_e = 0.088e^{3542.1/T_{abs}}$ --(22)

The activation energy was calculated as previous method as described for onion and the value of activation energy for diffusion of water from garlic cloves was found 7.87 kcal/g -mol. Khurshed (2002) found activation energy 7.04 and 8.07 kcal/g-mol for diffusional of water from Bangladeshi and Indian garlic. The differences in activation energy value may be attributed to the differences in chemical constituents and structure of the raw material undergoing drying (Islam, 1980).

3.3. Effect of temperature on drying time of ginger slices

To determine the influence of temperature of drying time, 5 mm thick ginger slices were dried in a mechanical drier using three different air-dry bulb temperatures (52^0C, 60^0C and 68^0C). The experimental data were analyzed using equation and plots of moisture ratio versus drying time were made on semi-log co-ordinate and the regression lines were drawn. Accordingly, the following equations were developed:

$MR = 0.9943e^{-0.1467t}$ (for 52^0C; t=hr) ----------------(23)

$MR = 1.0538e^{-0.3357t}$ (for 60^0C; t=hr) ---------------(24)

$MR = 1.0155e^{-0.4493t}$ (for 68^0C; t=hr) -----------------(25)

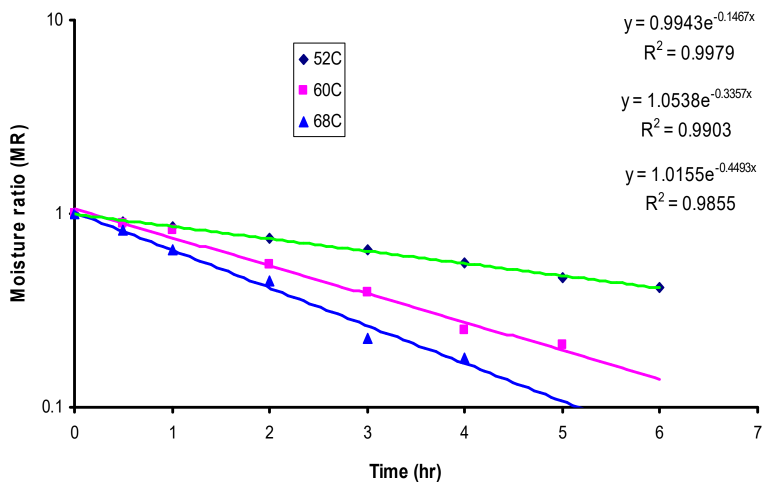

Fig.5 Effect of temperature on drying rate of ginger slices

From Fig (5) and the developed equation (23 to 25) it is clearly seen that when temperature is increased, drying rate constant is also increased. The drying time to a specific moisture ratio was decreased with the increase in drying temperature at constant sample thickness. As a result drying rate constant increased with increasing temperature. It was also noticeable that for a specific moisture ratio, the least drying time was achieved at 68^{o} C, followed by 60°C, while the highest drying time was required at 52°C to dry 5 mm ginger slices. The results are in agreement with Islam (1980) .

From the drying rate constant, the diffusion co-effcients were calculated. By plotting diffusion co-efficient (D_e) versus inverse absolute temperature ($1/T_{abs}$) in a semi-log scale (as per equation) a regression line was drawn (Fig 6). The equation of the straight line can be represented as (Fig.6).

From the slope of the resultant straight line, activation energy (E_a) for diffusion of water for ginger was calculated and found to be 15.868 Kcal/g-mole.

Islam (1980) found 7.7 Kcal/g-mole of activation energy for diffusion of water from potato and Uddin and Islam (1985) found 8.4 Kcal/g-mole for pineapple. Babu *et al.* (1997), however, found higher activation energy (26.83 Kcal/g-mole) for diffusion of water from onion. These differences in activation energy value from product to product are attributed due to product characteristics and process parameters as noted by Villota and Hawkes (1992). The dependence of diffusion coefficient on absolute temperature can be represented as:

$$D_e = 5E + 07\ e^{-7985.9}\ 1/T_{abs}\ \text{------------------}\ (26)$$

Where, D_e=Diffusion coefficient (cm^2/s), T_{abs}= Absolute temperature

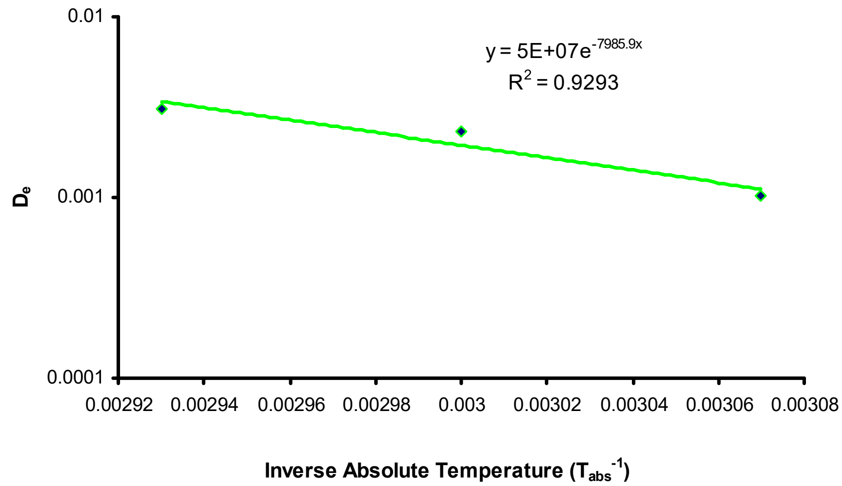

Fig.6 Effect of temperature on diffusion coefficient of ginger slices

3.3. Effect of thickness on drying time of ginger slices

To investigate the influence of thickness of ginger on drying behavior 3, 5 and 7 mm slices were dried at a constant air dry bulb temperature (60^0C) and at constant air velocity in a cabinet dryer. The results were analyzed by using equation and moisture ratio (MR) versus drying time (hr) was plotted on a semi-log graph paper and regression lines were drawn (Fig 7). For the three different thicknesses of samples, the following regression equations were developed:

These are:

$MR=1.0124e^{-0.5512t}$ (for 3mm; t=hr) -------------------- (27)

$MR=1.0538e^{-0.3357t}$ (for 5mm; t=hr) -------------------- (28)

$MR=1.0425e^{-0.315t}$ (for 7mm; t=hr) ------------------------(29)

The effect of different slice thicknesses on drying time is shown in Fig. 7 for ginger. The drying process took place in the falling rate period and no constant rate period was observed from the drying curves. From Fig 7 it was also observed that thickness had profound influence on drying time and as the thickness of the samples increased, the drying time to a specific moisture ratio also increased with resultant decrease in drying rate constant. It is also noticed that for a specific moisture ratio 3 mm thick slice required the least time, followed by 5 mm thick slice, while the highest time is required to dry 7mm thick ginger slices.

