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# Development and evaluation of fish ball from fish powder supplemented with potato flour

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## Abstract

Fish ball was formulated with fish mince powder supplemented with potato flour along with other ingredients. Higher percentage of fish mince powder contained higher amount of protein, fat and ash but lower amount of total carbohydrate and moisture compared to that containing lower percentage of fish mince powder. The water absorption and frying time increased with the increasing percentage of fish mince powder. Fish balls prepared from the ingredients having 35% fish mince powder had the highest score in flavor rating and fish ball containing 30% fish mince powder had the highest overall acceptability. The scores on color and texture of fish balls prepared from all samples were almost same, but the scores on flavor and over all acceptability varied due to the fishy flavor because some of the panelist disliked the fishy flavor. While studying the storage period, there were no remarkable changes in case of color, flavor and texture of the prepared fish ball. No molds growth was noticed on the storage period of 90 days. So, the percentage of fish mince powder had no influence on the stability of the fish ball at room temperature.

**Keywords:** Potato powder, Fish ball, Mrigal carp, Fish mince powder

## Introduction

Fish is a good source of first class protein and lipid that contains omega-3 fatty acids, especially, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Interestingly, fish is also a good source of various vitamins (A, D, $B_6$, $B_{12,}$ etc.) and minerals such as iron, zinc, iodine, selenium, potassium, sodium, etc. (Kris-Etherton *et al*., 2000). Fish is one of the most valuable commodities among various agricultural products. In developing countries, exported fishes are one of the major sources of foreign revenue. It is not only treated as a food item but also considered as the traditional part while felicitating the guests. Dried fishes are also preferred by many people. Presently fish and fisheries sector contribute 58% of total animal protein intake, 3.78% to GDP, 22.23% to agricultural production and 2.70% of foreign export earning of the nation (DOF, 2010). Bangladesh is the 5$^{th}$ largest inland fisheries producer in the world (FAO, 2016). The present per capita fish consumption is about 18.94 kg of fish per head per year where as 20.44 kg of fish is the standard required amount (BFRSS, 2010).

Being a riverine country, a wide variety of fishes is available in Bangladesh. Among them mrigal is one of the most common, popular and moderately cheap. Mrigal is popular as an important aqua cultured freshwater species as well as a food throughout South Asia. It is widely farmed as a component of a poly culture system of three Indian major carps, along with the rui and the catla. Mrigal is the benthopelagic and potamodromous plankton feeder. It inhabits fast flowing streams and rivers.

Potato (*Solanum tuberosum*) is a starchy, tuberous crop. According to USDA (2008), 100 g of potato contains 19 g carbohydrate, 2 g protein, 0.1 g fat, 2.2 g fiber, 75 g water, 12 mg calcium, 57 mg Phosphorus, 1.8 mg Iron, 23 mg Magnesium, 0.8 mg Thiamin, 4.8 mg Niacin, 20 mg Vitamin C and 320 kJ energy. On the another hand, Gumul *et al*. (2011) reported that 100 g dried potato contained 8.27g protein, 1.11 g fat and 3.98 g ash. The composition of potato flour is: carbohydrate 75.3%, protein 9.1%, fat 0.3% and ash 3.1% (Avula *et al*., 2006).

Different value added products can contribute to the preservation of fish as well as making a difference in the taste. Hence people can be able to enjoy the same product in different forms and different tastes. Among various value added products, fish ball is the most common and tasty one.

The purposes of this study were to analyze the proximate composition of raw and dried mrigal fish, raw and dried potato, and to develop fish ball, powder mixture for fish ball and to assess the storage stability and consumer's acceptability of the developed powder mixture product for fish ball.

## Materials and Methods

The experiment was conducted in the Laboratory of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. Mrigal carp fish and potato were the main raw materials needed for the study. Besides these, onion, garlic, red chili, ginger and cumin were also used. All the materials were collected from the local market. Other materials were used from the laboratory stock.

