Project ID: 661

Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Development of Low-cost Technology for Making Processed Cheese

Project Duration

July 2017 to September 2018

Department of Dairy Science
Faculty of Animal Husbandry
Bangladesh Agricultural University
Mymensingh 2202

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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Acronyms

ANOVA	: Analysis of Variance
A_w	: Water activity
cm	: Centimeter
EM	: Emulsifying salt
h	: Hour
Kg	: Kilogram
LSD	: Least Significant Difference
m	: Meter
mm	: Millimeter
P	: Probability
RBD	: Randomized Block Design
s	: Second
Tk.	: Taka
TP	: Tripolyphosphate
TPA	: Texture profile analysis

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Executive Summary

Processed cheese is a smooth, uniform cheese variety that is made by blending and melting together one or more rennet cheeses of different maturity or composition along with an emulsifying salt (such as disodium phosphate) and typically other ingredients (such as coloring, cream, water, or whey). Processed cheese is considered to be a safe product as the ingredients are cooked to a high temperature (usually 80-85°C) that kills almost all the microorganisms present in the ingredients. Usually low quality rennet cheese is used in manufacturing processed cheese which makes the product a relatively low priced product. Moreover, use of filler materials like skimmed milk, starch, etc. even reduces the price further. This type of cheese is widely used as single food as well as an ingredient in the bakery industry.

Processed cheese is becoming increasingly popular in Bangladesh with the spread of fast food culture, changing food habit and increasing purchasing capacity of the consumers. It is estimated that around 8,000 tons of processed cheese is imported annually worth BDT 240 million (anonymous, 2017). Therefore the primary objective of this research project was to make a blend of processed cheese using locally available ingredients which is comparable to, or even better than, the imported processed cheeses.

Surveys were carried out to detect the consumption pattern and market prices of the processed cheese in Bangladesh. It was found that majority of the processed cheese sold at the markets are consumed within the Dhaka and Chittagong regions, especially at fast food restaurants. Most of the processed cheese types available are imported from countries like Australia, the Middle East and the Europe. The whole sale price of processed cheese in the markets of Bangladesh was found to range from Tk. 680 – 990/kg, depending on the brand and country of origin. A number of initial blends were tried to finalize the treatment blends of processed cheese. Once parameters like range of microbial rennet, proportion of soft Dhaka cheese, and levels of salt and emulsifying salts were defined, trials for making processed cheese began. In total 27 blends of processed cheese were successfully prepared. All the samples were subjected to chemical, microbial and sensory analyses. Considering all the parameters studied e.g., organoleptic evaluation, moisture content, fat content, meltability and stretchability the sample T_{3BY} prepared with the recipe of 25% Short ripened, 25% Medium ripened and 50% Long ripened Dhaka cheese plus 3% emulsifying salt (ES) and 3% table salt was the best ($p<0.05$ to 0.05) cheese blend among the lot.

A major focus of this research was also to reduce the price of the product by 30% so that the breakeven point is set to a profitable margin. The aim of the project was thus to reduce the breakeven price of the processed cheese to Tk. 490/kg from the wholesale price of Tk. 700/kg in the market, through addition of novel ingredient like potato starch and modified whey protein. Through this research, processed cheese was made successfully with a breakeven cost ranging from Tk. 493±2 to 527±2. Thus, the developed processed cheese was significantly ($p< 0.05$) less costly (25-30%) as compared to processed cheese currently sold in the markets of Dhaka and Chittagong city, indicating that cost reduction could be possible if Processed cheese is manufactured locally using locally available ingredients. Future research should be focused on diversifying the processed cheese based products and increasing the shelf-life in different packaging consideration. The processed cheese technology could also be disseminated among the milk processor to increase production and product diversity in the dairy industry of Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
   Development of low-cost technology for making processed cheese.

2. **Implementing organization:**
   Department of Dairy Science, Faculty of Animal Husbandry, Bangladesh Agricultural University Mymensingh 2202

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):**
   a. Total: Tk. 25,00,000
   b. Revised (if any): None

5. **Duration of the sub-project:**
   c. Start date (based on LoA signed): 11 July 2017
   d. End date : 30 September 2018

6. **Justification of undertaking the sub-project**

Processed cheese (also named as prepared cheese, plastic cheese, or cheese singles) is a dairy product made from rennet cheese, to which optional ingredients, plus emulsifiers, extra salt, and food colorings are added followed by cooking in order to get a unique pasteurized cheese variety. As a result, many flavors, colors, and textures of processed cheese exist. This type of cheese is usually made from different varieties of hard or semi-hard cheese, to which 3-4% emulsifying salt and 25-

30% water are added, depending on the chosen type of processed cheese. The proportion of natural cheese as the base ingredient of processed cheese products ranges from 51 to 95% (Code of Federal Regulations, 1986; Fox *et al.*, 1996). Optional ingredients permitted may include dairy ingredients (dairy by-products like skim milk powder, cream, whey), non-dairy ingredients (saturated vegetable oils, sugar, spices, herbs, etc.), salts, emulsifying salts, flavors, colors, preservatives and water (Guinee *et al.*, 2004). The feasibility of using low quality rennet cheese as the base ingredient and the option of using low-cost ingredients have made the processed cheese a cheap and popular option for consumers as well as for dairy enterprises.

Processed cheese is becoming increasingly popular in Bangladesh with the spread of fast food culture, changing of food habit and increasing of purchasing capacity of consumers. This cheese is consumed as a snack, though widely used as a food ingredient in the fast food and bakery industries. However, this type of cheese is almost entirely imported to satisfy large market demand. It is estimated that around 8,000 tons of processed cheese is imported annually worth BDT 240 million (personal communication, 2017). If processed cheese could be made from locally available ingredients using indigenous technology, a substantial saving of foreign currency might be possible. Moreover, reduction in price could encourage consumption.

Making Processed cheese often requires expensive raw materials. So, research is needed to devise a new and cost-effective technology to manufacture processed cheese along with its standard of identification in order to satisfy the technological need of the cottage industry as well as the large milk processing plants in Bangladesh. If processed cheese could be made from indigenous raw materials, a substantial reduction in costs might be possible and the local production of processed cheese would be encouraged. Dhaka cheese could be one such raw material. Dhaka cheese is a semi-hard artisanal cheese made typically in Bangladesh from cow's milk. Furthermore, use of microbial rennet in making vegetarian processed cheese is a new concept and should be tested in the context of our country. The research should also generate information about the composition, texture and functionality, microbial quality, organoleptic properties, consumer acceptance, cost-benefit analysis, and market survey for processed cheese that was made from locally available ingredients.