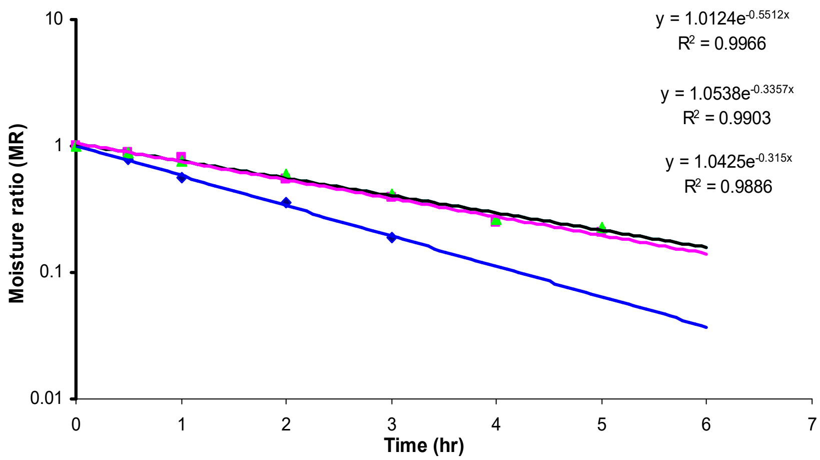

Fig.7 Effect of thickness on drying rate of ginger slices

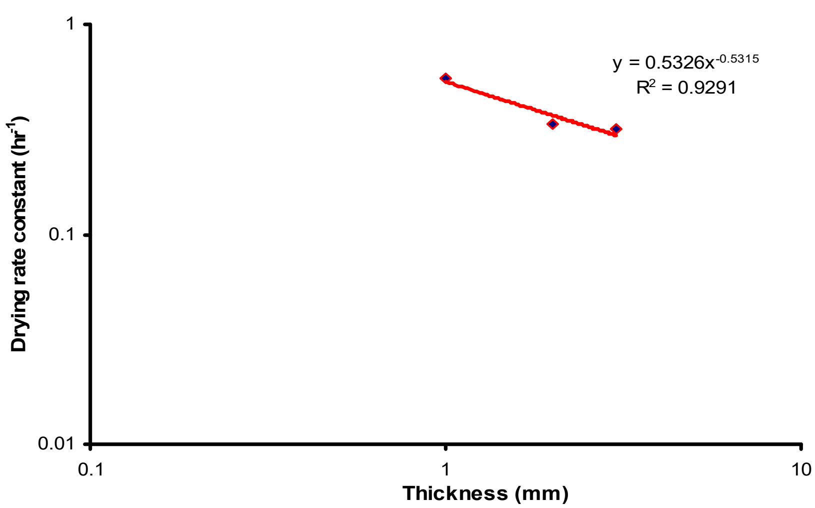

Fig.8 Effect of thickness on drying rate constant of ginger slices

The relationship between sample thickness and drying rate constant can be represented by power law equation as follows (Fig. 8).

$$m=0.5326L^{-0.5315} \quad (30)$$

Where,

m= Drying rate constant (hr^{-1})

L= Sample thickness (mm)

From equation 30, it is seen that the value of the index 'n' for ginger is 0.5315. This value is quite lower than 2 as predicted by Fick's unsteady state equation indicating that the external resistance to mass transfer was highly significant and internal resistance to mass transfer did not control the drying process under the given conditions. This conditions resulted primarily due to low airflow rate (<1 m/s), since similar samples did not indicate the presence of external mass transfer resistance under conditions of high air velocity (>2 m/s) as noted by Islam and Flink (1982 b). Islam (2003) found an n value of 1.57 for mechanical drying of indigenous varitey of onion and Hai (2002) found 0.49 for banana using similar air velocity (0.6m/s).

Study-4 : Effect of Packaging material on storage stability of dehydrated onion, garlic and ginger products

The weight ratio (W_t/W_o) of dehydrated onion, garlic and ginger packed in aluminium foil, ALF 0.08mm (T_1), different poly bags (PB) with variable thickness such as 0.09 mm (T_2), 0.03mm (T_3) and plastic pot (PP), 1.7mm (T_4) was estimated at 30 days interval at room temperature (RT, 20-25^{0}C) and refrigerated temperature (RFT, 5^{0}C) for a period up to 180 days. The data were recorded and the weight ratio was given against time in Fig.9, Fig.10 and Fig.11.

