STUDY ON THE PREPARATION OF RICE AND NOODLES FROM COMPOSITE FLOUR (POTATO, RICE AND WHEAT FLOUR)

A THESIS

BY

MD. ABDUL MOMIN SHEIKH
Student No.: 1105039
Session: 2011-12
Semester: January – June/ 2012

MASTER OF SCIENCE (MS)
IN
FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
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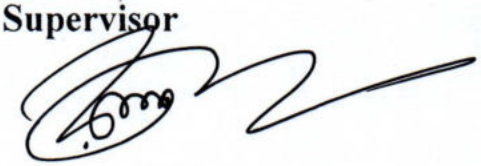
Supervisor



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DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

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DEDICATED TO
MY BELOVED PARENTS

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ABSTRACT

The present study was concerned with the preparation of potato flour with various treatments and formulation of rice and noodles incorporating potato flours as supplement to wheat flour. Four types of potato flours were prepared by treating the raw potato slices as blanched, blanched plus potassium meta- bisulphite (KMS), boiled and smashed and one as control without any treatment. Only blanched plus KMS treated potato flour was used because its colour and flavour was good. Various substitution levels such as 0, 10, 20, 30 and 40% of potato flour was used in the formulations of rice and noodles in conjunction with wheat flour. The raw potato, potato flour, wheat, wheat flour, rice, rice flour, prepared rice and noodles were analyzed for their composition. The organoleptic qualities of developed rice and noodles were assessed. The prepared rice and noodles containing various levels of potato flour were evaluated for their sensory attributes by a panel of ten (10) panellists. The results revealed that the colour, flavour, texture and overall acceptability of prepared rice containing 30% potato flour were significantly different from that of others and secured the highest scores in terms of all quality attributes and ranked as 'like moderately' to 'like very much'. The noodles containing 30% potato flour were most preferred for colour than the noodles containing various levels of potato flour and control noodles. Noodles with (control) 0% potato flour had least colour acceptability. The flavour, texture and overall acceptability of noodles containing 20% potato flour were significantly different from that of others and secured the highest scores in terms of all quality attributes and ranked as 'like moderately' to 'like very much'.

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CHAPTER I

INTRODUCTION

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the unique and most potential crops having high productivity, supplementing major food requirement in the world. It is rich in carbohydrates, proteins, phosphorus, calcium, vitamin C, β carotene and has high protein calorie ratio. Amongst the world's important food crop, potato is the fourth important food crop after wheat, rice and maize because of its' great yield potential and high nutritive value. The ratio of protein to carbohydrate is higher in potato than in many cereals and other tuber crops (Marwaha, 1999).

Potato is edible tuber of the cultivated plant *Solanum tuberosum* of the family Solanaceae. It is now one of the staple foods in Bangladesh. Most varieties are cultivated during the winter in all the districts of Bangladesh and harvested February-March. Of the total 401,850 hectares of land used for potato cultivation during 2007-2008, 81,370 hectares for local and 320,480 hectares for high yielding varieties. The gross production of potato during 2007-2008 was 6.65 million MT (BBS, 2008).

Potato is a semi perishable crop and spoils easily in humid sub tropic region. This is unlike the cereal crop that is harvested, dried and stored. Hence preservation methods of cereal crops could not be practiced in potato because of their high percentage of moisture content. At the same time the climatic condition of Bangladesh is also a barrier for this type of preservation. Cold storage practice may be followed but the numbers of usable cold storages are not sufficient. There are about 350 cold storages which have about 2.40 million MT of storage capacity and can accommodate only about 36% of the total production (BBS, 2008).

On the other hand, it is an expensive method of preservation. For inadequate storage facility and high cost of cold storage, potato sells at very low price during harvesting season though its price increase 2-3 times higher in off-season.

Sometimes the farmers heap their potatoes in the field and in their dwelling house where the potatoes sprouted and rotted or decayed due to high humidity and temperature, the potato become unacceptable to the consumers and the farmers loses their produce. The farmers are financially at a loss and eventually they become disinterested. Hence, the utmost duties and responsibilities of the post-harvest crop processors, researchers,

investigators and post harvest crop scientists are to find out the means and ways to preserve this potato for future use. Tubers and roots are important sources of carbohydrates as an energy source and are used as staple foods in tropical and sub tropical countries (Liu et al., 2006).

Rice is the staple food for more than half the population in the world and is becoming popular in other parts of the world as well. There are almost 25,000 varieties of rice all over the world, but the most commonly consumed ones are white rice and brown rice.

Processing is a fast growing factor within world potato economy. Due to the increased demand for convenience food and the expanding institutional market, the consumption of processed potato products is of increasing importance. The most popular processed products of potato are chips, French fries, powder, cubes, slices, starch. Processing is mainly confined to developed countries and it is only in its infancy stage in most of the developing countries with the exception of China (12%), Korea (6%) and Mexico (8%). Currently about half of the annual crop in the USA is processed.

Bangladeshi people love rice. Sometimes, particularly in villages, people consume rice three times a day. But the national production of rice is not enough to fulfill the current demands. Also the price of rice is high. On the other hand there is enough production of potato beyond the capacity of the cold storages existing in Bangladesh (only 36%). If potato could be consumed as a replacement of rice, the pressure on rice could be reduced and potato consumed at peak season would help farmers getting good price for their products. Farmer would be encouraged to maximize production, which would go a long way in solving the overall food deficit currently faced by the country.

This is where the potato will step in. If a product could be developed from potato which have energy, carbohydrate, protein and fat close to that of rice, it could be consumed as a replacement of rice or at least reduce the pressure on rice. Therefore, this research work is expected to develop a product from the mixture of potato, wheat and rice that can be used as alternative to rice for needy people.

Objectives of the Research Work:

With the above views in mind the present study was undertaken to achieve the following objectives:

i. To determine the proximate composition of potato, rice and wheat.

ii. To prepare potato flour and rice flour.

iii. To prepare composite flour from potato, rice and wheat flour.

iv. To develop rice and noodles from composite flour.

v. To determine the proximate composition of prepared rice and noodles.

vi. To asses the overall acceptability of prepared rice and noodles.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literature was reviewed on the following aspects with respect to the proposed research work.

2.1 Potato and its importance

2.1.1 Production of potato

Potato is one of the major food crops of the world. It ranks fourth in its importance after rice, wheat and maize. Potato is one of the important food crops of Bangladesh. It is considered as a vegetable in this country, and contributes alone as much as 55% of the total annual vegetable production (Anonymous, 1996).

Potato is now-a-days commercially grown in almost all countries of the world. At present the crop is being cultivated in a total area of 19455 thousand hectares of land producing 301552 thousand tons of potato annually in the world (Anonymous, 1993).

In Bangladesh, potato is taken as a vegetable supplement to rice and this greatly improves the nutritive value of the diet. This improvement occurs due to the fact that potato supplies lysine, the limiting essential amino acid of cereals while the cereals, in turn, supply cystine and methionine, the limiting essential amino acids of potato (Islam, 1980).

In Bangladesh, potato is a crop of great economic significance. The crop is grown during winter months when most of the lands remain fallow. Thus it, competes with any other crop for land in the existing cropping pattern of the country is not significant. In Bangladesh, area used for potato cultivation and production of potatoes from 2000-01 to 2010-11 are shown in table 2.1

The potato varieties introduced in the Asian-sub-continent in early 17^{th} century were subjected to environmental factor and lost their original characteristics and identity. These degenerated varieties are now known as indigenous varieties. Indigenous potato varieties differ from one another in several characteristics. An intimate knowledge of these characters is necessary for identifying a particular variety.