Therefore, this research project focused primarily on an investigation of the feasibility of making processed cheese from microbial rennet and to determine the effect of degree of maturity (1-week ripened, 2-week ripened, and 4-week ripened) on the physicochemical properties of processed cheese. Moreover, the most suitable blend and level of emulsifying salt was standardized. Furthermore, the appropriate level of table salt and optimum moisture content was standardized. As a whole, standards of identification (composition, physical properties, organoleptic characteristics, microbial standard, packaging, and labeling) were established along with shelf-life study. A short survey on market demand was conducted in two major local markets (different areas of Dhaka and Chittagong divisions). The price of processed cheese in the markets of Bangladesh ranges from Tk. 800 – 1200, depending on the brand and country of origin. The proposed research aims at reducing the price of the product by 30% so that the breakeven point is set to a profitable

margin. For example, if the wholesale price of processed cheese in the market is Tk. 700/kg, the project aims at reducing the breakeven price to Tk. 490/kg through addition of novel ingredient like potato starch, modified whey protein, etc.

There is no information about the texture or functionality of processed cheese made from Dhaka cheese. Information about the characteristics of this type of pasteurized processed cheese would help researchers in developing new products and also would help in understanding the impact of different cheese manufacturing conditions. This might have a significant contribution to the science of cheese making.

7. Sub-project goal:

To establish a cost-effective technology for making indigenous variety of processed cheese and thereby reducing the production cost by 30%.

8. Sub-project objective (s):

a) To estimate the consumption and the cost of processed cheese in Bangladesh

b) To invent recipes for making processed cheese using locally available ingredients

c) To determine the cost-effectiveness of the recipe for making processed cheese

9. Implementing location (s):

Markets in Dhaka and Chittagong cities (for consumer survey) and the Dairy Processing Pilot Plant, Department of Dairy Science, Bangladesh Agricultural University, Mymensingh (for technology development)

10. Methodology in brief:

10.1. Estimation of consumption and the cost of processed cheese in Bangladesh:

Market survey

A short survey was carried out at different markets in the Dhaka and Chittagong cities in order to estimate the cost, demand-supply and consumer preference for processed cheese. Twenty sellers and fifteen consumers were selected randomly to fill the questionnaires (enclosed).

10.2. Development of recipes for making processed cheese using locally available ingredients:

a. Preparation of processed cheese

Collection ingredients

Raw milk was collected from the Bangladesh Agricultural University (BAU) Dairy Farm and local milk producers around Mymensingh town. Both microbial rennet and freeze dried yoghurt starter culture

was purchased from local suppliers of Chr. Hansen, Denmark. Skim milk powder, emulsifying salt, table salt, colouring material was collected from local suppliers.

Preparation of cheese blend

Small batches (e.g., 2 kg) of processed cheese were made in an improvised twin-screw cooker dipped in hot water bath at 90°C. Minced rennet cheese (soft Dhaka cheese prepared in the laboratory), potable water, emulsifying salts (75% tripolyphosphate, 5% sodium citrate, 15% sodium carbonate and 5% calcium chloride) was mixed at 100 rpm for 3-8 minutes. During mixing, a minute amount of critic acid was added to adjust the pH of the final product to approximately 5.7. Molten processed cheese was poured into 0.25 kg moulds, cooled at room temperature, and stored at 4°C until analyses.

Treatments

The formulation of processed cheese for this work was intended to contain around 22% protein, 30% fat, and 43% moisture. Potato starch was used as a replacement of rennet cheese in the final blends. For each trial, different batches of processed cheese were made according to the treatment groups mentioned below.

Selection of optimum proportion of ripened cheese

Rennet cheese of different degrees of maturity (short/medium/long) was minced with knife and mixed with different proportions as per to standard practice reported by a various authors (Meyer, 1973; Walstra *et al.*, 2006):

T_1: 50% Short + 25% Medium + 25% Long,

T_2: 25% Short + 50% Medium + 25% Long, and

T_3: 25% Short + 25% Medium + 50% Long.

Then, 2.0 kg of minced cheese of a given treatment was cooked in a single batch.

Selection of optimum dose of emulsifying salts (ES)

Emulsifying salts were added to the following proportions:

T_A: Low level = 2%,

T_B: Medium level = 3%, and

T_C: High level = 4%.

Selection of optimum dose of table salt

Table salt was added to the following proportions:

T_X: Low level = 2%,

T_Y: Medium level = 3%, and

T_Z: High level = 4%.

In total 27 different types of processed cheese were made in 27 different treatment combinations as listed below in Table 1.

Table 1: Different treatment combinations for making experimental processed cheese

Sl. No.	Treatment	Specification
1	T_{1AX}	50% Short + 25% Medium + 25% Long + 2% ES + 2% salt
2	T_{1AY}	50% Short + 25% Medium + 25% Long + 2% ES + 3% salt
3	T_{1AZ}	50% Short + 25% Medium + 25% Long + 2% ES + 4% salt
4	T_{1BX}	50% Short + 25% Medium + 25% Long + 3% ES + 2% salt
5	T_{1BY}	50% Short + 25% Medium + 25% Long + 3% ES + 3% salt
6	T_{1BZ}	50% Short + 25% Medium + 25% Long + 3% ES + 4% salt
7	T_{1CX}	50% Short + 25% Medium + 25% Long + 4% ES + 2% salt
8	T_{1CY}	50% Short + 25% Medium + 25% Long + 4% ES + 3% salt
9	T_{1CZ}	50% Short + 25% Medium + 25% Long + 4% ES + 4% salt
10	T_{2AX}	25% Short + 50% Medium + 25% Long + 2% ES + 2% salt
11	T_{2AY}	25% Short + 50% Medium + 25% Long + 2% ES + 3% salt
12	T_{2AZ}	25% Short + 50% Medium + 25% Long + 2% ES + 4% salt
13	T_{2BX}	25% Short + 50% Medium + 25% Long + 3% ES + 2% salt
14	T_{2BY}	25% Short + 50% Medium + 25% Long + 3% ES + 3% salt
15	T_{2BZ}	25% Short + 50% Medium + 25% Long + 3% ES + 4% salt
16	T_{2CX}	25% Short + 50% Medium + 25% Long + 4% ES + 2% salt
17	T_{2CY}	25% Short + 50% Medium + 25% Long + 4% ES + 3% salt
18	T_{2CZ}	25% Short + 50% Medium + 25% Long + 4% ES + 4% salt
19	T_{3AX}	25% Short + 25% Medium + 50% Long + 2% ES + 2% salt
20	T_{3AY}	25% Short + 25% Medium + 50% Long + 2% ES + 3% salt
21	T_{3AZ}	25% Short + 25% Medium + 50% Long + 2% ES + 4% salt
22	T_{3BX}	25% Short + 25% Medium + 50% Long + 3% ES + 2% salt
23	T_{3BY}	25% Short + 25% Medium + 50% Long + 3% ES + 3% salt
24	T_{3BZ}	25% Short + 25% Medium + 50% Long + 3% ES + 4% salt
25	T_{3CX}	25% Short + 25% Medium + 50% Long + 4% ES + 2% salt
26	T_{3CY}	25% Short + 25% Medium + 50% Long + 4% ES + 3% salt
27	T_{3CZ}	25% Short + 25% Medium + 50% Long + 4% ES + 4% salt