### Preparation of fish mince

The collected fishes were cut, degutted, beheaded and washed in tap water very well. The bodies of the fishes were cut into pieces. The cut pieces were put into boiled water and cooked for sometimes until the skin from the fleshes became easy to remove. Finally, the water was drained off and the pieces were cooled, and the skin and bones were removed and the fleshes were minced well and dried at 60°C in a mechanical drier.

### Preparation of potatoes mesh

The potatoes were peeled, washed and sliced thinly by using a slicer at a uniform thickness. The pieces were blanched for 2.5 minutes and cooled immediately by running tap water. Then, there were dried in a mechanical dryer until they became crispy.

### Preparation of onion, garlic, ginger and cumin seed powder

The collected onion, garlic and ginger were peeled, washed and cut into small longitudinal pieces by a knife and dried into the mechanical drier at temperature of 60°C. The cumin seeds were grounded well.

### Formulation of fish ball powder mix

The formulations powder mixture for preparation of fish balls are presented in the Table 1. Four samples were prepared. For each sample, the percentages of spices were 15% and it was always kept constant. The percentage of fish powder was 35%, 40%, 45% and 50% in the sample $S_A$, $S_B$, $S_C$ and $S_D$, respectively. All the ingredients: dried fish mince, dried potato mesh, onion, garlic, ginger, red chili and cumin were weighed accurately. Finally, the weighed materials were taken in a grinder and grinded well, and stored it for further use.

**Table 1. Basic formulation of 100 g powder mixture for fish ball**

| Ingredients (g) | Samples | | | |
|---|---|---|---|---|
| | $S_A$ | $S_B$ | $S_C$ | $S_D$ |
| Fish | 45 | 40 | 35 | 30 |
| Potato | 40 | 45 | 50 | 55 |
| Onion | 6 | 6 | 6 | 6 |
| Garlic | 4 | 4 | 4 | 4 |
| Ginger | 3 | 3 | 3 | 3 |
| Red chilli | 1.5 | 1.5 | 1.5 | 1.5 |
| Cumin | 0.5 | 0.5 | 0.5 | 0.5 |

### Preparation of fish ball and frying

One hundred (100) gram of powder for fish ball for each sample was taken, and required amount of water and salt were added to make dough. Small balls were made from the prepared dough. The prepared balls were coated with egg white and then they were fried in vegetable oil (soybean oil) until they became golden brown.

### Chemical analysis

The raw fish and dried fish, the raw potato and dried potato, and the prepared powder samples for fish ball were analyzed for moisture, protein, fat and ash content by AOAC (2004) and AOAC (2012) methods.

The percentage of moisture content in food sample was calculated as follows:

$$\%\,\text{Moisture} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

The ash content is expressed as:

$$\%\,\text{Ash} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

Percentages of nitrogen and protein were calculated by the following equation:

$$\%\,\text{Nitrogen} = \frac{[(T)]_s - T_b) \times \text{Normality of HCl} \times \text{Meq. of } N_2}{\text{Weight of sample (g)}} \times 100$$

Where, $T_s$ = Titre volume of the sample (ml), $T_b$= Titre volume of the blank (ml), Meq. of $N_2$=0.014
Therefore, % Protein= % Nitrogen $\times$ 6.25

The percentage of fat was calculated by the following equation:

$$\%\,\text{Crude fat} = \frac{\text{Weight of the ether - soluble material}}{\text{Weight of sample}} \times 100$$

Total carbohydrate content of the samples was determined as total carbohydrate by subtracting the measured protein, fat, ash and moisture content from 100 (Srivastava and Sanjeev, 2002).

### Storage studies of powder mixture for fish ball

The prepared powder samples for fish ball were stored at ambient temperature and at 79–87% relative humidity (RH) for period of 90 days. The stored powder samples were analyzed at 15 days interval up to 90 days. During storage, the changes in moisture content, texture, color and flavor were observed.