Table 2.1 Cultivated area and Production of potatoes in Bangladesh

Year	Cultivated area (Thousand acres)	Production (Thousand M. tons)	Per acre yield (M. tons)
2000-01	615	3216	5.22
2001-02	587	2994	5.10
2002-03	606	3386	5.58
2003-04	669	3908	5.84
2004-05	806	4856	6.02
2005-06	744	4161	5.59
2006-07	853	5167	6.05
2007-08	993	6648	6.69
2008-09	977	5268	5.39
2009-10	1073	7930	7.39
2010-11	1137	8326	7.32

Source: Statistical Year Book of Bangladesh, 2008, 2011

A large number of indigenous potato varieties are grown in different parts of Bangladesh. Some of these varieties give reasonably high yields, and have desirable characteristics, which could possibly be used in varietals improvement. But the indigenous varieties grown in Bangladesh have not yet been described and characterized properly. There also exists a considerable confusion in nomenclature and identifying the varieties.

The world potato sector is undergoing major changes. Until the early 1990s, most potatoes were grown and consumed in Europe, North America and countries of the former Soviet Union. Since then, there has been a dramatic increase in potato production and demand in Asia, Africa and Latin America, where output rose from less than 30 million tones in the early 1960s to more than 165 million tones in 2007. FAO data show that in 2005, for the first time, the developing world's potato production exceeded that of the developed world. China is now the biggest potato producer, and almost a third of all potatoes are harvested in China and India.

Table 2.2 Top potato producers in the world, 2007

Countries	Quantity (tones)
1. China	72 040 000
2. Russian Fed.	36 784 200
3. India	26 280 000
4. United States	20 373 267
5. Ukraine	19 102 300
6. Poland	11 791 072
7. Germany	11 643 769
8. Belarus	8 743 976
9. Netherlands	7 200 000
10. France	6 271 000
Source: FAOSTAT	

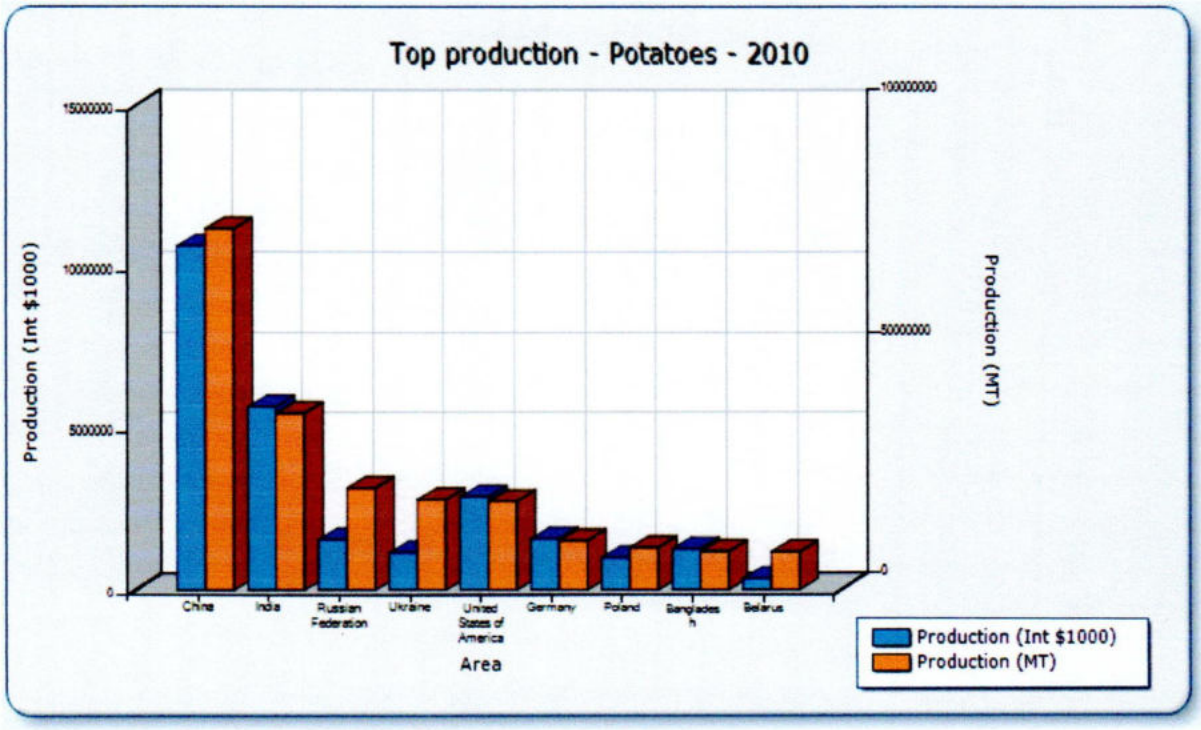


Figure 2.1 Top potato producers in the world, 2010

Ahmed and Kader (1981) reported that some indigenous varieties produced a good yield when uniform seed rate by weight was used. They reported that some varieties such as Dohazari Shada and Futke produced as much as 19.6 and 16.7 tons of tubers per hectare, respectively. Other varieties like Madraji, Dohazarilal, Lal Kaberi, Lal Madda, Basualal and Shilbilati produced acceptable yields. Most of the indigenous varieties produced much smaller tubers in the grade below 28mm, but surjamuki was very close to Kufri Sindhuri in respect of grades (Khan *et al.*, 1981). Other recommended high yielding varieties are Kufri Chamiatkar, Kufri Sindhuri, Kufri Chandramukhi , Kufri Alankar,

Kufri Kuber, Kufri Red, Kufri Safaid, kufri Kundan, Kufri Kisan, kufri Neela, Kufri Sheetman, kufri Deva, for plains and Kufri Jyoti, Craigs Defiance, Kufri Jeevan, Kufri Neelmani. Kufri Nakin, Kufri Khasigaro for hills.

Table 2.3 Top potato producers in the world, 2010

Rank	Area	Production (MT)
1	China	74799084
2	India	36577300
3	Russian Federation	21140500
4	Ukraine	18705000
5	United States of America	18337500
6	Germany	10201900
7	Poland	8765960
8	Bangladesh	7930000
9	Belarus	7831110
10	France	7216210
11	Netherlands	6843530
12	United Kingdom	6056000
13	Turkey	4548090
14	Canada	4421770
15	Iran (Islamic Republic of)	4054490
16	Peru	3814370
17	Malawi	3673540
18	Egypt	3643220
19	Brazil	3547510
20	Belgium	3455800

Source: FAOSTAT

2.2 Potato processing and preservation

2.2.1 Potato processing

Potatoes were washed by dipping them into water at 15^{0}C for 5 min, peeled by means of an automatic mechanical peeler (Aurea, Bologna, Italy) and then cut into 1 cm sided cubes by a three blades cutter (Bertuzzi, Milano, Italy). Afterwards, the cubes were submitted to either thermal or chemical or mechanical preliminary treatment (Carillo et al., 2009). Thermal treatment (blanching) consisted in heating cubes immersed in water at 100^{0}C for 3 min and then cooling them in water at 15^{0}C for 1 min. Chemical treatments were performed by dipping cubes in water solutions containing either 1% citric acid or 1% lactose, 0.5% citric acid or 5000 p.p.m. NaHSO4 at room temperature for 3 min. In mechanical treatments, cubes were processed at pressures of either 400 or 600 MPa at 15^{0}C for 10 min in a high hydrostatic pressure plant (FLOW, Columbus, OH, USA). Only

the cubes submitted to thermal treatment were smashed by means of a rotating extractor (Bertuzzi, Milano, Italy) obtain potato puree. For potato powder production a single-drum dryer (Gouda, The Netherlands) was used. The potato puree was spread as a thin layer on the surface of the rotating drum with the aid of four applicator rolls rotating in the opposite sense. The drum surface, heated by steam under pressure condensed inside it, dried the puree layer removing water just in the time corresponding to a drum rotation. The obtained dry layer was then cut by a still blade and discharged by means of proper rolls. Drying tests were carried out at three different steam pressure values (0.2, 0.3 and 0.4 MPa corresponding to temperatures of 118, 130 and 139^{0}C, respectively) and three drum rotation speed values (0.5, 1.0 and 2.0 rpm, corresponding to times of 90, 45 and 22.5 s). The dry layer was powdered by a Braun Multiquick chopper (Braun, Frankfurt, Germany). The powder was packaged by a thermo welder under vacuum (Vacuumpump, Lecco, Italy) into commercial bags of polypropylene for food use.