b. Analysis and quality evaluation

The organoleptic quality and microbiological parameters was analyzed 24 hours after manufacture. Chemical composition, physical parameters and texture profile was tested within a week.

Chemical analyses: The samples of processed cheese were evaluated in triplicate with respect to the following physicochemical parameters:

I. pH was determined using a pH meter with a combined glass electrode (pH meter 420A, Orion Research, Beverly, MA, USA) at room temperature;
II. Moisture content was determined by a gravimetric method according to International Dairy Federation (1982);
III. Ash content was determined by a gravimetric method according to International Dairy Federation (1982);

IV. Protein content (total percentage N×6.38) was determined by Kjeldahl method (2300 Kjeltec Analyzer Unit, Foss Tecator, Eden Prairie, MN, USA) (International Dairy Federation 1986);
V. Fat content was determined according to Marshall (1992); and
VI. Salt content was determined by titration.

Microbial examination: Total bacterial count, coliform count, and yeast-mould count was performed by standard methods as specified by the American Public Health Association (2004) in duplicate.

Organoleptic evaluation: Organoleptic properties were evaluated by a panel of experts and a general consumer panel using a standard score card.

Texture Profile Analysis (TPA): The processed cheese made in this project was mechanically compared with the imported processed cheese available in the market for texture characteristics so that similar products could be developed. This process was essential to establish the cheese as an international variety. The textural properties of processed cheese was evaluated by the method of texture profile analysis by uni-axial compression test (two bites) as described by Bourne (2002). Cylindrical shaped samples measuring 20 mm in diameter and 20 mm in height were prepared from the processed cheese block. The samples were kept in a refrigerator at 4°C. The texture profile was determined by a FOOD TEXTURE ANALYZER with 1500 g load cell, by allowing a 10 mm aluminum cylindrical probe to penetrate the sample twice in a rapid succession, 16 mm into the sample (80% of their original height) at a speed of 1 mm/s every time. The data obtained for force as a function of time were analyzed using suitable software. The values for the hardness (Newton, N), springiness, cohesiveness, gumminess, and adhesiveness were obtained. All determinations were carried out in triplicate.

Meltability test: The melting property of processed cheese was determined by glass-tube method in duplicate.

Shelf-life study: Cheese samples prepared using different treatments was stored at both room temperature (25-32°C) and at refrigeration temperature (4-5°C) until signs for changes in flavour, pH, microbial population and composition. Recommendations were made for proper storage limit and temperature.

10.3 Determination of cost-effectiveness of the recipe for making processed cheese:

Cost-benefit analysis: All inputs (materials, packaging, fuel, labour, depreciation, storage, transportation, etc.) required to prepare each kg of processed cheese was quantified and compared with available commercial samples to calculate the profitability.

Statistical analyses: Statistical analysis of data was carried out using the Split Plot Design, where 'proportion of ripened cheese' was the main treatment, 'dose of emulsifying salts' was the plots, and 'dose of table salt' was the sub-plots. Analysis of variance (ANOVA) was performed to determine

the significance of main effects using SPSS 18.0 (SPSS Inc., Chicago, IL). Factorial test was carried out to determine the interaction effects. Least significant difference (LSD) values was determined at the significant level of $P<0.05$ to rank the samples.

Different steps in the making of experimental processed cheese samples are shown below in the Figures 2-10 along with a market sample of processed cheese Figure 1.

Figure 1: Market sample of processed cheese

Figure 2: Microbial rennet used for rennet cheese

Figure 3: Coagulation of milk for making cheese

Figure 4: Grinder used to melt rennet cheese

Figure 5: Grinding of rennet cheese

Figure 6: Addition of emulsifying salt

Figure 7: Addition of annatto

Figure 8: Blending processed cheese

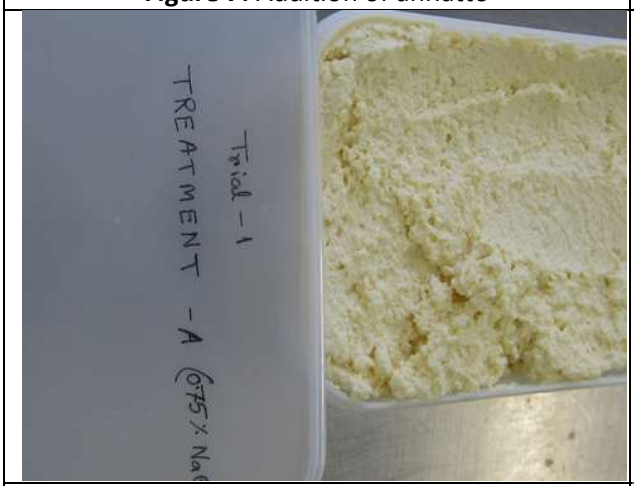

Figure 9: Freshly prepared processed cheese

Figure 10: Storage of processed cheese

11. Results and discussion:

11.1. Estimation of consumption and the cost of processed cheese in Bangladesh:

One of the key objectives of this study was to define, segment, and project the size of the Processed Cheese market based on company, product type, end user and key regions in Bangladesh. This report focuses on the sales of Processed Cheese in the market of Dhaka and Chittagong cities and categorizes the market based on brands and amount of consumption (Table 2).