### Sensory evaluation

To assess the consumer's acceptability of the developed fish ball, the fried fish balls were evaluated by a testing panel. The panelists were selected from the students, teachers and employees of the Department of Food Technology and Rural Industries. The panelists (10) were asked to assign appropriate score to each product tested on a 1 to 9 point hedonic scale (Singh, 2002) for the characteristics of color, flavor, texture and overall acceptability of the fried fish ball prepared from the dried fish ball powder. The scale was arranged as: 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; 1 = dislike extremely.

### Statistical analysis

The hedonic rating test was performed to assess the degree of acceptability of fish ball containing different levels of fish and potato. The results were evaluated by analysis of variance and Duncan's New Multiple Range Test procedures of the Statistical Analysis system (SAS, 1985).

## Results and Discussion

### Composition of raw mrigal fish, dried mrigal fish, raw potato and dried potato powder

The proximate compositions of raw mrigal fish, dried mrigal fish, raw potato and dried potato powder were analyzed for moisture, protein, fat, ash and total carbohydrate content in both wet weight basis and dry weight basis. The results are given in Table 2. The raw mrigal fish contained 77.82% moisture, 17.45% protein, 2.03% fat, 1.47% ash and 1.61% total carbohydrate in wet weight basis. Usually moisture and lipid contents in fish fillets are inversely related and their sum is approximately 80% (FAO, 1999). According to Ahmed *et al.* (2012), mrigal carp contains 70.23% moisture, 17.16% protein, 1.95% fat and 1.66% ash, respectively. On the other hand, the dried fish had 6.68% moisture, 67.87% protein, 9.51% fat, 2.94% ash and 13.12% total carbohydrate in wet weight basis. These results are closely related to the composition of dried silver carp powder found by Rahman *et al.* (2012). They found 7.89% moisture content, 64.98% protein, 13.87% fat and 2.97% ash content.

**Table 2. Proximate compositions of raw fish, raw potato and dried mrigal carp powder**

| Components | Raw fish | | Dried fish | | Raw potato | | Dried potato powder | |
|---|---|---|---|---|---|---|---|---|
| | wb | db | wb | db | wb | db | wb | db |
| Moisture (%) | 77.82 | 350.86 | 6.68 | 7.16 | 78.77 | 371.03 | 8.84 | 9.7 |
| Protein (%) | 17.45 | 78.67 | 67.87 | 73.8 | 1.46 | 6.88 | 6.63 | 7.10 |
| Fat (%) | 2.03 | 9.06 | 9.51 | 10.13 | 0.12 | 0.57 | 0.93 | 1.02 |
| Ash (%) | 1.47 | 6.62 | 2.94 | 3.15 | 0.65 | 3.06 | 2.3 | 2.52 |
| Total carbohydrate (%) | 1.61 | 7.26 | 13.12 | 14.06 | 18.9 | 89.02 | 81.4 | 89.29 |

The moisture, protein, fat, ash and total carbohydrate content in the potato tubers were 78.77%, 1.46%, 0.12%, 0.65% and 18.9%, respectively. The potato contains 19% carbohydrate, 2% protein, 0.1% fat, 2.2% fiber and 75% water (USDA, 2008). The dried potato powder contained 8.84% moisture, 6.63% protein, 0.93% fat 2.3% ash and 81.4% carbohydrate. Avula *et al.* (2009) found the composition of potato flour as carbohydrate 75.3%, protein 9.1%, fat 0.3% and ash 3.1%. Gumul *et al.* (2011) reported that 100g dried potato contained 8.27% proteins, 1.11% fats and 3.98% ash.

### Composition and energy value of prepared powder mixture for fish ball

The four different samples of powder for fish ball such as $S_A$, $S_B$, $S_C$, and $S_D$ were analyzed for moisture, protein, fat, ash and total carbohydrate content. The results are presented in Table 3. The sample $S_A$ contained 6.38% moisture, 38.69% protein, 4.49% fat, 2.89% ash and 47.55% total carbohydrate. The $S_A$ contained higher amount of protein (38.69%), fat (4.49%) and ash (2.89%) than the other samples. The sample $S_D$ contained higher amount of total carbohydrate (58.16%) than the other samples.