In the United States potato processing for food uses is much more extensive than in any other country. Crisp (chips) are the most important Form of processed potatoes. In 1966, it is estimated that about 6.5 million cwt. were utilized for crisp which is approximately seven percent of the total used human consumption (Hampson, 1966). Fairly large amounts also are utilized in processing frozen French fries, but comparatively small quantities are processed into dehydrated products. Wiertsema (1966) estimates the extent of potato processing for food in Western European countries as shown in Table 2.4;

Frozen products, of which French fries take the lion share, chips and dried products are the main kinds of processed food obtained from potato. Of them, the frozen products appear to occupy the highest position, chips being the next and dried products occupy third position. Though the frozen products appear to occupy the highest position in many countries, yet it is an expensive process. It is not appropriate for Bangladesh. Except frozen products, production of chips and dried products from potato appear to be relatively inexpensive.

Table 2.4 Tons of potatoes processed for food in Western Europe, 1964-65

Country	Potato production in Million (Tons)	French fries (Tons)	Chips (Tons)	Dried products (Tons)	Remain (Tons)	Total (Tons)
West Germany	18.1	97000	17000	233000	8000	345000
France	12.0	8000	18000	24000	4500	54500
Netherlands	3.2	166000	27000	39000	4500	234500
Great Britain	7.2	350000	320000	40000	100000	810000
Denmark	0.91	-	5000	2000	-	7000
Switzerland	1.2	1000	6000	15000	-	22000
Italy	3.8	-	25000	-	-	25000
Spain	4.3	-	8000	22000	-	30000
Ireland	1.7	-	5000	5000	-	10000
Sweden	1.2	-	3000	5000	-	8000
Norway	1.1	-	3000	-	-	3000
Austria	2.7	-	3000	-	-	3000

Source: Wiertsema, (1966).

In India, processing of potatoes constitutes less than 0.5% of the total annual production. Thus, there is a considerable scope for expansion of this processing industry in India, (Marwaha, 1999). To be competitive in global potato trade, the India needs to accelerate the development and diffusion of suitable quality enhancing technologies in the processing sector. However, institutional innovations must accompany the technological progress for attaining a leading role in international potato processing trade. Potato processing proves to be an important option for India becoming self reliant in sustaining the food and nutrition. (Pandey *et al.*, 2006) Minimal or lightly processing means the operations like washing, sorting, trimming, peeling, slicing or chopping and preventing browning that affect the freshness of vegetables. The minimal processing is a method of preparing convenient fresh products that can be consumed, utilized straight away in less time with two objectives. Firstly, it keeps the produce fresh which is yet to supply in convenient form without losing its nutritional quality. Secondly, the minimally processed

products should have a shelf life acceptable to its intended consumers (Kaur and Kapoor, 2000).

2.2.2 Potato preservation

Preservation of potato is a great problem in our countries for tropical climate. It cannot be stored in ordinary temperature and humidity for long time. Now-a-days, cold storage is the only method of potato storage in our country. However capacity of storage is very inadequate due to high capital investment. Cold storage also being a high energy consuming preservation method, its use result in 3-4 times higher prices for the product. For solving these problems we can produce various items of potato products, which are more attractive and favorite foods to the consumers. There is several potato products produced in many countries. These are chips, dehydrated products, French fries, frozen French fries, canned products, starch and flour etc.

Smith (1977) stated that from 1975 crops, the food processors of the United States processed about 57% of the crop which was used for food. Excluding potato starch and flour this amounted to 151.5 million cwt. of potatoes. The potato chip business has reached a plateau during the past three years and it consumed over 22% of the total processed volume. He stated that frozen products were increasing at the most rapid rate and from the 1975 crop, utilized about 53% of the processed volume with the reminder being processed as canned, mash, stews, soup etc.

2.3 Composition and nutritive value of potato

The Potato is a good source of dietary energy and some micronutrients. But balanced diets need to other vegetables and whole grain foods. Potato is a versatile, carbohydrate- rich food highly popular worldwide and prepared and served in a variety of ways. Freshly harvested potato contains about 80 percent water and 20 percent dry matter. About 60 to 80 % dry matter is starch. On dry matter basis, the protein content of potato is similar to that of cereals and is very high in comparison with other roots and tubers (Lima and Peru, 2008).

The proximate compositions of (100gm) potato are reported to be; energy 87 kcal, water 77g, fat 0.1 g, protein 2 g, carbohydrate 20 g, iron 0.3 mg, calcium 5 mg, potassium 380 mg, phosphorus 44 mg, niacin 1.5 mg, thiamin 0.1 mg, vitamin C 13 mg. (National

Institute of Nutrition, 1980). Watt and Merrill (1963) reported that the proximate composition of potato were about water 77.5%, protein 2%, fat 0.10%, ash 1% and total carbohydrate 19.4% .

Schwimmer and Barr (1967) reported that potato contains 77.5% water, 2% protein, 0.02% fat, 19.2% carbohydrate, and 1% ash. Fat also contains ascorbic acid, niacin, thiamin (B_1), iron and riboflavin. The proximate composition of potato is shown in Table (2.5).

Table 2.5 Proximate analysis of potato

Components	Composition in average	Range (%)
Water	77.5	63.2-86.9
Total solid	22.5	13.1-36.8
Protein	2.0	0.7-4.6
Fat	0.1	0.02-0.96
Carbohydrate	19.2	13.3-30.53
Crude fibre	0.6	0.17-3.48
Ash	1.0	0.44-1.9

Source: Schwimmer and Barr (1967)

2.4 Composition and nutritive value of potato flour and Wheat flour

Mollik and Shams-Ud-Din (2007) analyzed the whole meal flour for chapatti making for Moisture, protein, fat, ash carbohydrate contents and the results are presented in Table 2.7 shown in below. The authors found the whole meal flour contained moisture 13.63 %, protein 11.44 %, fat 0.88%, ash 1.15% and total carbohydrate 72.9%.

Table 2.6 Nutritional value of raw potato per 100 g (3.5 oz)

Energy	320 KJ
Carbohydrates	19g
Starch	15g
Dietary fiber	2.2 g
Fat	0. 1 g
Protein	2.0 g
Water	75g
Vitamin	
Thiamin	0.08 mg
Riboflavin	0.03 mg
Niacin	1.1 mg
Vitamin B	0.25 mg
Vitamin C	20 mg
Minerals	
Calcium	12 mg
Iron	18 mg
Magnesium	23 mg
Phosphorus	57 mg
Potassium	421 mg
Sodium	6 mg

Source: wikipedia, 2008

Table 2.7 Composition of whole meal flour and potato flour

Components	Whole meal flour (1) (%)	Potato flour (2) (%)
Moisture	13.63	11.5
Protein	11.44	5.50
Fat	0.88	0.87
Ash	1.15	2.40
Gluten (dry %)	12.55	--
Crude fibre (%)	1.8	4.30
Total carbohydrate (% by difference)	72.9	75.43

Source: 1) 2007, Journal of Ag. Engg. of Bangladesh 2) Schwimmer and Ban- (1967)

Table 2.8 Nutrient value per 100 g of potato flour

Nutrient factor	Content	Unit
Energy calculated	1535 KJ	KJ
Carbohydrate, available	73.5 g	g
Fat, total	4.3 g	g
Protein, total	5.7 g	g
Alcohol	0 g	g

Source: Anonymous (2009), National Institute for Health and Welfare, Finland

The analysis for proximate composition of potato flour reported by Schwimmer and Barr (1967) shown in Table 2.7 which showed that the potato flour contained moisture 11.5%, protein 5.5%, fat 0.87%, ash 2.40%, crude fibre 4.30% and total carbohydrate 75.43%.