Table 2: Sales (approximate) of processed cheese in the market of Dhaka and Chittagong cities

Brand	Sales per annum (ton)	Market share (%)	Growth/year (%)
Kraft	6,000,000	25.0	~3
Savencia	2,000,000	8.3	~2
Fonterra	3,000,000	12.5	~4
Aarong	2,000,000	8.3	~5
Kishan	1,000,000	4.2	~3
Almarai	6,000,000	25.0	~9
Miscellaneous	4,000,000	16.7	~5
Total consumption	24,000,000	100.0	~4.4

Processed cheese brands available in the markets of Bangladesh are Kraft, Savencia, Fonterra, Aarong, Kishan, Almarai, etc. The local processed cheese industry has a rather high concentration. The major brands are concentrated in the Middle East, Australia and Europe. Processed Cheese downstream is wide and recently Processed Cheese has acquired increasing significance in various fields of Catering, Ingredients and Retail. Now a day, the processed cheese market is mainly driven by growing demand for Catering, Ingredients and Retail. The national market for Processed Cheese is expected to grow at roughly 12% over the next five years, will reach BDT 267 million in 2024, from BDT 240 million in 2019, according to this study. Further countrywide in-depth study on the current state of processed cheese consumption in Bangladesh is needed.

11.2. Development of recipes for making processed cheese using locally available ingredients:

Processed cheese is one of the leading cheese varieties in the world (Biswas, 2014). This variety is usually made by grinding and blending natural rennet cheese of different degrees of maturity, to which emulsifying salts and other dairy and non-dairy ingredients are added, followed by continuous mixing under high heat (80-95°C for 5-15 minutes while stirring) followed by cooling to form a homogeneous product with an extended shelf-life (Guinee *et al.*, 2004). This pasteurized cheese differs from natural cheeses in that they are not made directly from milk, but rather from various ingredients such as natural cheese, skim milk, water, butter oil, casein, vegetable oils, vegetable proteins and minor ingredients like salt and emulsifying salts. The formulation of processed cheese typically contains around 22% protein, 30% fat, 49% whey fat in the solids and 43% moisture. This article focuses on the basic manufacturing technique of processed cheese products

This type of cheese is typically a stable oil-in-water emulsion. The consistency and functional characteristics of processed cheese is influenced by many factors, including variety of cheese used, degree of maturity of natural cheeses used, pH of cheese melting, type and concentration of emulsifying salt (sodium phosphate, sodium citrate, sodium triphosphate, calcium phosphate), processing conditions, moisture content, fat content, presence and concentration of ions, and other ingredients added during manufacturing (especially calcium), use of hydrocolloids (Thomas 1973; Hanna and Nader, 1996; Marchesseau *et al.*, 1997; Zehren and Nusbaum 2000; Bowland and Foegeding, 2001; Guinee*et al.*, 2004; Lee *et al.*, 2004; Shirashoj i*et al.*, 2006; Dimitreli and Thomareis, 2007; Gustaw and Mleko, 2007; Lu *et al.*, 2007; Cernikova*et al.*, 2008; Chen and Liu, 2012). The flavor of processed cheese distinctly differs from that of rennet cheese, partly due to the heat treatment, and partly due to the melting salts (Walstra *et al.*, 2006).

Processed cheese offers a wide variety in flavour, texture (e.g., meltability, streatchability, etc.), cooking attributes (e.g., degrees of flowability, browning, viscosity), size and shape of the final product and overall consumer appeal (Mann, 1993, 1997; Subak and Petranin, 2001). Its popularity with children is attributed to safe ingestible consistency (for infants), mild flavors and their packaging (color, caricatures, strength, ease of opening, size, etc.) and shape (e.g., triangles, fingers, cartoon characters, etc.). High nutritive value of processed cheese products (e.g., especially as a source of calcium and protein) make them an ideal food for children (Guinee *et al.*, 2004). Processed cheese is one of the leading cheese varieties in the world, and available in several forms, such as slices, blocks, shreds and spreadable (Biswas, 2014). This type of cheese has numerous applications, though it is frequently consumed as a food ingredient. Processed cheese has become a very important dairy product in the fast food industry. Customers' acceptance of processed cheese depends on several functional and textural attributes like hardness, springiness, adhesiveness, cohesiveness, gumminess, meltability, and uniform flow of cheese on heating (Biswas, 2014). The term meltability can be described as the extent of melted cheese flow and spread upon heating (Kuo *et al.*, 2001).

Processed cheese products are used in many applications in both for direct consumption (e.g., on bread and crackers or in sandwiches and burgers) or as an ingredient in different foods (table spread, sauces, dips, dry soup). Processed cheese products are also used as an ingredient in several cookery applications, e.g., in pasta or noodle dishes, filling in confectionery items, etc. Global production of processed cheese products is estimated to be more than 2.0 million tons/annum, which is equivalent to around 13% of natural cheese production (Guinee *et al.*, 2004). Processed cheese has become a very important dairy product in the modern fast food industry.

The experimental cheeses were made from rennet cheese with different degrees of maturing as blended by different proportions, to which different levels of common salt and emulsifying salts were added. The ingredients could be a suitable selection from the following (Meyer, 1973; Guinee *et al.*, 2004; Walstra *et al.*, 2006):

a) Natural cheese: most common varieties used are Cheddar, Gruyere, Mozzarella, Emmental, Gouda, etc. Certain cheeses such as cream cheese and cottage cheese are not used.
b) Milk fat: cream, dehydrated cream, anhydrous milk fat, butter.
c) Milk proteins: casein, whey proteins, milk protein concentrates, skim milk powder.
d) Lactose: skim milk powder, whey powder, whey permeate powder.
e) Vegetable fat: soybean oil, palm oil, corn oil, saturated vegetable oil.
f) Vegetable protein: soy protein.
g) Stabilizers:
    i. Emulsifying salts: sodium citrates, sodium hydrogen orthophosphates, sodium pyrophosphates, sodium tripolyphosphates, sodium polyphosphates and sodium aluminium phosphates.
    ii. Hydrocolloids: carrob bean gum, guar gum, xanthan gum, sodium carboxymethyl cellulose, carrageenan.
h) Acidifying agents: food-grade organic acids (e.g., lactic, acetic, citric, phosphoric acids).
i) Flavourings: enzyme-modified cheese, spices, herbs.
j) Flavour enhancers: NaCl, yeast extract.
k) Sweetening agents: sucrose, dextrose, corn syrup, hydrolysed lactose.
l) Colours: annato, paprika, any other food-grade color.
m) Preservatives: nisin, potassium sorbate, Ca- or Na- propionate

Manufacturing protocol for Processed Cheese

The manufacture of the experimental processed cheese was carried out as per Guinee *et al.*, (2004).