In dry weight basis, sample $S_A$ contained 6.81% moisture, 41.33% protein, 4.8% fat, 3.1% ash and 50.79% total carbohydrate; sample $S_B$ contained 6.86% moisture, 37.68% protein, 4.52% fat, 3.03% ash and 54.77% total carbohydrate; sample $S_C$ contained 6.93% moisture, 35.13% protein, 3.98% fat, 2.97% ash and 57.92% total carbohydrate and sample $S_D$ contained 7.03% moisture, 31.11% protein, 3.71% fat, 2.92% ash and 62.25% total carbohydrate. The samples containing higher proportion of fish mince powder had higher calorie value than the samples those containing lower amount of fish mince powder.

**Table 3. Composition and energy value of prepared powder mixture for fish ball**

| Components | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *$S_A$ | | $S_B$ | | $S_C$ | | $S_D$ | |
| | wb | db | wb | db | wb | db | wb | db |
| Moisture (%) | 6.38 | 6.81 | 6.42 | 6.86 | 6.48 | 6.93 | 6.57 | 7.03 |
| Protein (%) | 38.69 | 41.33 | 35.26 | 37.68 | 32.85 | 35.13 | 29.07 | 31.11 |
| Fat (%) | 4.49 | 4.8 | 4.23 | 4.52 | 3.72 | 3.98 | 3.47 | 3.71 |
| Ash (%) | 2.89 | 3.10 | 2.84 | 3.03 | 2.78 | 2.97 | 2.73 | 2.92 |
| Total carbohydrate (%) | 47.55 | 50.79 | 51.25 | 54.77 | 54.17 | 57.92 | 58.16 | 62.25 |
| Calorie value per 100 g | 385.37 | | 384.11 | | 381.56 | | 380.15 | |

*$S_A$ = Powder with 45% dried fish, 40% dried potato and 15% spices; $S_B$ = Powder with 40% dried fish, 45% dried potato and 15% spices ; $S_C$ = Powder with 35% dried fish, 50% dried potato and 15% spices and $S_D$ = Powder with 30% dried fish, 55% dried potato and 15% spices.

**Composition and energy value of fried fish balls prepared from powder mixture**

The fried fish balls from powder mixture were analyzed for their moisture, protein, fat, ash, total carbohydrate content and energy value. The results are given in Table 4. The sample $S_D$ contained higher amount of moisture (45.49%) and total carbohydrate (19.65%) than the other samples. On the other hand, the sample $S_A$ contained higher amount of protein (27.51%), fat (17.74%) and ash (3.37%) than the other samples. When the nutritive value of dry matter of the fish ball samples and the fried samples were compared, it was observed that the fried fish balls contained significantly higher amount of fat and protein and lower amount of carbohydrate. Though, the protein content (dry weight basis) should be lower than that of the powder mixture as protein might be denatured. It absorbed considerable amount of fat during frying but here it increased. It may happen as a result of coating the fish balls with egg white prior to frying and experimental inaccuracy. The moisture content increased and the calorie values decreased. Deep-fat frying involves immersion of food in hot edible oil at a temperature above the boiling point of water for a given period of time (Farkas *et al*., 1996). The process involves both mass transfer (mainly represented by water loss and oil uptake) and heat transfer (Vitrac *et al*., 2002). Fat uptake is considered the major nutritional critical point of deep-fat frying because; it causes obesity and had negative effects of excess oil consumption on human health. The amount of fat is the major concern in fried products. Fat uptake varies depending upon various factors, e.g. oil viscosity, porosity of the product, interfacial tension between oil and air, frying temperature, frying time, etc.