Table 2.9a Carbohydrate components per 100 g of potato powder

Carbohydrate components	Content	Unit
Organic acid, total	2.3	g
Starch, total	67.4	g
Sugars, total	6.1	9
Sucrose	0.5	9
Lactose	4.2	g
Fructose	0.7	g
Sugar alcohol	0	g
Fiber, total	6.7	g
Fiber, water soluble	4.8	g
Polysaccharides, non-cellulosic, water Soluble	1.9	g
Glucose	0.7	g
Maltose	0	g

Source: Anonymous (2009), National Institute for Health and Welfare, Finland

Table 2.9b Fats found in per 100 g of potato powder

Fats	Content	Unit
Fatty acid, total calculated as IAG	2.9	g
Fatty acid, total	2.8	g
Fatty acid, saturated	1.0	g
Fatty acid, monounsaturated cis	1.3	g
Fatty acid, polyunsaturated	0.1	g
Fatty acid, Total trans	0.4	g
Linoleic acid	80	mg
Alpha-linoleic acid	22	g
Ecosa Pentanoic Acid (EPA)	0	g
Docusa Hexanoic Acid (DHA)	0	g
Cholesterol (GC)	2.6	g
Sterol, total	21.6	g

Source: Anonymous (2009), National Institute for Health and Welfare, Finland

2.5 Drying method for making potato flour

Kamal et al. (2002) studied the physicochemical properties of potato flour made from boiled and raw tubers of the variety Kufri Jyoti. Tubers were steam-cooked, peeled, hand sliced and sun-dried in the first method while 1.5-mm thick slices from raw potatoes were dipped in 0.5% acetic acid solution for 15 minutes and then sun-dried in the second method. The dried slices in both cases were ground into flour and then analysed. The values of water absorption, moisture content, total sugars and reducing sugars were higher in the flour from boiled potatoes, while starch content was higher in flour made from raw slices. There was not much difference in quality of the flour prepared from boiled and raw potatoes.

Oliveira et al. (2006) studied on the Production of potato flour by sun drying. A study was conducted to evaluate the sun-dried and stove-dried grated potatoes to determine their flour quality and to verify the effect of sodium bisulfite addition on the final product. The analyses showed that solar drying was successful for potato flour production. The potato flour samples according to observations showed visco-amylographic properties which good enough to be used on bakery products. The average input from solar drying prevents oxidation. The potato flour production process and technology reported by Ritika (2009)

is shown below in flow chart. Cooking>– Washing >– Pulping>– Drum drying>– Potato Powder>– Packaging

2.6 Potato flour

Potato flour is the oldest commercial potato product and is widely used in the baking industry. Potato flour has long been associated with the baking of bread. It is well known that small amounts of added potato solids help to retain the freshness of bread and also impart a distinctive, pleasing flavour and improved toasting qualities (Willard & Hix, 1987). The most simple and widely used procedure consists of dehydrating potatoes in the form of slices and then grinding to make flour (Srivastava, Singh, & Verma, 1973). Roy Choudhuri et al. (1963) suggested a faster way of drying the slices by using a kiln or a flow drier for large-scale production of potato flour. Pant and Kulshreshta (1995) prepared potato flour from six potato varieties by pressure cooking the potatoes at 10 lb/cubic inch for 22 min, cooling under running water to room temperature within 3 min and further drying in a cabinet drier at 60^0C. Treadway et al. (1950) reported the average percentage composition of flour (carbohydrates 77–79%, protein 9–11%, ash 4–4.5%, crude fiber 1.17–1.18% and fat 0.1–0.2%) from different American potato cultivars. Potato flour is used for its characteristics, which differ significantly from those of flour from other plant sources (Willard & Hix, 1987). Identification and screening of potato genotypes is required for desired functionality and unique properties. The physicochemical properties of potato flours vary with genotype and cultural practices (Pant & Kulshrestha, 1995; Willard & Hix, 1987).

2.7 Composition of potato flour

The composition of potato flour generally reflects the composition of the potato tubers from which it is prepared. The composition (average values) of potato varieties from the United Kingdom (Paul and Southgate, 1978), the United States (Treadway et al., 1950), Nigeria (Okorie et al., 2002), and India (Chandra Shekara and Shurpalekar, 1983) is given in Table 2.10. The values given for potato varieties from the United Kingdom and the United States are similar. However, differences were observed in the other two cases. These differences could be due to differences in variety, growing location, environmental conditions during crop growth, and analytical methods used. Furthermore, the table shows that potato is a good source of potassium and ascorbic acid

Table 2.10 Composition of potato flour

Potato Flour				
Moisture (%)	7.6[a]	7.4[b]	10.0[c]	-
Carbohydrate (g)	79.9	79.0	78.4	87.3[d]
Crude Fiber (g)	1.6	1.6	2.9	1.3
Cruder Protein (g)	8.0	7.6	3.9	8.1
Fat (g)	0.8	1.0	1.3	-
Ascorbic acid (mg)	19	-	-	-
Thiamin (mg)	0.4	-	-	-
Riboflavin (mg)	0.1	-	-	-
Niacin (mg)	3.4	-	-	-
Ash(g)	3.7	3.3	3.3	2.5
Calcium (mg)	33	34.3	-	-
Phosphorus (mg)	178	176	-	-
Iron (mg)	17.2	13.9	-	-
Sodium (mg)	-	41.3	-	-
Potassium (mg)	-	1373	-	-

[a]All data in this column from Paul and Southgate (1978).

[b]All data in this column from Treadway et al. (1950).

[c]All data in this column from Okorie et al. (2002).

[d]All data in this column from Chandra Shekara and Shurpalekar (1983)

2.8 Composite flour

In the 1960 and 1970 composite flours very often found themselves at the focus of attention in European and international cereal research. Most of the studies in this field were supported by the FAO (Food and Agriculture Organization of the United Nations).

In these two decades, bread consumption increased continuously in many of the developing countries. Three main reasons for this:

- a steadily growing population;
- changes in eating habits;

An overall increases in income, which meant that a larger proportion of the income could be spent on food.

Although it is well known that no other crop can achieve the baking properties of wheat, composite flours became the subject of numerous studies. For the developing countries the use of composite flours had the following advantages;

- a saving of hard currency;
- promotion of high-yielding, native plant species
- a better supply of protein for human nutrition;
- Better overall use of domestic agricultural production: (Berghofer, 2000; Bugusu *et al.* 2001).

2.8.1 Definition of composite flours

Composite flours are quite different from the 255 ready-mixed flours familiar to millers and bakers. Whereas ready-mixed flours contain 256 all the non-perishable constituents of the recipe for certain baked product. Composite flours are only a mixture of different vegetable flours rich in starch or protein, with or without wheat flour, for certain groups of bakery products. This gives rise to the following definition;

"Composite flours are a mixture of flours from tubers rich in starch (e.g. cassava, yam, and sweet potato) and/or protein-rich flours (e.g. soy, peanut) and/or cereals (e.g. maize, rice, millet, buckwheat), with or without wheat flour"

2.8.2 Composition of composite flours

The goal of earlier research with composite flours was to save the largest possible percentage of wheat flour and the production of certain baked products. The extents to which wheat flour could be replaced by other vegetables flour dependent on the nature of the products to be baked.