Recipe formulation

Formulation involved selection of the correct type and quantity of natural cheeses, emulsifying salt, water and optional ingredients to give the final product a desired composition, textural and functional properties. The consistency of the product depended on the type, the blend and the degree of maturity of the cheeses selected for processing. Processed cheese was made from a single variety of semi-hard cheese known as Dhaka cheese. This cheese variety gave firmer, longer-bodied processed products (Meyer, 1973). Degree of maturity had a major effect on the final quality. An excess of young cheese with some extra mature cheese was added for good flavor (Walstra *et al.*, 2006). Young cheese (70-90% intact casein) was used to manufacture block processed cheeses with good streatchability and meltability, whereas predominantly medium ripe cheese (60-75% intact casein) was used for making cheese that spreads (Meyer, 1973).

The ground rennet cheese, emulsifying salts, table salt, potato starch and flavour were dissolved in a portion of hot water, which was then heated at 85°C under agitation. Heating of the blend was necessary to impart a gluey texture and proper functioning of emulsifying salt. Agitation resulted in homogeneous distribution of the constituents, giving the final product a desired characteristics and physico-chemical stability. It was reported that processing under high heat (e.g., 80-95°C for 4-15 minutes) killed potential pathogenic and spoilage microorganisms, giving the product an extended

shelf-life (Guinee *et al.*, 2004). High cooking temperature and vigorous stirring resulted in the formation of a smooth, homogeneous, stable product (Meyer, 1973).

After packaging, the product was cooled rapidly to 4°C. Cooling helped the homogeneous molten viscous mass to set in its characteristic body through protein-protein interactions, fat crystallization, and interactions between the dispersed emulsified fat globules and the *para-casein* matrix. Storage temperature was set from 18 to 20°C (Tamime *et al.,* 1990; Walstra *et al.*, 2006).

It was observed that processed cheese containing 3% level of emulsifying salts showed the best result ($p<0.05$) in terms of body and texture. Lower level (e.g., 2%) of emulsifying salts resulted in a more brittle product, while higher level (e.g., 4%) of the salt showed a firmer body. Emulsifying salts played a major role in processed cheese making process. The flavor and texture of processed cheese made was quite different from that of Dhaka cheese used, partly due to the high heat treatment, and partly due to the high levels of emulsifying salts added. Emulsifying salt required was~10% of the quantity of protein in the blend, which led to levels of 2 to 3% in the final product (Walstra *et al.*, 2006). Emulsifying salts are not emulsifiers themselves; rather they convert para-casein into an active emulsifying agent. This was accomplished by the partial rehydration, solubilization, and dispersal of the insoluble aggregated para-casein (matrix), the main structural component of rennet cheese, through a series of physico-chemical changes in the presence of high heat and shear (Bowland and Foegeding, 2001). The dispersed droplets of free fat released by heating were then emulsified into small globules as new membranes, made of protein, developed and coated the surfaces of free fat particles (Carić and Kaláib, 1993). Immobilization of a large amount of free water helped to maintain the stability of emulsion (Phillips, 1981; Mulvihill, 1992). The re-hydrated protein thus bond moisture and transformed the rennet casein of natural cheese into a concentrated emulsion in which oil-in-water properly blended with para-caseinate. The rehydration of *para-casein* resulted in an increase in the viscosity of the melting processed cheese mass. This phenomenon is often termed to as *creaming* (Guinee *et al*., 2004). Other changes induced by emulsifying salts include calcium sequestration (lowering the calcium ion activity), upward pH adjustment and stabilization (buffering), emulsification and structure formation (Cavalier-Salou and Cheftel, 1991). These salts raised the pH of processed cheese upwards (typically from ~5.3 in the natural cheese to ~5.8 in the processed cheese). This high pH was stabilized by virtue of high buffering capacity of the emulsifying salts (Marchesseau *et al.,* 1997). Sodium salts of citric or polyphosphoric acids were preferred as the calcium salts of these acids form a little amount of precipitate (Walstra *et al.*, 2006).

Processed cheese made had several advantages over natural Dhaka cheese, as following:

a. Longer shelf-life: This is due to high heat treatment during processing. Nisin can be added to prevent the growth of spoilage microorganisms like *Clostridia*. (Walstra *et al.*, 2006)
b. Uniform look and physical behavior: Rennet cheese of unsatisfactory quality can be manufactured into processed cheese with enhanced market value. Low grade cheese is usually blended with cheese of satisfactory quality, resulting in an acceptable product with uniform quality and appearance (Walstra *et al.*, 2006).

c. Dramatically lower cost: This is due to the use of ingredients that are widely varied and of lower quality and cost.
d. Uniform melting when cooked: The use of emulsifying salt in processed cheese results in a product that melts without separating into a mix of lumpy, molten protein gel and liquid fat when cooked. Because, these salts (typically sodium phosphate, potassium phosphate, tartrate, or citrate) reduce the tendency for tiny fat droplets to coalesce and pool on the surface of the molten cheese. Furthermore, heating does not alter its taste, which is not unlikely in unprocessed cheeses (Anonymous, 2016).

Table 3: Principal parameters of processed cheese made by using different levels of rennet cheese, salt and emulsifying salt