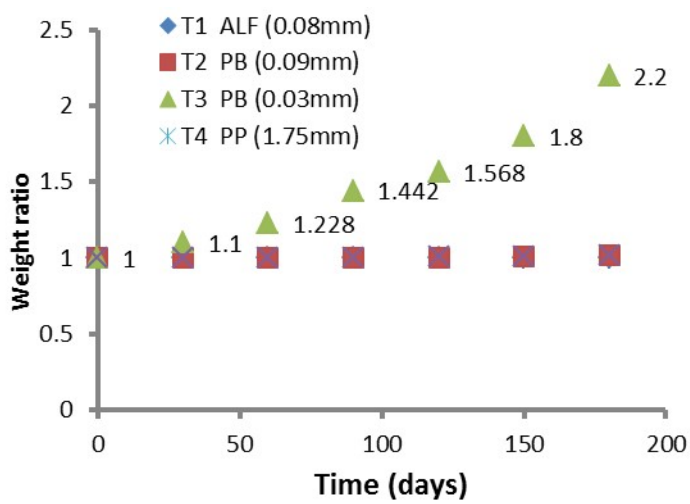

Fig. 9 Effect of packaging on the weight ratio in dehydrated onion during storage

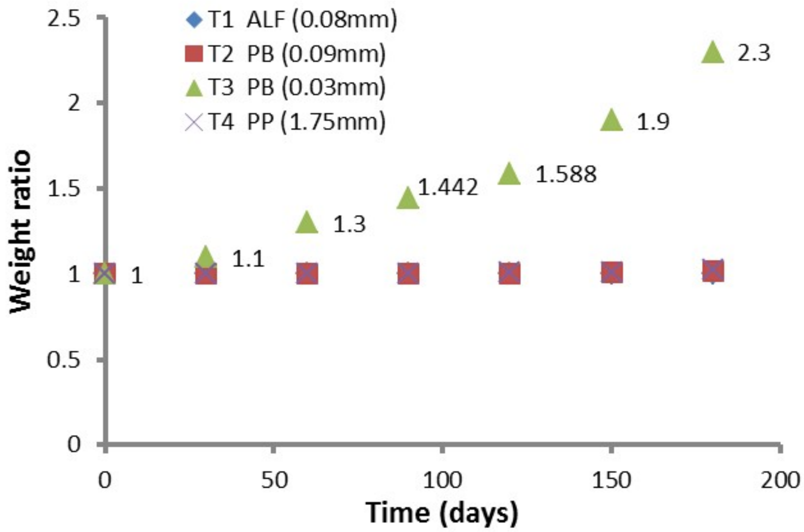

Fig. 10 Effect of packaging on the weight ratio in dehydrated garlic during storage

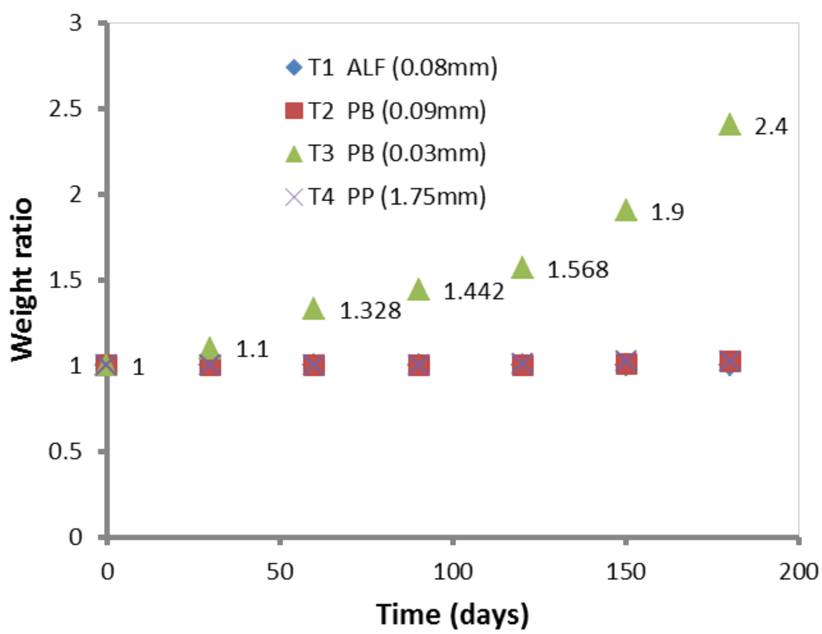

Fig.11 Effect of packaging on the weight ratio in dehydrated ginger during storage

4.1 Effect of packaging on the weight ratio in dehydrated onion, garlic and ginger during storage

It is seen from Fig. 9, that weight ratio of dehydrated onion, increases with time except product packed in ALF-0.08mm (i.e sample T_1). After 180 days of storage period the highest WR (2.40) was found in T_5 (Poly bag-0.03mm) followed by T_4 (Plastic pot PP- 1.75mm) with WR 1.20, T_2 (Poly bag-0.09mm) with WR 1.022 and while sample T_1 (ALF-0.08mm) did not show any weight gain. It is also seen that T_1 (ALF-0.08mm) and T_2 (PB-0.09mm) with almost similar thickness but T_1 gave quite low WR (1.0) indicating better performance of ALF compared to PB. It is also indicated that ALF 0.08 mm (T_1) give negligible weight gain and is followed by T_2 and T_4, while highest water uptake is given by T_3 for the storage period (i.e 180days). It is also observed that during refrigeration storage samples T_1, T_2, T_3 and T_4 show very little moisture gain (WR).

The results from Fig. 10 and Fig. 11 for garlic and ginger storage it is seen that after 180 days of storage the highest weight ratio 2.3 and 2.4 were given by dehydrated garlic and ginger packed in PB-0.03mm (T_3) and successively followed by sample in PB-0.09mm (T_2) with WR 1.022, PP- 1.75mm (T_4) with WR 1.02 and ALF -0.08mm (T_1) with WR 1.00 .

[

The weight ratio thus also moisture gain in T_3 (0.03 mm PB) was the highest due to lower resistance to vapour transmission or higher permeability constant compared to PP (T_4) and ALF (T_1). Farall (1976) found that water vapour transmission rate (0.5-0.6 and 0.3-0.6 g/24hr/100 sq.in.) and permeability (3.8-10.5 and 2.0-5.0 cm^2/sec/atm) for PP and HDPE respectively. Foil of low thickness (T_3-65µm) might have microscopic discontinuities (pinholes) and allow limited diffusion of gases and vapours. The thicker aluminium foil such as ALF-0.08mm (T_1) have low water vapour permeability constant. Karel (1975) reported that at 100^0F and 95% vs 0% R.H (relative humidity) 0.00035 inch ALF and 0.0014 inch ALF give 0.1 to 1.0 and <0.1 permeability constant (g mil $24hr^{-1}$ 100 in^2) respectively. Thus permeability constant varies with composition of packaging material and the higher the thickness, the lower is the constant. The observation that at RFT products in all films (PP, PB ALF) bags gained very little moisture with resultant low rate constant compared to those at RT may be related to dependence of rate constant as well as permeability constant on temperature. In fact these constants have exponential relationship with temperature as per well-known Arrhenius equation (Karel, 1975, Villota and Hawkes, 1992). Graf *et al.* (1998) also observed that generally at higher temperature the quality of food products drops significantly and that the higher the temperature the higher is the activation energies of those films, so that the permeability rates rise.