2.9 Biochemical parameters

Fuller and Hughes (1984) opined that the reducing sugar levels were generally higher at the basal part of the tuber than at the apical end of the potato and consequently, the correlation between fry colour and reducing sugar further the variation in colour was associated with variation in reducing sugar in the tuber. Hence it was suggested that the potato for processing be taken from the basal region of the tubers to have an idea on sugars and its effect on colour.

Processing of potato is very old and people use to dehydrate the potatoes to provide potato products in off season. A key quality problem in processing and preparation of various products from potato is enzymatic browning or discoloration on the surface of

processed products. This discoloration is mainly as a result of disruption of compartmentation that occurs when cells are broken allowing substrates and oxidase enzyme to come in contact. Wounding also induces synthesis of some enzymes involved in browning reaction or substrate synthesis (Rolle and Chism 1987).

2.10 Packaging

Anonymous (1992) showed that out of various packaging materials like natural fibre sacs, gunny bags, corrugated fibre board boxes use of plastics etc. are very pronounced for packaging of fruits with a purpose to extend their storage life. Plastic packaging helps in minimizing the cost of packaging material in the market the whole process less dependent on scarce material like wood, thereby conservation of environment.

Roy *et al.* (1993) from the studies on various types of plastic packaging material showed that the use of plastic is beneficial as has good mechanical strength having non-conducting behaviour and its transparency and limited produce ability to gases and water vapours create a better room for its acceptability in packaging industry.

Balasubramanyam and Anandswamy (1979), reported that the moisture content of 3.5 percent is critical with respect to crispiness of the potato chips, based on the moisture absorption in slices the packaging materials with water vapor transmission rate may be expected to offer a reasonable shelf life to the products. Among the different packaging materials the selection of functional packaging material for products like potato chips, which is predominantly moisture, oxygen and light sensitive, has a considerable influence on the shelf life of the product. Thus they showed that 200-300 gauge high, density polyethlylene or low density polyethelylene, polymer coated (MXX7) and combination of plastic with paper showed the better and were also economically feasible.

Carlin *et al.* (1990), observed that the changed atmosphere for storage of grated carrot with special packing materials like packs sealed with OPP (Oriented Propylene) or low density polythene had a good effect on the storage and shelf life, which is due to rapid change during the first three days preceded an equilibration of CO_2 and O_2 concentration. Variations were also found with different packs, higher variation in least permeable films and vice versa. Thereby packaging of fresh, grated carrots films of high permeability allow better preservation, considerable reduction in all factors related to fermentation.

Charles *et al.* (1991) reported that potatoes packaged in citric acid solutions maintained lightness, which was similar to or better than sulfated potato and the effect on potato colour was caused by interaction of storage time and treatment solution. Significantly acceptable colour was observed for 18 days storage and this was attributed to the fact that potatoes in solution had reduced oxygen concentration at the cut surfaces and storageing potatoes in this manner diluted polyphenol substrate involved in the browning/ darkening reaction.

Sukanya *et al.* (1996) reported that, the dehydrated vegetables, viz., cluster bean, hemp and fenugreek leaves stored in polythene bag obtained maximum scores followed by that stored in aluminium box and cloth bag.

Sagar and Roy (1997) reported that packaging and storage of potato powder is influenced by moisture, SO_2 concentration, and relative humidity and also showed that potato powder packed in 400 gauge polyethylene bags had more satisfactory quality as compared to the material packed in 200 gauge polyethylene bags, and opined that higher gauge polyethylene bags gained less moisture as compared to lower gauge polyethylene bags.

Gunes and Lee (1997) reported that potatoes treated with L-cystein (0.5%) and citric acid (2%) prevented browning of potatoes packaged in active modification with a highly permeable multilayered poly film packaging material gave better result and longer shelf life.

Lee *et al.* (1998) reported that only slight weight losses occurred for packaged vegetable like carrot, garlic etc. and decrease sugar content showed significant in unwrapped and no significant change during storage. Further there was no any off flavor at initial four days of storability using low permeability film for short term packaging.

2.11 Organoleptic properties

Sagar *et al.* (1997) reported that, the organoleptic scores for colour, flavour, texture and overall acceptability were found to be significantly high in dehydrated potato slices and cubes with the samples pre-treated with KMS.

Waghmore *et al.* (1999) showed that pre-treatment of NaCl at 2 per cent were optimum for 1 mm to 1.5 mm thickness and 7.5 per cent Nacl for slices having 2 mm thickness. Further they also observed that, the KMS at 50 ppm concentration were optimum for 1

mm and 100 ppm concentration for thickness of 1.5 mm and 2 mm thickness for better sensory quality of potato chips. Mushroom samples dried after blanching in citric acid and salt solution and stepping in KMS + citric acid solution for three min. showed the best overall acceptance (Rama and Jacob, 2000).

The methi leaf samples pre-treated with 15 per cent hot brine (60°C) received higher scores for colour and appearance (7.5), flavour (7.9), texture (7.3), taste (8.0) and overall acceptability (7.7) after completing drying and dehydration (Birar *et al.,* 2001). Palak leaves dehydrated at 60°C after pre-treatment with hot brine (15%) and stored in 300 gauge polyethylene bag could score high value for colour, flavour, texture and overall acceptability score of 8.00 at the end of dehydration. Maximum score for colour and appearance (4.03), taste (3.64), texture (4.0) and overall acceptability (3.39) were recorded in dried sapota slices pretreated with 50 brix sugar syrup + 0.1 per cent KMS + 0.5 per cent citric acid (Basavaraj, 2002).

Organoleptic evaluation of dehydrated ber slices revealed that overall acceptability was found maximum (2.81) in case of ber slices dipped in 50 brix syrup with 0.5 per cent citric acid and 0.2 KMS for 15 hrs before drying (Nagaraju, 2002).

2.12 Health benefits of using potato

Potato is one of the most important and versatile foods from a nutritional standpoint. Potato protein has particularly favorable lysine content in comparison with cereal proteins, whose amino acid scores, on the basis of human requirements, are much lower (Woolfe, 1987). In terms of quantities required to maintain nitrogen balance in adult humans, the potato protein has better nutritive value than the protein of wheat flour or rice or corn. The unleavened flat bread called chapaties, a staple food in northern India, is generally prepared from wheat flour, which has 8-12% protein, but is limited in certain essential amino acids. Partial substitution with other flours can help improve the nutritional quality of chapaties. Lysine contents in potatoes are similar to those in animal protein, and potato flour can be utilized to overcome protein and calorie malnutrition in the general population (Anjum et al., 2008). Substituting wheat flour with potato flour at 20% was found acceptable for the preparation of the leavened flat bread naan. A high intake of potatoes prevents weight gain in men (Halkjaer et al., 2004). A study carried out in Australia found that one of the foods contributing to resistant starch intake was

potatoes. In a study performed in Sweden, potato products and bread were found to be the main sources of resistant starch in the Swedish diet. Boiled potato has a low level of resistant starch (1.2%) and a high level of digestible starch (78.2%) and it is therefore considered a high glycemic index food (Garcia Alonso and Goni, 2000). However, retrograded potato flour has higher resistant starch (10.4%) and lower digestible starch (68.9), and therefore it has a lower glycemic index. Potatoes contain antioxidants, predominantly vitamin C.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter describes the method of preparation of potato flour from potato and composite flour from potato, rice and wheat flour. Finally rice and noodles were prepared from composite flour and the quality attributes of the product were assessed. The study was conducted in the laboratories of the Department of Food Engineering and Technology, Food Science and Nutrition, Food Processing and Preservation and Agricultural Chemistry of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

3.1 Materials

Good quality potatoes, rice and commercial wheat flour of 'Pata' brand (12-13% moisture and 8-9% protein) were collected from the local market. Necessary chemicals and solvents such as Potassium Meta-bisulphite (KMS), Salt (NaCl), Sodium Benzoate, Potassium Nitrate (KNO_3), Starch powder, Ammonium Sulphate ($(NH_4)_2SO_4$) were used from laboratory stocks. Wheat flour (12-13% moisture and 8-9% protein) was commercial wheat flour of 'Pata' brand. High density polyethylene bags were used for package and storage of the samples. Other minor ingredients were used from laboratory stocks.