Treatment	Total Score	Moisture (%)	Fat (%)	pH	Meltability (mm)	Streatchability (mm)	Costing (Tk/Kg)
T_{1AX}	80±2	42.8±0.2	30.2±0.2	5.78±0.05	90±3	2.0±0.3	493±2
T_{1AY}	81±2	41.4±0.2	30.4±0.2	5.77±0.05	91±2	1.8±0.3	493±2
T_{1AZ}	81±2	41.0±0.3	30.5±0.2	5.74±0.05	91±2	1.8±0.2	494±2
T_{1BX}	84±2	42.6±0.2	30.1±0.2	5.77±0.02	92±3	1.5±0.2	494±2
T_{1BY}	85±2	41.3±0.1	30.0±0.1	5.77±0.05	94±2	1.5±0.2	494±2
T_{1BZ}	83±2	39.7±0.2	30.9±0.1	5.73±0.05	94±1	1.6±0.3	495±2
T_{1CX}	83±2	42.2±0.2	30.8±0.1	5.76±0.05	93±0	1.4±0.2	495±2
T_{1CY}	83±2	41.1±0.1	30.5±0.1	5.75±0.05	93±2	1.4±0.1	495±2
T_{1CZ}	83±2	39.7±0.3	30.9±0.1	5.75±0.05	95±2	1.3±0.1	497±2
T_{2AX}	88±2	41.7±0.2	30.6±0.1	5.74±0.05	97±3	1.1±0.2	497±2
T_{2AY}	87±2	40.7±0.1	30.9±0.1	5.74±0.05	98±2	1.0±0.1	508±2
T_{2AZ}	87±2	40.1±0.1	31.0±0.1	5.72±0.05	98±2	1.0±0.1	508±2
T_{2BX}	89±2	41.9±0.1	30.7±0.3	5.73±0.02	99±3	1.0±0.2	508±2
T_{2BY}	89±2	40.6±0.1	30.9±0.1	5.72±0.05	99±2	1.0±0.1	509±2
T_{2BZ}	89±2	38.8±0.1	31.2±0.1	5.72±0.05	100±1	0.8±0.1	509±2
T_{2CX}	91±2	41.5±0.1	30.8±0.1	5.73±0.05	102±3	0.7±0.1	510±2
T_{2CY}	90±2	40.6±0.2	30.9±0.1	5.72±0.05	103±2	0.7±0.1	510±2
T_{2CZ}	91±2	39.0±0.3	31.5±0.1	5.71±0.05	103±2	0.7±0.1	511±2
T_{3AX}	90±2	41.1±0.1	30.8±0.1	5.73±0.05	107±3	0.6±0.1	523±2
T_{3AY}	90±2	40.2±0.2	30.8±0.1	5.73±0.05	108±2	0.6±0.1	523±2
T_{3AZ}	89±2	39.5±0.2	30.9±0.2	5.72±0.00	108±2	0.6±0.1	524±2
T_{3BX}	94±2	41.2±0.2	30.7±0.2	5.72±0.05	109±3	0.6±0.1	524±2
T_{3BY}	98±2	40.0±0.2	30.8±0.2	5.71±0.00	112±2	0.5±0.1	525±2
T_{3BZ}	97±2	38.5±0.3	31.9±0.1	5.72±0.05	112±2	0.5±0.1	525±2
T_{3CX}	92±2	41.0±0.2	31.0±0.1	5.70±0.05	114±1	0.5±0.1	526±2
T_{3CY}	91±2	40.1±0.2	31.3±0.1	5.70±0.05	114±2	0.5±0.1	526±2
T_{3CZ}	91±2	38.4±0.2	31.9±0.1	5.70±0.05	115±2	0.5±0.1	527±2
Level of Significance	0.05	0.05	0.05	0.05	0.05	0.05	0.05

As shown in Table 3 the organoleptic evaluation score (out of 100 points) varied significantly ($p<0.05$). The highest score was for the sample T_{3BY} (25% Short + 25% Medium + 50% Long + 3% ES + 3% salt), while the lowest score was obtained by T_{1AX} (50% Short + 25% Medium + 25% Long + 2% ES + 2% salt). The moisture contents of experimental cheese samples ranged from 38.4±0.2 to 42.8±0.2. The moisture level showed significant differences ($p<0.05$). It was evident that as the level of salt and cheese maturity increased, the moisture content decreased. The reverse was evident for fat content. The means for fat content varied significantly ($p<0.05$), with the highest fat percentage for the sample T_{3CZ} (25% Short + 25% Medium + 50% Long + 4% ES + 4% salt). This high fat percentage could be attributed to higher percentages of fat in the rennet cheese. In fact, moisture and fat contents of all the samples were within the range for processed cheese as stated by Mayer (1973). The pH values varied significantly ($p<0.05$), along with decrease in moisture level. The figures for meltability and streatchability were inversely related along with significant differences ($p<0.05$). The costing of the processed cheese samples also varied significantly ($p<0.05$). It was evident that, as the proportion of mature cheese and emulsifying salt in the blend increased, the costing also increased. Considering all the parameters studied, it was evident that sample T_{3BY} (25% Short + 25% Medium + 50% Long + 3% ES + 3% salt) was the best cheese blend. The shelf-life of the products was found to be 117±9 days with best ($p<0.05$) shelf-life for the samples T_{1AZ} and T_{1AX}.

11.3. Determination of cost-effectiveness of the recipe for making processed cheese:

The proposed research aimed at devising a cost-effective recipe of processed cheese made from locally available ingredients. The local ingredients were so chosen as to reduce the price of the product to a breakeven point that gives a profitable margin. While the average wholesale price of processed cheese in the market ranged from Tk. 680 to 990 per kg, the blends in the current experiment cost Tk. 493±2 to 527±2 per kg including wholesale profit and distribution costs. Thus, the developed processed cheese was 25-30% less costly as compared to processed cheese currently sold in the markets of Dhaka and Chittagong city. So, significant ($p< 0.05$) cost reduction could be possible if manufactured locally. Therefore, it could be concluded that processed cheese can successfully be made using locally available ingredients with an international quality. Future research should be focused on diversifying the processed cheese based products and increasing the shelf-life in different packaging consideration. The processed cheese technology should also be disseminated among the milk processor to increase production and product diversity in the dairy industry of Bangladesh.

12. Research highlight/findings:

- Majority (~95.8%) of the processed cheese available in Bangladesh are imported, mostly from Europe, Australia and the Middle East.
- The retail price of processed cheese sold in the markets of Dhaka and Chittagong cities ranged from Tk. 680-990 per Kg depending on brand and country of origin.
- Consumers mostly prefer sliced processed cheese wrapped in individual packs.
- The demand of processed cheese is steadily increasing (~4.4% growth per year) in Bangladesh.
- Processed cheese with medium hardness, moderately streatchable, and strong cheesy flavour was found to be the most preferred.
- Processed cheese blend that was made using the recipe of 25% short ripened, 25% medium ripened and 50% long ripened Dhaka cheese plus 3% emulsifying salt and 3% table salt found to be the best ($p<0.05$ to 0.05).
- The shelf-life of the products was found to be 117±9 days.
- Processed cheese could be successfully made in the pilot scale with a breakeven costing ranging from Tk. 493±2 to 527±2 using locally available ingredients.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	0	0	0	0	
(b) Lab &field equipment	10,00,000	10,00,000	10,00,000	10,00,000	Food Texture Analyzer Purchased
(c) Other capital items	0	0	0	0	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Repair, renovation and maintenance	1,50,000	1,50,000	1,50,000	1,50,000	Cheese processing unit refurbished

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	0	0	0	Not applicable	
(b) Workshop	0	0	0	Not applicable	