Study-5: Nutritional study of fresh and dehydrated onion, garlic and ginger products

Nutrient retention in fresh and dehydrated onion

The present investigation was carried out to evaluate and compare chemical composition of dehydrated onion with fresh sample of the same variety. The product was analyzed for moisture, protein, ash, vitamin C, fat, carbohydrate, beta carotene, crude fibre, and sulpher dioxide.

Table 5.1 The chemical composition of fresh and dehydrated summer onion

Treatment	% Mc	% Protein	% Ash	Vit.C mg/100gm	% Fat	% Carbohydrate	β Beta carotene	% Crude fiber	Sulfur di-oxide (SO_2) ppm
T_1	8.10	11.55	3.36	23.52	1.41	69.54	12.147	6.04	62.93
T_2	6.39	10.50	2.46	39.21	1.61	74.85	6.823	4.19	-
T_3	7.34	15.75	3.89	31.36	0.66	67.31	5.802	5.05	-
T_4	7.27	11.55	3.38	19.60	0.96	68.81	5.084	8.03	142.27
T_5	6.58	15.05	3.43	43.13	1.75	67.47	9.326	5.72	2.91
T_0	86.28	1.38	0.50	12.00	0.13	11.00	-	0.70	-

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_5- Without pretreatment dried (Control), T_0 –Fresh onion

5.1 Moisture

The moisture content of fresh and dehydrated summer onion were found 86.28 and 6.39-8.10 %. The value of fresh onion was lower and dehydrated onion was higher than those found by Pandey *et al.* (2004) and Pruthi (2001). They reported that fresh and dehydrated onion contain 86.6 to 86.8 and 4.6, percent moisture respectively. Watt and Merrill (1950) found that dehydrated onion contained 4% moisture. The variations in moisture content may be due to differences in variety and region.

5.2 Protein

The protein content of fresh and dehydrated onion was 1.38 and 10.50-15.75% which is closer to the values reported by Pandey *et al.* (2004) and Pruthi (2001). They showed that the protein content of fresh and dehydrated onion were 1.38, 1.2 and 9.89, 10.6 % respectively. Watt and Merrill (1950) found that dehydrated onion contain 10.8% protein. This small variation in protein content of onion in present study may be due to same reason explained earlier for moisture content.

5.3 Fat

The fat content of fresh and dehydrated onion were calculated and found to be 0.13 and 0.66-1.75 %. This value is an agreement with literature (Pandey, 2004) and Pruthi (2001). Dry weight basis calculation shows only slight loss in fat which may be due to oxidation during air drying (Okos *et al.*, 1992).

5.3 Fibre

The fibre content of fresh and dehydrated onion was 0.7 and 4.19-8.03 % which is closer to the values reported by Bose *et al.* (1993) and Pruthi (2001). Bose *et al.* (1993) found that the fresh onion contained 0.6g /100g fibre and Pruthi (2001) stated that onion powder contained 8.4% fibre. The variation may be attributed to soil condition, variety, maturity, climatic condition etc.

5.4 Ash/ Minerals

The ash content of fresh and dehydrated onion were found 0.50 and 2.46-3.89 which is closer to those found by Pandey *et al.* (2004) who reported ash content of fresh and dehydrated onion is 0.4 and 3.5 % respectively. Pruthi (2001) showed that onion powder contain 3.5% mineral matter (total ash) and Watt and Merrill (1950) found that dehydrated onion contain 3.9% ash. The plants get this mineral from soil. The physiological characters of plants varieties dictate the uptake of nutrient from the soil. Hence, the variety of onion and the soil where it grows may affect its chemical composition. Furthermore the slight variation in ash/minerals content of fresh and dehydrated products (3.64 vs 3.54 % on dry weight basis) might be due to variation in maturity of onion, experimental error etc.

5.5 Total carbohydrate

Total carbohydrate content of fresh and dehydrated onion was determined by difference, that is by subtracting the measured protein, fat, ash, minerals and moisture from 100 and found 11 and 67.31-74.85 % respectively. Pruthi (2001) reported that fresh onion bulb contains 11.6% and onion powder contains 74.1% carbohydrate. Pandey (2004) showed that fresh big onion contained 11.1 % and dehydrated onion contains 74.1 % carbohydrate. Watt and Merrill (1950) found that dehydrated onion contained 80.2% carbohydrate. The difference in carbohydratte content between the current study and the literature value is very little and may be attributed to, among others, sample to sample variations due to variety, maturity, weather conditions as well as moisture content of dried onion.

5.6 Vitamin C/Ascorbic acid

Vitamin C, a water soluble vitamin is involved in tissue development and repair and it prevents scurvy and acts as antioxidant (Conn and Stumpf, 1976). This important vitamin is moderately available in fresh and dried onion 12 mg and 77.18 mg/100g and this vitamin can be easily analyzed in laboratories in Bangladesh. Furthermore, it is easily destroyed during processing (such as drying) and storage. Thus vitamin C content in fresh onion and different dehydrated onion was determined and found to be 12 and 19.60-43.13 mg/100g respectively. Bose (1993) reported that fresh onion contained 11.0 and Pandey (2008) stated that dehydrated onion contained 147 mg/100g sample. The differences in vitamin C content in fresh and dehydrated onion may be due to differences in variety , climatic conditions, experimental procedures, moisture content of fresh and dried onion as well as drying conditions such as temperature, air velocity etc. It is a well known fact that vitamin C is sensitive to heat and oxidation, and its protection is particularly difficult to achieve especially when products are air dried. Other important factors include water activity or product moisture content, P^H and metal traces such as copper and iron (Villota and Hawkes 1992).