**Table 4. Composition and energy value of fried fish balls prepared from powder mixture**

| Components | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *$S_A$ | | $S_B$ | | $S_C$ | | $S_D$ | |
| | wb | db | wb | db | wb | db | wb | db |
| Moisture (%) | 44.98 | 81.75 | 45.23 | 82.58 | 45.37 | 83.05 | 45.49 | 83.45 |
| Protein (%) | 27.51 | 50.00 | 24.78 | 45.24 | 22.68 | 41.52 | 20.89 | 38.32 |
| Fat (%) | 17.74 | 32.24 | 15.69 | 28.65 | 13.24 | 24.24 | 11.78 | 21.61 |
| Ash (%) | 2.37 | 4.31 | 2.29 | 4.18 | 2.22 | 4.06 | 2.19 | 4.02 |
| Total carbohydrate (%) | 7.4 | 13.45 | 12.01 | 21.93 | 16.49 | 30.18 | 19.65 | 36.05 |
| Calorie value per 100 g | 299.3 | | 288.37 | | 275.84 | | 268.18 | |

*$S_A$ = fish ball with 45% dried fish, 40% dried potato and 15% spices; $S_B$ = fish ball with 40% dried fish, 45% dried potato and 15% spices ; $S_C$ = fish ball with 35% dried fish, 50% dried potato and 15% spices and $S_D$ = fish ball with 30% dried fish, 55% dried potato and 15% spices.

### Storage studies of prepared powder mixture for samples fish ball

The prepared powder mixture for fish ball was stored at a temperature of 32–37$^{o}$C and 79–87% RH (Table 5). The moisture contents were 6.38% for sample $S_A$, 6.42% for sample $S_B$, 6.48% for sample $S_C$ and 6.87 for sample $S_D$. Moisture content gradually increased from the 1$^{st}$ day to 90$^{th}$ day of preservation. After 90 days of storage, the moisture content became 8.37% for $S_A$, 8.56% for $S_B$, 8.71% for $S_C$, 8.94% for $S_D$. There was no remarkable change of color, flavor and texture after 90 days. The color and flavor were good and the texture was also free flowing after 90-day observation. No mold growth was detected during the storage period of 90 days.

**Table 5. Storage studies of prepared fish ball powder mix samples**

| Storage condition | Storage period (days) | Samples | Observations | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Moisture content (%) | Color | flavor | texture | Mold growth | Remarks |
| Ambient temperature (32-37°C) and 79 to 87% RH | 0 | *$S_A$ | 6.38 | Very good | Very good | Free flowing | No | Very good |
| | | $S_B$ | 6.42 | Very good | Very good | Free flowing | No | Very good |
| | | $S_C$ | 6.48 | Very good | Very good | Free flowing | No | Very good |
| | | $S_D$ | 6.57 | Very good | Very good | Free flowing | No | Very good |
| | 15 | $S_A$ | 6.57 | Very good | Very good | Free flowing | No | Very good |
| | | $S_B$ | 6.73 | Very good | Very good | Free flowing | No | Very good |
| | | $S_C$ | 6.77 | Very good | Very good | Free flowing | No | Very good |
| | | $S_D$ | 6.89 | Very good | Very good | Free flowing | No | Very good |
| | 30 | $S_A$ | 7.39 | Very good | Very good | Free flowing | No | Very good |
| | | $S_B$ | 7.45 | Very good | Very good | Free flowing | No | Very good |
| | | $S_C$ | 7.64 | Very good | Very good | Free flowing | No | Very good |
| | | $S_D$ | 7.72 | Very good | Very good | Free flowing | No | Very good |
| | 60 | $S_A$ | 7.92 | Very good | Very good | Free flowing | No | Very good |
| | | $S_B$ | 7.93 | Very good | Very good | Free flowing | No | Very good |
| | | $S_C$ | 7.98 | Very good | Very good | Free flowing | No | Very good |
| | | $S_D$ | 8.15 | Very good | Very good | Free flowing | No | Very good |
| | 90 | $S_A$ | 8.37 | Very good | Very good | Free flowing | No | Very good |
| | | $S_B$ | 8.56 | Very good | Very good | Free flowing | No | Very good |
| | | $S_C$ | 8.71 | Very good | Very good | Free flowing | No | Very good |
| | | $S_D$ | 8.94 | Very good | Very good | Free flowing | No | Very good |