3.2 Methods

3.2.1 Treatments of potato before drying

Four different treatments were given on raw potato to prepare potato flours. One sample of raw potato was cleaned with water and sliced (3 min thickness) with hand knife. Second sample of raw potato was cleaned with water, sliced (3 min thickness) with hand knife, immediately blanched in water at 90 °C for 10 minutes and cooled quickly in cold water. Third sample was cleaned, sliced, immediately blanched for 10 minutes at 90^0C and then treated with KMS solution (the slices were soaked in 0.25 % Potassium Meta-bisulphite (KMS) solution for 10 minutes using 0.5 kg of solution per kg of potato slices) and another sample of raw potato was cleaned with water, boiled and smashed with hand. Thus four samples were prepared as follow:

-Sample without treatment (Control);

-Sample blanched in hot water at 90 °C for 10 minutes;

-Sample blanched in water at 90 °C for 10 minutes followed by soaking in 0.25% KMS solution for 10 minutes.

-Sample boiled and smashed with hand.

These samples were subsequently used for the preparation of potato flours.

3.2.2 Preparation of potato flour

The selected potatoes were cleaned and washed using potable water. Then potatoes were peeled and sliced into 2 or 3 mm thickness with a knife. The potato slices were soaked in hot water at 90^0C for about 10 minutes. The potato slices were dipped into 0.25% KMS solution for 10 minutes. Cabinet dryer was used for dehydration of potato slices. Air was blown by a fan passed over a heater and trays containing the sample to be dried. The slices were dried for about 8 hours at 65°C and then about 4 hours at 45°C. The potato flour was prepared by grinding the dried potato slices in a blender and the flour was kept in polyethylene bags for potato rice and noodles manufacture. Flow diagram of potato flour manufacture is shown in figure 3.1

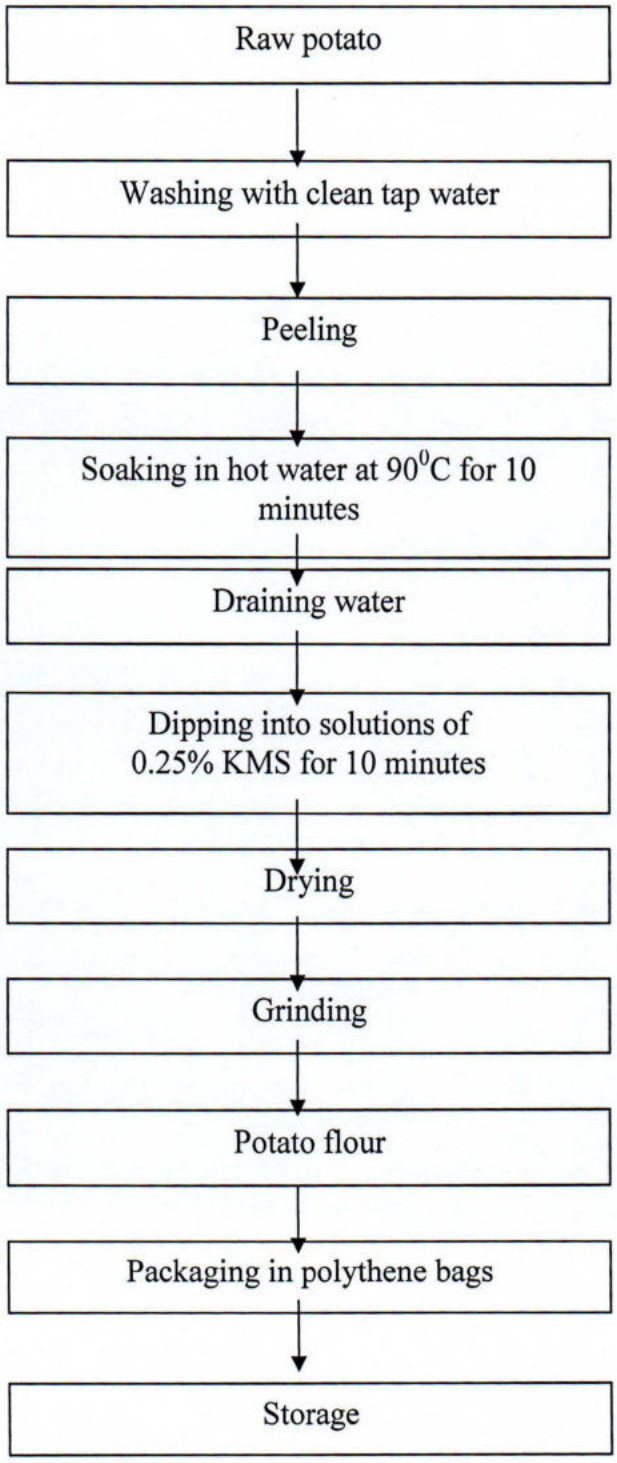


Fig. 3.1 Schematic diagram of preparation of potato flour

Fig. 3.2 Raw potato

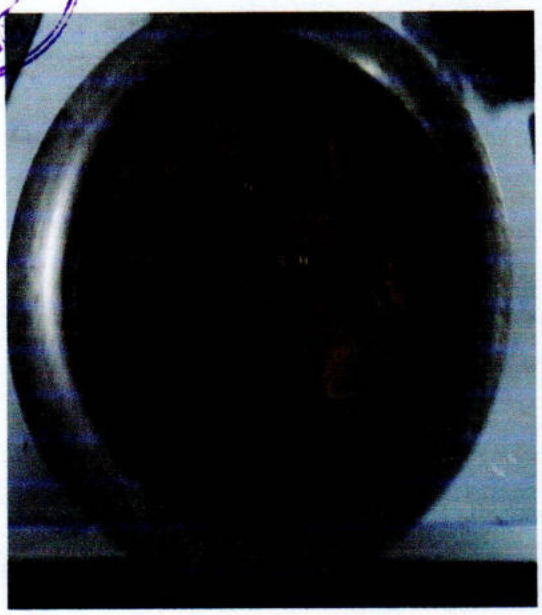


Fig. 3.3 Potato slices soaked in KMS solution.

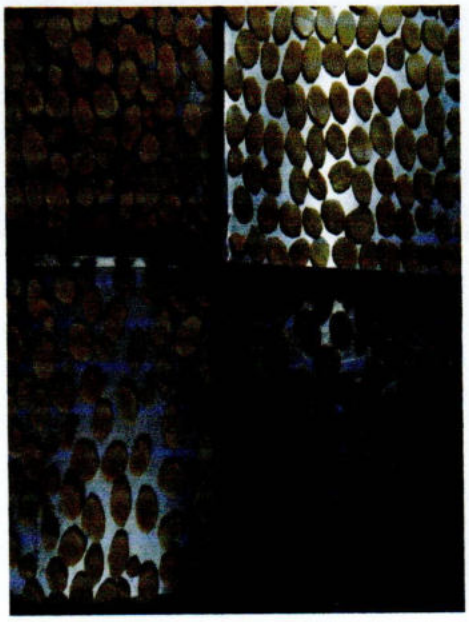


Fig.3.4 Potato slices spread on tray for drying.