Nutrient retention in fresh and dehydrated garlic

The fresh and dried garlic were analyzed for moisture, protein, ash, vitamin C, fat, total carbohydrate, beta carotene, crude fibre, and sulpher-dioxide. The results were presented in Table 6. The moisture, protein, fat, ash and carbohydrates in fresh garlic was found 61.30, 6.55, 0.10, 1.25 and 30.00 percent but Alam *et al.* (2002) reported that the moisture, protein, fat, ash and carbohydrates in fresh garlic was 61.45, 6.35, 0.26, 1.22 and 30.72 percent respectively. The percent of moisture, protein, fat and carbohydrate were observed in the present study were very close to those reported by Alam *et al.* (2002). In different dehydrated garlic percent of moisture, protein, ash, vitamin C, fat, crude fiber and carbohydrate were found 6.12-10.0, 11.55-22.05, 1.81-3.10, 19.60-58.82, 0.51-1.01, 2.60-2.77 and 65.30-72.39. On the other hand Mariam *et* al. in 2016 reported that dehydrated garlic contain moisture, protein, ash, vitamin C, fat, crude fiber and carbohydrate 3.91, 19.75, 3.39, 41.79, 0.49, 1.73 and 66.36 respectively. The variation may be attributed to soil condition, variety, maturity, climatic condition etc.

Table 5.2: The chemical composition of fresh and dehydrated garlic

Treatment	% Mc	% Protein	% Ash	Vit.C mg/100gm	% Fat	% Carbohydrate	β Beta carotene	% Crude fiber	Sulfur di-oxide (SO_2) ppm
T_1	6.34	18.90	2.09	58.82	0.82	69.08	5.140	2.77	188.17
T_2	6.12	19.95	3.10	39.21	0.51	67.71	4.064	2.61	-
T_3	6.93	18.20	2.32	19.60	0.71	69.17	4.522	2.67	-
T_4	10.0	11.55	2.40	19.60	1.01	72.39	4.218	2.65	502.67
T_5	7.29	22.05	1.81	23.89	0.89	65.30	6.00	2.66	9.36
T_0	61.30	6.55	1.25	13.00	0.10	30.00	-	0.80	-

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_5- Without pretreatment dried (Control), T_0 –Fresh garlic

Nutrient retention in fresh and dehydrated ginger

The fresh and dried ginger was analyzed for moisture, protein, ash, vitamin C, fat, total carbohydrate, beta carotene, crude fibre and sulpherdioxide. The results were presented in Table 5.3. The moisture, protein, fat, ash and carbohydrates in fresh ginger was found 80.50, 2.28, 0.80, 1.25, and 9.27 percent but Akter *et al.* (2002) reported that the moisture, protein, fat, ash and carbohydrates in fresh ginger was 80.20, 2.12, 0.6, 1.19 and 15.89 percent respectively. The percent of moisture, protein, fat and carbohydrate observed in the present study were very close to those reported by Akter *et al.* (2002). In different dehydrated ginger percent of moisture, protein, ash, vitamin C, fat, crude fiber and carbohydrate were found 6.74-8.88, 5.95—10.15, 2.32-3.92, 27.44-43.13, 2.15-3.69, 4.64-6.19 and 68.20-77.16. and on the other hand Pruthi *et* al. in 1998 reported that dehydrated garlic contain moisture, protein, ash, vitamin C, fat, crude fiber and carbohydrate 6.90, 8.60, 5.7, 12.0, 6.4, 5.9 and 66.5 percent respectively. The variation may be attributed to soil condition, variety, maturity, climatic condition etc.

Table 5.3 The chemical composition of fresh and dehydrated ginger

Treatment	% Mc	% protein	% Ash	Vit.C Mg/100gm	% Fat	% Carbohydrate	β Beta carotene	% Crude fiber	Sulfur di-oxide (SO_2) ppm
T_1	7.42	9.10	3.92	27.44	3.69	69.87	67.861	6.00	159.53
T_2	7.01	5.95	2.32	35.28	2.92	77.16	95.061	4.64	-
T_3	8.88	10.15	3.83	31.36	3.21	68.20	85.439	5.73	-
T_4	8.36	7.35	3.39	43.13	2.15	72.61	78.060	6.14	590.14
T_5	6.74	7.0	3.07	31.36	3.39	73.61	95.766	6.19	47.81
T_0	80.50	2.28	1.25	-	0.80	9.27		5.90	-

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10min + Soaking in 1500ppm $Na_2O_5S_2$for 6 hr and dried, T_5- Without pretreatment dried (Control), T_0 –Fresh ginger

Study-6: Sensory Evaluation of dehydrated onion, garlic and ginger products

Sensory evaluation

The present investigation was carried out to evaluate the sensory quality of different dehydrated onion, garlic and ginger when they are packed in aluminium foil (ALF) and stored in room temperature (RT). Organoleptic evaluation was also undertaken for selecting the suitable one. The colour. smell, pungency, texture, taste and overall acceptability of 5 samples were evaluated. The mean scores are presented in Table 6.1, Table 6.2, Table 6.3 and Table 6.4.

Table 6.1 Different sensory attributes of dehydrated dried onion

Types of samples	Sensory Attributes					
	Colour	Smell/ flavour	Pungency	Texture	Taste	Overall acceptability
T_1	**8.00 a**	**7. 00 a**	**7.00 a**	**8.00 a**	**8.00a**	**9.0a**
T_2	**5.00 c**	**4.20 c**	**6.80 b**	**7.80 a**	**4.00 c**	**5.20c**
T_3	**4.20 c**	**5.00bc**	**7.00 a**	**6.60 b**	**7.10 a**	**5.80c**
T_4	**8.10 a**	**7.60 a**	**7.20 a**	**7.70 a**	**8.10 a**	**9.00a**
T_5	**6.60 bc**	**7.10 a**	**7.10 a**	**6.30 b**	**7.10 a**	**7.00b**

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_5- Without pretreatment dried (Control).