***$S_A$** = fish ball powder with 45% dried fish, 40% dried potato and 15% spices; **$S_B$** = fish ball powder with 40% dried fish, 45% dried potato and 15% spices ; **$S_C$** = fish ball powder with 35% dried fish, 50% dried potato and 15% spices and **$S_D$** = fish ball powder with 30% dried fish, 55% dried potato and 15% spices

### Water absorption and frying characteristics of powder samples for fish ball

The four different samples were analyzed for the water absorption and frying characteristics (Table 6). The sample $S_A$ absorbed the highest amount of water (151 g) followed by sample $S_B$ (136 g), $S_C$ (129 g) and $S_D$ (117 g). Ramirez *et al*. (2003) reported that high values of water absorption index indicated low starch degradation during cooking. So, the percent of water absorption by the samples is inversely proportional to the amount of starch in the samples, which perfectly matched with our results. Twelve balls of same diameter (about 0.75 inch) were made from each sample. The lowest frying time was 6 min for the sample $S_C$ and $S_D$. The highest frying time required for sample $S_A$ was 8 minutes.

**Table 6. Water absorption and frying time of fish ball prepared from fish ball powder mix**

| Samples | Weight of dried powder (g) | Weight of dough (g) | Water absorption (g) | Number of balls made from 100 g powder | Frying time for one ball (min) |
|---|---|---|---|---|---|
| *$S_A$ | 100 | 251 | 151 | 12 | 8 |
| $S_B$ | 100 | 236 | 136 | 12 | 7 |
| $S_C$ | 100 | 229 | 129 | 12 | 6 |
| $S_D$ | 100 | 217 | 117 | 12 | 6 |

***$S_A$** = fish ball powder with 45% dried fish, 40% dried potato and 15% spices; **$S_B$** = fish ball powder with 40% dried fish, 45% dried potato and 15% spices ; **$S_C$** = fish ball powder with 35% dried fish, 50% dried potato and 15% spices and **$S_D$** = fish ball powder with 30% dried fish, 55% dried potato and 15% spices.

### Sensory evaluation of the fried fish balls

The color, flavor, texture and overall acceptability of four samples of fish balls prepared from fish ball powder mixture were evaluated by taste testing panel and the mean scores for color, flavor, texture and overall acceptability of different samples are presented in Table 7. There was no significant difference for colour among all samples. For flavor, sample $S_C$ attained the highest score (8.2) but sample $S_A$ got the lowest (6.3), the difference was significant. On the other hand, sample $S_C$ and sample $S_D$ did not differ significantly. Therefore, flavor of fish ball prepared from fish ball powder containing lower quantity of fish powder were more preferable to the panelists. There was no significant difference for texture among all samples. The highest score for over all acceptability was gained by the sample $S_D$, (8.2) and sample $S_B$ gained the lowest score (6.3). The samples $S_D$ and $S_C$ were more acceptable than the other samples at 5% level of significance.

**Table 7. Mean sensory scores of fish ball prepared fish ball powder mix**

| Samples | Sensory attributes | | | |
|---|---|---|---|---|
| | Color | Flavor | Texture | Overall acceptability |
| *$S_A$ | $8^a$ | $6.3^b$ | $6.9^a$ | $6.4^b$ |
| $S_B$ | $8^a$ | $6.4^b$ | $7^a$ | $6.3^b$ |
| $S_C$ | $8.3^a$ | $8.2^a$ | $7.3^a$ | $7.8^a$ |
| $S_D$ | $7.9^a$ | $8^a$ | $7^a$ | $8.2^a$ |
| LSD value; P<0.05 | 0.661 | 0.831 | 0.492 | 0.721 |

***$S_A$** = fish ball powder with 45% dried fish, 40% dried potato and 15% spices; **$S_B$** = fish ball powder with 40% dried fish, 45% dried potato and 15% spices ; **$S_C$** = fish ball powder with 35% dried fish, 50% dried potato and 15% spices and **$S_D$** = fish ball powder with 30% dried fish, 55% dried potato and 15%.