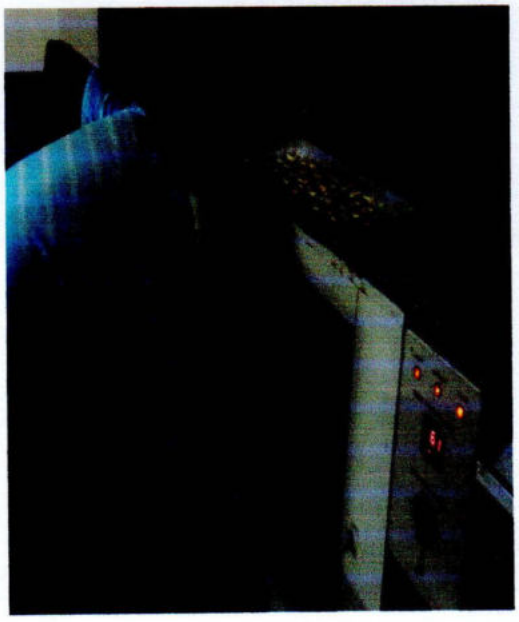


Fig.3.5 Potato slices drying in Cabinet dryer

Fig. 3.6 Potato flour prepared from potato with various treatments.

3.2.3 Preparation of rice flour

The selected rice (BRRI Dhan 29) was collected from local market. Then the rice was washed and soaked for about 3-6 hours. The rice was drained in a fine mesh strainer for 10-15 minutes. The rice was spreaded out on a triple layer of paper towels to dry for an

hour or so. Then, the rice flour was prepared by grinding rice in a blender and the flour was kept in polythene bag. Flow diagram of rice flour manufacture is shown in figure 3.8.

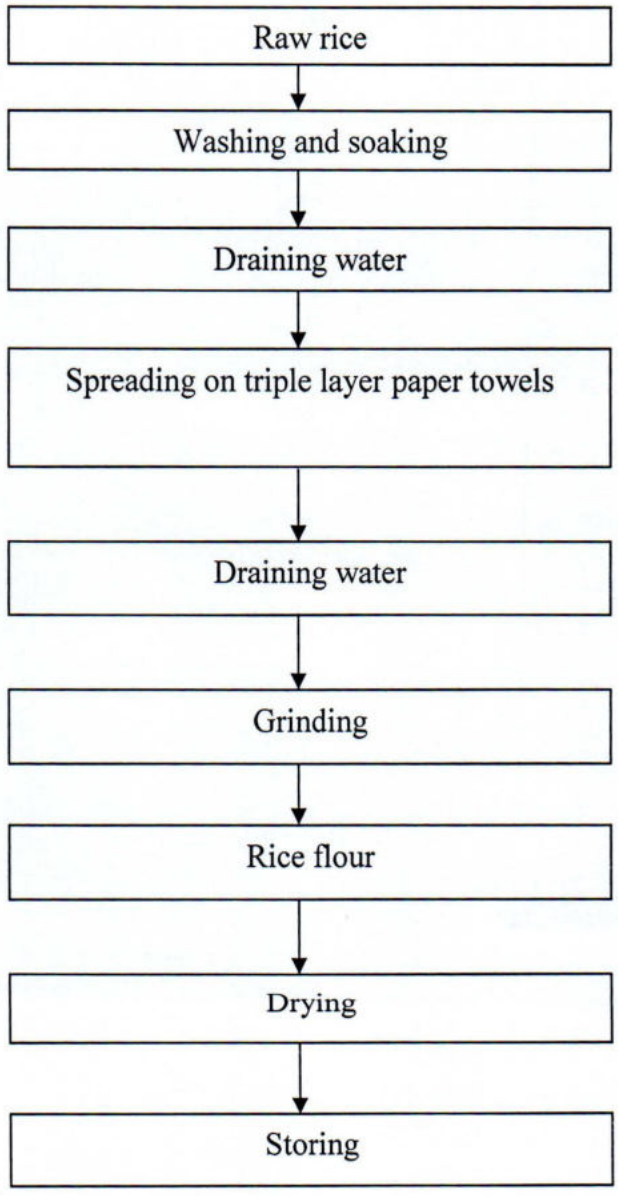


Fig. 3.7 Schematic diagram of preparation of rice flour

Fig 3.8 Raw rice

Fig 3.9 Rice spread on paper towels

Fig 3.10 Rice grinding in a blender

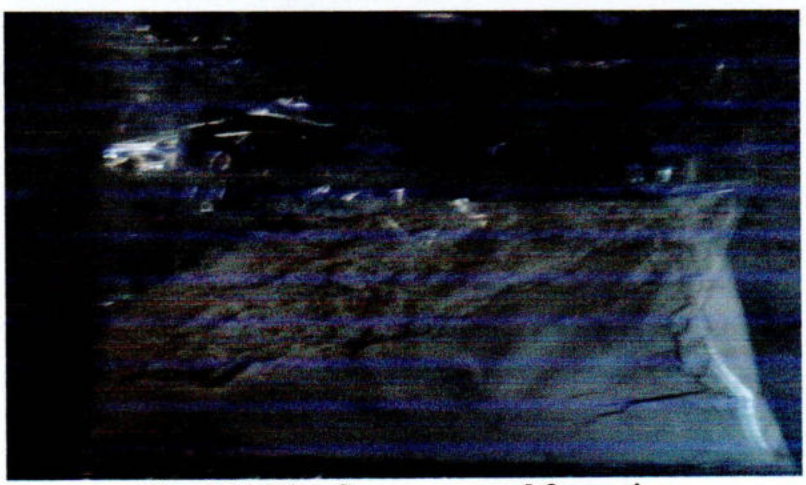


Fig. 3.11 Rice flour prepared from rice

3.3 Product Development

3.3.1 Formulation of composite flour from wheat, rice and potato flour

The basic formulation of composite flour is shown in table 3.1. The additions of wheat flour in the formulations were made with 0, 10, 20, 30 and 40% of potato flour.

Table 3.1 Basic formulations of composite flour on 100 gm flour basis.

Ingredients	Sample CS1	Sample CS2	Sample CS3	Sample CS4	Sample CS5
Wheat flour	100	80	70	60	50
Rice flour	0	10	10	10	10
Potato flour	0	10	20	30	40

CS1= Composite flour sample 1, CS2= Composite flour sample 2, CS3= Composite flour sample 3, CS4= Composite flour sample 4, CS5= Composite flour sample 5.

3.3.2 Formulation of rice and noodles for composite flour on 100 g basis

The basic formulation of rice and noodles are shown in table 3.2.

Table 3.2 Basic formulations of rice and noodle for composite flour on 100 g basis

Ingredients	Sample S1	Sample S2	Sample S3	Sample S4	Sample S5
Composite flour	98 g of CS1	98 g of CS2	98 g of CS3	98 g of CS4	98 g of CS5
Starch powder	0.7 g	0	0	0	0
Salt	1.3 g	1.3 g	1.3 g	1.3 g	1.3 g
Sodium Benzoate	0.03g	0.03g	0.03g	0.03g	0.03g

3.3.3 Preparation of rice and noodles

The dough was formulated by mixing 98% composite flour, 1.3% salt, 0.03% sodium benzoate and 35-40% distilled water. Starch powder (0.7%) was used only in sample 1. The mixer machine (blender) was operated for 1 min (at speed 1) and 4 min (at speed 3). The dough was made ruti for slicing to make sticks. Then the sticks were kept in cabinet dryer for drying. The temperature of dryer was maintained at 30-35^{0}C for 2 hours, then 45-50^{0}C for 2 hours, finally the sticks were dried at 70-75^{0}C for 50-60 min (until final moisture became 7-10% wb). Then it was kept for 15 min at ambient temperature. The sticks were packed in polythene bag for future use. Flow diagram of rice and noodles manufacture is shown in figure 3.13.