In case of dehydrated onion powder for colour the highest score, 8.10 was given by sample T_4 followed by T_1 with score 8.0 while sample T_3 secured the lowest score, 4.20. It is also seen that for flavour preference the highest score, 7.60 was given by sample T_4 while sample T_2 secured the lowest score 4.20. For pungency the highest score, 7.20 was given by sample T_4 while sample T_2 secured the lowest score, 6.80. Again for texture and taste highest score, 8.0 was given by sample T_1 while sample T_5 and T_2 secured the lowest score 6.30 and 4.0. Finally in case of overall acceptability the highest score, 9.0 was given by sample T_1 and T_4 while the 2nd highest score 7.0 is attained by sample T_5 and the lowest score, 5.20 was given by sample T_2. The samples were statistically different from each other.

Table 6.2 Different sensory attributes of dehydrated garlic powder

Types of samples			Sensory Attributes			
	Colour	Smell/flavour	Pungency	Texture	Taste	Overall acceptability
T_1	**8.10 a**	**7.50 a**	**7.20 a**	**7.90 a**	**7.30 a**	**7.70a**
T_2	**7.90 a**	**7.20 a**	**6.80 a**	**7.80 a**	**7.00 a**	**7.20a**
T_3	**7.20 ab**	**7.00 a**	**7.00 a**	**7.60 a**	**7.20 a**	**6.80a**
T_4	**8.10 a**	**7.60 a**	**7.10 a**	**7.70 a**	**7.10 a**	**7.20a**
T_5	**7.60 ab**	**7.10 a**	**7.10 a**	**7.30 a**	**7.10 a**	**7.00a**

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_5- Without pretreatment dried (Control).

In case of dehydrated garlic powder for colour the highest score, 8.1 was given by sample T_1 and T_4 while T_3 secured the lowest score, 7.2. It is also seen that for flavour preference the highest score, 7.60 was given by sample T_4 while sample T_3 secured the lowest score, 7.0. For pungency the highest score, 7.20 was given by sample T_1 while sample T_4 and T_5 secured similar score 7.10 and the lowest score, 6.80 was given by T_2. Again for texture and taste highest score, 7.9 and 7.3 was given by sample T_1 while sample T_5 and T_2 secured the lowest score 7.3 and 7.0 in both cases. Finally in case of overall acceptability the highest score, 7.70 was given by sample T_1 while the 2nd highest score 7.20 is attained by sample T_4 and T_2 and the lowest score, 6.80 was given by sample T_3. Almost all the samples were equally acceptable.

Table 6.3 Different sensory attributes of dehydrated ginger powder

Types of samples *			Sensory Attributes			
	Colour	Smell/flavour	Pungency	Texture	Taste	Overall acceptability
T_1	**7.00b**	**7.50a**	**7.80 a**	**7.10a**	**7.30a**	**7.50a**
T_2	**6.90b**	**5.60b**	**5.90 c**	**8.00a**	**7.30a**	**6.90ab**
T_3	**6.20b**	**6.50ab**	**6.60 bc**	**7.30a**	**6.30ab**	**6.20b**
T_4	**8.70a**	**7.40a**	**7.30 ab**	**7.80a**	**7.40a**	**7.90a**
T_5	**6.90b**	**6.40ab**	**6.40 bc**	**7.00a**	**5.30b**	**6.00b**

T_1- Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_2- Soaking in 10% salt solution for 6 hr and dried, T_3- Steam blanching for 10 min and dried, T_4- Steam blanching for 10 min + Soaking in 1500ppm $Na_2O_5S_2$ for 6 hr and dried, T_5- Without pretreatment dried (Control).

In case of dehydrated ginger powder for colour the highest score, 8.70 was given by sample T_4 and the 2^{nd} highest score 7.0 was given by sample T_1 while sample T_3 secured the lowest score, 6.20. It is also seen that for flavour preference the highest score, 7.50 was attained by sample T_1 while sample T_2 secured the lowest score, 5.6. For pungency the highest score, 7.80 was given by sample T_1 while sample T_2 secured the lowest score, 5.9. Again for texture highest score, 8.0 was given by sample T_2 while lowest score 7.0 was attained by sample T_5. In case of taste preference the highest score, 7.40 was given by sample T_4 while sample T_5 secured the lowest score 5.3. Finally in case of overall acceptability the highest score, 7.9 was given by sample T_4 while the 2nd highest score 7.5 is attained by sample T_1 and the lowest score, 6.0 was given by sample T_5. All the samples are statistically different from each other.

The above results are in agreement with the finding of Revaskar and Chang. Revaskar *et al.* (2007) informed that white onion was dried using an osmo-convective drying technique which was done by dipping the onion slices in 10, 15 and 20 brix NaCl solution at ambient temperature and subsequently drying at 50, 60 and 70^{0}C and the products were superior in respect of colour and flavour strength. Chang *et al.* (2004) showed that NaCl affected onion fresh weight and altered onion flavour intensity and quality. They also mentioned that onion pungency increased at the highest NaCl concentration. Total flavour precursors and methyl cysteine sulfoxide content increased in response to NaCl.

It is also observed that Sample T_4 (blanched and sulphited) showed better performance in respect of colour, smell, crispness and overall acceptability. This result is in agreement with the findings of several researchers (Rajkumar *et al.* 2001; Sagar *et al.* 2009; Kadam *et al.* 2009). Rajkumar *et al.* 2001 mentioned that onion flakes dehydrated at 60^{0}C with 0.3% sulfitation level scored the maximum points. Sagar *et al.* (2009) cited that ginger, onion and garlic mix powder treated with 1% KMS, dried in a cabinet dryer at 60^{0}C and stored up to 6 month in HDPE at low temperature with better pungency and other nutrient contents. The authors also stated that the powder was stable at low temperature as compared to high temperature in respect of colour, flavour and texture. Kadam *et al.* (2009) observed that onion slices pretreated in 0.25% and 0.50% KMS and dried, were found best after 6 months of storage period.