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Additional fund to be released/ refunded**
A. Contractual staff salary	4,28,760	3,49,760	3,49,760	79,000	81.6	-
B. Field research/lab expenses and supplies	7,01,240	7,00,528	7,00,528	712	99.9	-
C. Operating expenses	90,000	90,000	90,000	0	100.0	-
D. Vehicle hire and fuel, oil & maintenance	1,00,000	1,00,000	1,00,000	0	100.0	-
E. Training/workshop/ seminar, etc.	0	0	0	0	0	-
F. Publications and printing	1,20,000	93,650	50,000	70,000	41.7	-
G. Contingencies	60,000	57,958	57,958	2,042	96.6	-
H. Capital expenses	10,00,000	9,98,800	9,98,800	1,200	99.9	-
Total	25,00,000	23,90,696	23,47,046	1,52,954	93.9	-

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)**
a) To estimate consumption and the cost of processed cheese in Bangladesh	Market survey was carried out to detect the consumption pattern and retail price	• Majority (~95.8%) of the processed cheese available in Bangladesh are imported, mostly from Europe, Australia and the Middle East. • The retail price of processed cheese sold in the markets of Dhaka and Chittagong cities ranged from Tk. 680-990 per Kg depending on brand and country of origin.	The developed low-cost processed cheese types have a huge prospect in Bangladesh with the market of more than 16

		• Consumers mostly prefer sliced processed cheese wrapped in individual packs. • The demand of processed cheese is steadily increasing (~4.4% growth per year) in Bangladesh. • Processed cheese with medium hardness, moderately streatchable, and strong cheesy flavour was found to be the most preferred.	million people. Although the market is now confined in large cities, mass production and advertisement could easily spread the consumer base in small towns and rural areas.
b) To invent recipes for making processed cheese using locally available ingredients	Trials on different blends of processed cheese ware conducted to detect the best recipe along with compositional and functional analyses	• In total 27 blends of processed cheese were successfully prepared. • Processed cheese blend that was made using the recipe of 25% short ripened cheese, 25% medium ripened cheese, 50% long ripened Dhaka cheese plus 3% emulsifying salt and 3% salt found to be the best ($p<0.05$ to 0.05). • The shelf-life of the products was found to be 117±9 days.	
c) To determine the cost-effectiveness of the recipe for making processed cheese	Costs of the prepared cheeses were calculated to find out the cost-effective blends	• Processed cheese could be successfully made in the pilot scale with a breakeven costing ranging from Tk. 493±2 to 527±2 using locally available ingredients. • The developed processed cheese was 25-30% less costly as compared to processed cheese currently sold in the markets of Dhaka and Chittagong city.	

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

Publication	**Number of publication** **Completed and published**	**Remarks (e.g. paper title, name of journal, conference name, etc.)**
Technology bulletin/ booklet/leaflet/flyer etc.	1 leaflet published	"Processed Cheese" (enclosed)
Journal publication	1 paper submitted & 1 draft prepared	1. "Quality of soft cheese made from different levels of low fat milk" (submitted) 2. "Effect of emulsifying salt on the quality of processed cheese" (draft)
Information development	1 project completion report submitted	"Development of low-cost technology for making processed cheese"
Other publications, if any	1 Masters thesis submitted	"Effect of fat reduction on the quality of soft cheese"

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

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

The recipe for making processed cheese using locally available ingredients has been finalized. The mix was identified as: 25% Short ripened Dhaka cheese + 25% Medium ripened Dhaka cheese + 50% Long ripened Dhaka cheese + 3% Emulsifying Salt + 3% common salt blended in potable water at 85°C for 8 minutes.

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

Use of potato starch as a partial replacement of rennet cheese shows promise of making a low-cost blend. Further research is needed to devise a recipe of processed cheese using potato starch as filler.

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

Leaflets circulated at key markets and industry to increase producer and consumer awareness.

iv. Policy Support

Dairy manufacturers in Bangladesh should focus on the large scale manufacture of this cheap but promising dairy product (Processed cheese).

G. Information regarding Desk and Field Monitoring

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

Monitoring Team	Date of visit	No. of visit	Output
PIU-BARC, NATP-2	12.03.2018	1	Important suggestions regarding financial management and reports preparation

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

Monitoring Team	Date of visit	No. of visit	Output
Technical Team, Livestock Division, BARC	04/03/2018	1	Important suggestions about trials, product quality, and survey

H. Lesson Learned/Challenges (if any)

i) Close contact with the PIU was critical for a smooth operation of the project.
ii) Members from the PIU, the Technical Division, and the Finance Division from the BARC should have made more frequent visits to monitor the project progress.

iii) Principal Investigators of the NATP projects should maintain close liaison to update each other about technical management of the project.

I. <u>Challenges (if any)</u>

1. OTM method for the procurement of capital machinery was found to be difficult.
2. Skilled part-time accountant for the project was scarce.

Signature of the Principal Investigator
Date 12/03/2019
Seal

Counter signature of the Head of the organization/authorized representative
Date 12/03/2019
Seal

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APPENDIX-1: Sample of Leaflet

What is processed cheese!

Processed cheese (also named as prepared cheese, plastic cheese, or cheese singles) is a dairy product made from rennet cheese, to which optional ingredients, plus emulsifiers, extra salt, and food colourings are added followed by cooking in order to get a unique pasteurized cheese variety. As a result, many flavours, colours, and textures of processed cheese exist.

This type of cheese is usually made from different varieties of hard or semi-hard cheese, to which 3-4% emulsifying salt and 25-30% water are added, depending on the chosen type of processed cheese. The proportion of natural cheese as the base ingredient of processed cheese products ranges from 51 to 95%. Optional ingredients permitted may include dairy ingredients (dairy by-products like skim milk powder, cream, whey), non-dairy ingredients (saturated vegetable oils, sugar, spices, herbs, etc.), salts, emulsifying salts, flavours, colours, preservatives and water.

The feasibility of using low quality rennet cheese as the base ingredient and the option of using low-cost ingredients have made the processed cheese a cheap and popular option for the consumers as well as the dairy industry.

Processed cheese

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The long-life cheese!

Processed cheese is produced by melting and emulsifying different varieties of cheese via a thermal process. The cheeses are selected by maturity, moisture content, flavor and fat and, and then grated and mixed with emulsifying salts, milk fat, milk proteins, milk solids and water in different amounts. It is also common to add other ingredients such as starch, synthetic aromas, coloring agents, and spices. Processed cheese contains 10--70% rennet cheese, which contributes not only to taste, but also to the structure, texture and functionality of the processed cheese. Often young cheese is mixed with more ripened cheese in the formulations of the blend.