## Conclusion

It may be concluded that the formulations of sample $S_C$ and $S_D$ were more acceptable to the consumers and sample $S_D$ was better, but from the nutritional point of view, the formulation of sample $S_C$ may be accepted as it contains higher amount of protein and energy than sample $S_D$. Further studies may include detailed analysis of nutritional constituents and functional properties of fish ball powder mixture.

## References

Ahmed, S., Rahman, A.F.M.A., Mustafa, M.G., Hossain, M.B. and Nahar, N. 2012. Nutrient composition of indigenous and exotic fishes of rainfed waterlogged paddy fields in Lakshmipur, Bangladesh. World Journal of Zoology, **7**(2):135–140.

AOAC. 2004. Official Method of Analysis. Association of Official Agricultural Chemist. 12th Ed. Washington, D.C., USA.

AOAC. 2012. Official Method of Analysis. Association of Official Agricultural Chemist.12th Ed. Washington, D.C., USA.

Avula, R.Y., Guha, M., Tharanathan, R.N. and Ramteke, R.S. 2006. Influence of drying conditions on functional properties of potato flour. European Food Research Technology, 233:533–560.

BFRSS. 2010. Fishery Statistical Year Book of Bangladesh, 2008-2009. Bangladesh Fisheries Resource Survey System, Department of Fisheries, Dhaka, Bangladesh.

DOF. 2010. Fisheries Statistical Year Book of Bangladesh 2009–2010. Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock.

FAO. 1999. World Production of Fish, Crustaceans and Mollusks by Major Fishing Areas. Fisheries Information and Data and Statistics Unit. (FIDI), Fisheries Department, Food and Agricultural Organization of the United Nations , Rome.

FAO. 2016. Food and Agriculture Organization of the United Nations, The State of World Fisheries and Aquaculture, 2016.

Farkas, B.E., Singh, R.P. and Rumsey, T.R. 1996. Modeling heat and mass transfer in immersion frying. Journal of Food Engineering, 29:211–226.

Gumul, D., Ziobro, R., Noga, M. and Sabat, R. 2011. Characterisation of five potato cultivars according to their nutritional and pro-health components. Acta Sci. Pol., Technol. Aliment, 10(**1**):73–81.

Kris-Etherton, P.M., Taylor, D.S., Yu- poth, S., Huth, K., Moriarty, K., Fishell, V., Hargrove, R.L., Zhao, G. and Etherton, T.D. 2000. Polyunsaturated Fatty Acids in the Food Chain in The United States. American Journal of Clinical Nutrition 71**:** 179–188.

Rahman, M., Saifullah and Islam, M.N. 2012. Fish powder in instant fish soup mix. MS Thesis. Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Ramirez, A., Silva, B.J.T., Euzebio, N.R. and Ramirez, A.D.P. 2003. Functional properties of precooked macaroni based on raw quinoa flour (*Chenopadium quina* wild) and rice flour (*Oryza sativa*). Alimentaria 40(342): 71–75

SAS. 1985. SAS users guide: Statistics, Version 5th edition. SAS Institute Inc., Cary, NC.

Singh, R. 2002. Hand Book of Analysis of Quality Control for Fruit and Vegetables Products. Second edition Tata Me Graw Hill pub. Co. Ltd., New Delhi.

Srivastava, R.P. and Sanjeev, K. 2002. Fruit and Vegetable Preservation Principles and Practices. Third Revised and Enlarged Edition, International Book Distribution Co. 3653–364.

USDA. 2008. Nutrient data for potato. United States Department of Agriculture, National Nutrient Database for Standard Reference, Retrieved July 2008.

Vitrac, O., Dufour, D., Trystram, G. and Raoult-Wack, A.L. 2002. Characterization of heat and mass transfer during deep-fat frying and its effect on cassava chip quality. Journal of Food Engineering, 53(2):161–176.