6.4 Organoleptic evaluation of processed spices compared to fresh spices in beef curry

In order to determine the suitability of processed dehydrated spices (onion, garlic and ginger) in a practical situation when fresh spices are used in a curry, it was decided to conduct organoleptic taste test of beef curry using 3 different samples. These are (1) sample no. 315 (Fresh onion + Dehydrated garlic powder + Dehydrated ginger powder + other spices), sample no 387 (Dehydrated onion powder + Dehydrated garlic powder + Dehydrated ginger powder + other spices); sample no. 427 (Fresh onion paste + Fresh garlic paste + Fresh ginger paste and other spices) (Control). It may be mentioned here that dried samples with pretreatments were selected on the basis of previously conducted sensory evaluation presented in section 6.3 and these samples secured the highest positions.

The mean score of colour, flavour, pungency, texture, taste and overall acceptability of curry using different types of dehydrated and fresh onion, garlic and ginger are presented in Table 6.4

A two way analysis of variance was carried out and the DMRT results (Table- 6.4) revealed that there were no significant ($P<0.01$) difference in colour, flavour, pungency, texture, taste and overall acceptability in curry using fresh and dehydrated spices.

Table: 6.4 Mean score (DMRT) for different sensory attributes of beef curry using fresh and different types dried spices

Types of samples *			Sensory Attributes			
	Colour	Smell/flavour	Pungency	Texture	Taste	Overall acceptability
315	**7.50a**	**7.00 a**	**7.50 a**	**7.70 a**	**8.10 a**	**7.60a**
387	**7.60 a**	**7.20 a**	**7.70 a**	**7.50 a**	**7.90 ab**	**7.80a**
427	**7.50 a**	**7.50 a**	**7.20 a**	**7.10 a**	**7.10 b**	**6.90b**

T_1- Fresh onion + Dehydrated garlic powder + Dehydrated ginger powder + other spices;T_2- Dehydrated onion powder + Dehydrated garlic powder + Dehydrated ginger powder + other spices; T_3- Fresh onion paste + Fresh garlic paste + Fresh ginger paste and other spices (Control).

For colour the highest score (7.6) was given by sample 387 (Table 6.4) which was closely followed by 315 and 427 with score 7.5. In case of flavor/smell preference (Table 6.4) sample 427 secured the highest score, 7.50 and was closely followed by sample 387 and 315 securing 7.20 and 7.00 and these samples are equally acceptable at 1% level of statistically insignificance. It is also observed that the highest score (7.7) for pungency was attained by sample 387 which was closely followed by sample 315 securing 7.50 and the lowest (7.20) was given by sample 427 and these samples are equally acceptable. From Table 6.4 it is found that the highest score (7.7) for texture was given by sample 315 and is closely followed by sample 387 securing 7.50 and the lowest score 7.10 was given by sample 427 and these samples are also equally acceptable. In case of taste preference it is noticed that the highest score (8.10) was given by sample 315 (Table 6.4) which was closely followed by 387 with score 7.9 while the lowest score 7.10 was given by sample 427 and there were significant different among the treatments. For overall acceptability preference (Table 6.4) the highest score (7.80) was given by sample 387 while the 2nd highest score 7.60 is attained by sample 315 and the 3rd highest score, 6.90 was given by sample 427. However all these samples (315, 387 and 427) are almost equally acceptable at 1% level and statistically insignificance.

From Table 6.4 and foregoing discussion, sample 315 (Fresh onion + Dehydrated garlic powder + Dehydrated ginger powder + other spices) and sample 387 (Dehydrated onion powder + Dehydrated garlic powder + Dehydrated ginger powder + other spices) are undoubtedly the best samples (among the samples tasted) since these samples secured the highest scores for all quality attributes and were equally acceptable at 1% level and statistical insignificance. Samples 427 however secured the highest numerical score for flavor but equally acceptable with other sample and ranked as like moderately.

Conclusion:

The drying, packaging, nutritional, and organoleptic analysis showed that dehydrated spices (onion, garlic and ginger) are well acceptable in comparison to the fresh spices. So, treated dehydrated onion and garlic powder packed in aluminium foil (ALF), and treated dehydrated ginger powder packed in aluminium foil/plastic pot and stored in room temperature (RT) is highly recommended for consumers as well as for industrial processing.

Fig. Onion storage structure at Faridpur

Fig. Onion and garlic storage survey

Fig. Onion storage structure (Inner view)

Fig. Onion storage structure (Bottom view)

Fig. Onion storage in Rajshahi **Fig. Ginger storage practice**

Fig. Onion curing at Lalmonirhat **Fig. Onion storage at Pabna**

Fig. Garlic storage at cow shed

Fig. Onion storage at Rajshahi using mud in ceiling

Fig. Farmers' Interview

Fig. Garlic storage practice at Rajshahi

Step-1: Sliced fresh Onion

Step-2: Blanching procedure of onion

Step-3: Blanched onion

Step-4: Blanched onion in $Na_2O_5S_2$ solution

Step-5: Dehydration procedure of onion

Step-6: Dehydrated onion powder

Fig. 3. Different steps of onion processing

Step-1: Fresh garlic

Step-2: Peeled garlic

Step-3: Garlic blanching procedure

Step-4: Blanched garlic

Step-5: Dehydration procedure of garlic

Step 6. Dehydrated garlic powder

Fig. 4. Different steps of garlic processing

Step-1: Fresh sliced ginger

Step-2: Blanching procedure of ginger

Step-3: Blanched ginger in $Na_2O_5S_2$ solution

Step-4: Ginger sliced after pre treatment

Step-5: Dehydrated sliced ginger

Step-6: Dehydrated ginger powder

Fig. 5. Different steps of ginger processing

Fig.6 Beef curry using fresh and dehydrated spices

Fig.7 Sensory evaluation is done by CSO spices

Fig.8 Sensory evaluation is done by SRC scientist

Fig. 9 Sensory evaluation is done by SRC scientist

12. Research highlight/findings (Bullet point – max 10 nos.):

Major findings are

- The traditional storage practices of onion, garlic and ginger are not good enough to minimize the postharvest losses.
- Farmers are interested to use these processed spices in curry.
- The study thus shows that high quality shelf-stable onion, garlic and ginger powder can be developed utilizing available low cost dehydration processes and thereby, post-harvest losses of these spices can be reduced to an acceptable level.
- Onion, garlic and ginger powder packed in ALF stored in RT and RFT were most acceptable more than one years.
- Organoleptic acceptability of these developed powder in curry were found satisfactory.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laptop, Desktop, Camera, Book shelf, portable hard disk, Scanner	175000/-	Achieved	175000	
(b) Lab & field equipment	Mechanical dryer	500000	Achieved	498000	
(c) Other capital items					