Thermal treatment is performed in powerful batch cookers, with pasteurization temperatures varying from 80°C to 95°C, which increase the shelf life of the end product. The combination of ingredients and the thermal treatment determines the processed cheese type.

Uses of processed cheese

Processed cheese is used in fast food (e.g., burger, pizza, etc.) or as a spread on bread or as a dip for snacks. It is often consumed as an individual snack, especially by the children. It is considered as a rich source of dietary protein and fat with unique cheesy flavor. Processed cheese is sold in either slices, blocks or spreads.

Textural and functional properties

The most common texture properties of processed cheeses include hardness, cohesiveness, springiness, gumminess and adhesiveness. The most important functional properties are spreadability, shreddability, sliceability, meltability and remeltability. These properties are highly dependent on the type of cheese used and the nature of ingredients added to the blend. Emulsifying salts and stabilizers are often used to create better control of the desired parameters, which have significant effect on the processed cheese.

Altering Processed cheese ingredients
It is possible to adjust the textural and functional properties in processed cheese by altering milk protein content. Change in the ratio of mature and mild rennet cheeses in the formulation also affect the property. The amount of natural cheese needed is often as high as 70% in total.

It is possible to reduce the total amount of rennet cheese below 10%. In that case, artificial cheese flavor should be added to satisfy the consumer. To minimize the cost, other filler agents like starch, soy protein, skimmed milk powder, etc. could be added. The reduction in the proportion of natural cheese often results in a product with lower price. Replacing butter fat in the processed cheese with vegetable oil is also another cost-cutting approach.

Nutrition Facts

Serving Size: 1 slice, NFS (20 g)

Amount Per Serving

Calories from Fat 48		
Calories 69		
		% Daily Values*
Total Fat 5.29g		**8**%
Saturated Fat .	128 g	**16**%
Polyunsaturated Fat	0.233 g	
Monounsaturated Fat	1.515 g	
Cholesterol 17mg		**6**%
Sodium 266mg		**11**%
Potassium 61mg		
Total Carbohydrate 1.64g		**1**%
Dietary Fiber	0.0 g	**0**%
Sugars	1.56 g	
Protein 3.86g		

Note: The composition may vary widely.

Producing low fat products

Low fat processed cheese has a rubbery texture, often associated with a dry mouthfeel and transparent appearance. Use of vegetable fat up to 70% of the fat content plus adjusting the moisture content could give a creamier product with better prices.

Producing low-sodium product

There is a growing trend to reduce the sodium content in processed cheese as much as possible for health conscious consumers. Both emulsifying salts and table salt contribute to sodium content. It is possible to reduce the sodium content by more than 50% by altering the recipe and modification of manufacturing process.

Manufacturing process

It is possible to alter the processed cheese manufacturing process in a way that results in lower cost and better consumer acceptability. The primary objective is to reduce the proportion of natural rennet cheese as the main ingredient with functional milk protein. Part of the milk fat is also replaced by refined vegetable oil. The processing time is thus reduced. Other novel food ingredients like starch and cheese powder can also help to solve some of the major challenges in processed cheese making process.

The total operation is conducted in a twin blade double jacket mixer with thermal control. Blending and cooking is done for few minutes depending on the recipe. The blend is then cooled to 4°C for setting.

Appendix-2: Seller Survey Questionnaire

1. What is your name?

   _____

2. What is your functional title?
   - Salesman
   - Store manager
   - Store owner

3. Are you currently selling processed cheese in your store?
   - Yes
   - No, but we did in the past
   - Not at all

4. How much processed cheese do you sale per week?
   - Less than 10 kg
   - More than 10 kg
   - More than 20 kg
   - More than 30 kg
   - More than 40 kg
   - Other amount (please specify) _____

5. What is the unit cost of processed cheese you sale?

   _____

6. Where do you procure your stock from?
   - Directly from importer
   - From a distributor
   - From wholesalers
   - From an unknown supplier
   - Local manufacturer (please specify) _____

7. What factors make you decide to buy from a certain supplier?
   Quality of the product
   - Dependability of supply
   - Reputation
   - Price of the cheese and potential margin
   - Customers' familiarity with the brand
   - Others (please specify) _____

8. What is the unit cost of processed cheese you buy?

   _____

9. What challenges do you encounter in selling processed cheese?

   _____

   _____

10. What opportunities do you think exist for locally produced processed cheese?

    _____

x

Appendix-3: Consumer Survey Questionnaire

1. What area do you live in?

   _____

2. How frequently do you consume processed cheese?
   - 7 days a week
   - At least weekly
   - Twice per month
   - Once per month
   - Less than once per month
   - Never
3. What type of processed cheese do you prefer?
   - High salted
   - Low salted
   - Spicy
   - Semi-soft
   - Soft
   - Spreadable
4. I like processed cheese because:
   - It's a good source of protein
   - It's a good source of minerals
   - It's low in fat
   - It tastes good
   - It goes well with other foods
   - Other (please specify) _____
5. When purchasing a processed cheese, what do you consider processed?
   - Labeled as processed
   - Known brand
   - Other (please specify) _____
6. Do you purchase other cheeses?
   - No
   - Yes

   If yes, then what variety? _____
7. Where do you buy processed cheese from?
   - Local groceries
   - Grocery chain stores
   - Wholesalers
   - Online
   - Fast food shops
   - Other sources (please specify) _____

Please turn over

8. Which form do you buy processed cheese?
    - Sliced
    - Blocks
    - Spreads
    - Refrigerated
    - Kept in room temperature
9. What type of packaging do you prefer the most?
    - Ploy ethylene wrap
    - Cellophane packs
    - Glass containers
    - It doesn't matter
10. On what occasion do you consume processed cheese?
    - Cooking ingredient
    - Snack
    - Appetizer
    - Used as complement with other foods (i.e. crackers)
    - As topping on the fast foods
11. How important are the following attributes of processed cheese?
    - Taste
    - Made with cow milk
    - Health attributes (fat content, salt content)
    - Price
    - Packaging size
    - Type of packaging
    - Material of packaging
    - Locally manufactured
    - Imported
    - Brand
12. How much more would you be willing to pay for Bangladeshi processed cheese that imported processed cheese?
    - None
    - Less than 20%
    - 20% more
    - 30% more
    - 50% more
    - More than 50%