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					Not applicable
(b) Workshop	-	-	-	-	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	246712	246712	246712	-	100%	-
B. Field research/lab expenses and supplies	433235	384663	384663	-	100%	
C. Operating expenses	279673	277423	277423	-	100%	
D. Vehicle hire and fuel, oil & maintenance	75000	67500	67500	-	100%	
E. Training/workshop/seminar etc.	100000	00	00	-	-	Tk. Returned by Cheque to Director, PIU, BARC
F. Publications and printing	105000	25500	25500	-	24.286	
G. Miscellaneous	87500	50000	50000	-	57.143	
H. Capital expenses	672750	672750	672750	-	100%	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To identify post-harvest practices and to determine the post-harvest losses of onion, garlic and ginger in farmers field	A lot of farmer's field visited in Faridpur Rajshahi, Pabna and Lalmonirhat district. Before visit for survey a pretested questionnaire was prepared by PI. After interviewed of farmers many information were found regarding pre and post-harvest practices of onion, garlic and ginger.	The thickness of onion and garlic storing on ceiling is about 4-18 inches. The thickness of onion storing varies on variety to variety. Most of farmers dry whole garlics with plant in sun before storing. After drying in sun they stored garlic making beni with garlic dry leaves and hang with ceiling. Normally ginger is stored in pit (earthen hole). Sometime it is stored in house floor covered with ginger leaves. Most of farmers reported that they stored ginger in pit but within few days sprout and roots are found. That's why additional labour is required when they want to sell ginger. But if ginger kept out of pit it become shrivel within few days. The farmers do not have the accurate data on the post-harvest losses of onion, garlic and ginger. But they assume that the losses become 20-40%. The post- harvest losses of onion, garlic and ginger include sprouting, decay or rotting, physiological loss of weight, splitting of bulbs, discoloration, shrinkage and rooting. In case of summer onion (which onion produce in our country in summer season) the losses become 70-80%.	Awareness has been created among the farmers regarding post-harvest practice and post-harvest losses of spices crops
To study storage stability and determine organoleptic acceptability of developed products	This research was undertaken to develop processing techniques to reduce post-harvest losses and preserve high yielding summer onion, garlic and ginger using low cost conventional technology based on dehydration process. The dehydration was carried out by pretreatment followed by air drying in a cabinet dryer.	Thus shelf stable products were developed by mechanical drying with or without pretreatments. Studies on packaging materials showed that for long time storage at room temperature (RT) aluminum foil, ALF-0.08mm, Poly bag PB-0.09mm and plastic pot PP- 1.75 may be used as packaging material, while for storage at refrigerated temperature (RFT) all films can be used. The chemical compositions of the fresh and dehydrated onion, garlic and ginger products were determined and it was observed that the qualities of the products were satisfactory. Organoleptic taste testing showed that all the developed products were accepted by the panelists.	New technology will be disseminated among the spices farmers
To minimize the post- harvest losses and optimize process parameter to obtain high quality process products of onion, garlic and ginger	The study thus shows that high quality shelf-stable onion, garlic and ginger products can be developed utilizing available low cost dehydration processes.	Post-harvest losses of these spices were reduced to an acceptable level. The processed spices products were ready to use.	Farmers' capacity will be developed on manufacturi-ng of shelf stable value added processed products from onion, garlic and ginger

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any		**03, June 2018 (News paper)**	“মসলা জাতীয় ফসলের সংগ্রহ, সংরক্ষন ও প্রক্রিয়াজাতকরণ” **Agri News24.com Agricare24.com Agrilife24.com**

F. Technology/Knowledge generation/Policy Support (as applied):

i. **Generation of technology (Commodity & Non-commodity)**

Dehydrated powder from onion, garlic and ginger

ii. **Generation of new knowledge that help in developing more technology in future**

iii. **Technology transferred that help increased agricultural productivity and farmers’ income**

Postharvest loss of onion, garlic and ginger due to improper storage, handling, processing and preservation is one of the vital issues which need to be addressed without delay. Bangladesh has a deficit in production of these spices. The gap between supply and demand of spices to a great extent when the scanty produce is lost for the above reasons. In the mean time several technologies related to processing and preservation of spices have been developed. These technologies can play a vital role in reducing the post-harvest losses of spices. Thus we can help in increasing agricultural productivity and farmers’ income.

iv. **Policy Support**

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

Organoleptic information, post-harvest loss data, Quantification of post-harvest loss, Trainees' feedback, blanching time of different crop should be included. A workshop on "Monitoring and Evaluation of Research Activities" was held on 15.05.2018 at BARC, Dhaka. Another "Annual Research Review Workshop" was held on 18.09.2018 at BARC, Farmgate, Dhaka.Through this desk monitoring, the research activities of project was improved and different lacking were recovered.

ii) Field Monitoring (time& No. of visit, Team visit and output):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Remarks
Technical Division/ Unit, BARC			
PIU-BARC, NATP-2	19-03-2018	One time	
Internal Monitoring			
Others Visitors (if any)	Chief whip, 15-03-2018 DG, BARI, 03-06-2018	One time Two time	

I. Lesson Learned/Challenges (if any)

i) Lack of Institutional facility and support
ii) Lack of knowledge and quality agricultural input

J. Challenges (if any)

Onion, garlic and ginger price is low and post-harvest loss is more at harvesting season.

Signature of the Principal Investigator
Date …………………………

Seal

Counter signature of the Head of the organization/authorized representative
Date …………………………..
Seal