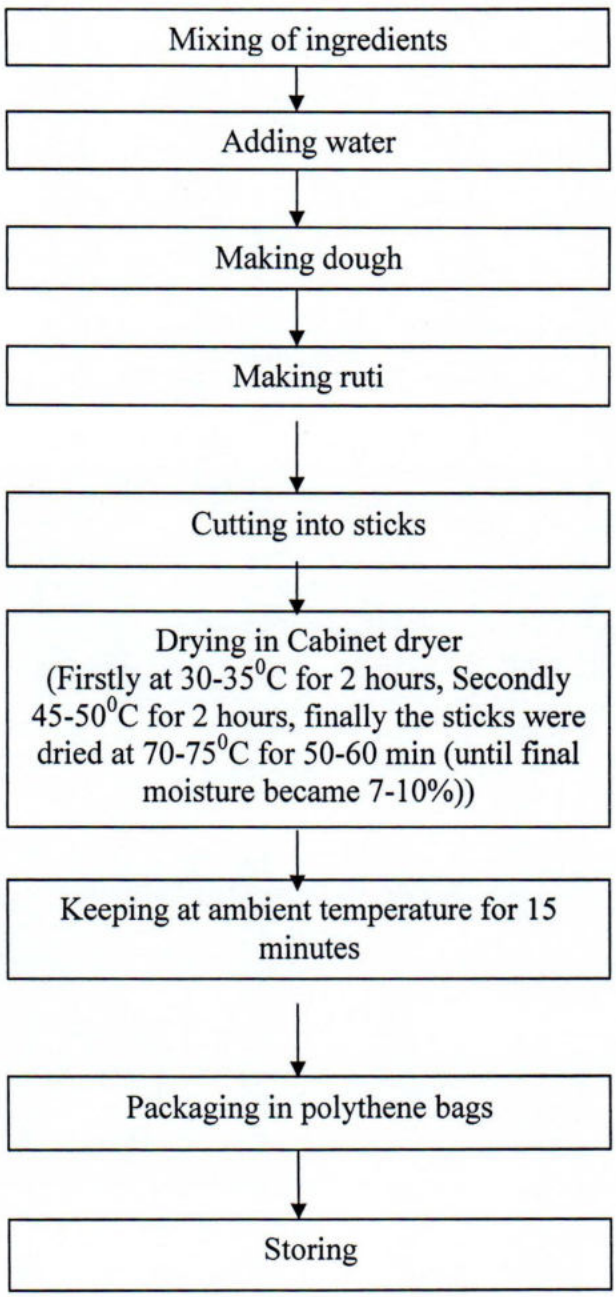


Fig. 3.12 Schematic diagram of preparation of rice and noodle

(**Note:** The procedure of making rice and noodles from composite flour mentioned here was developed through trial and error following other procedures for similar products.)

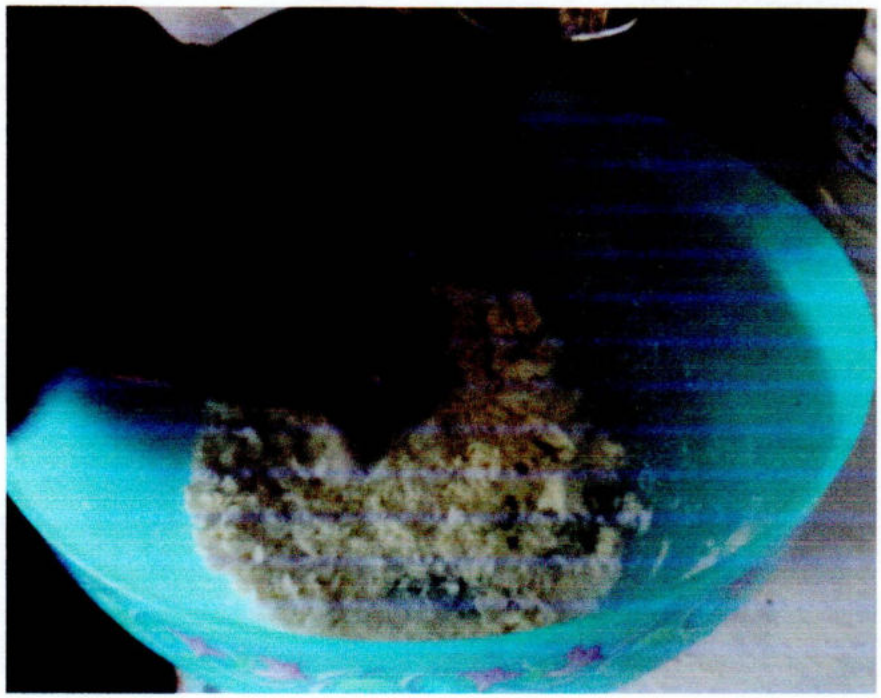


Fig. 3.13 Making dough from composite flour

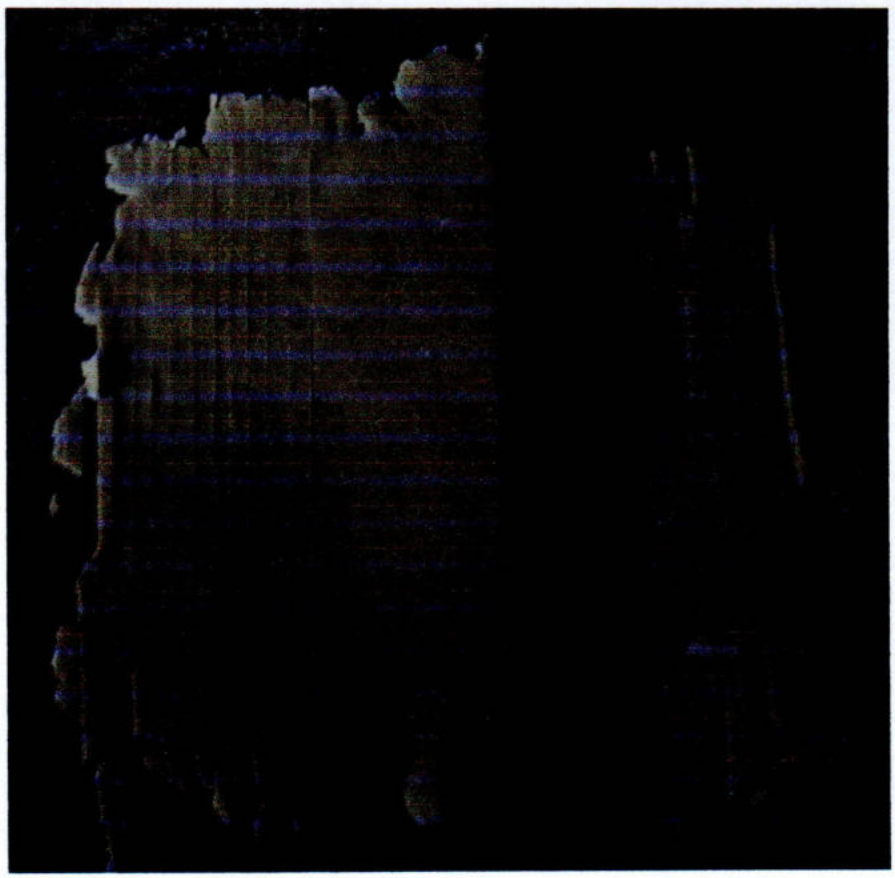


Fig. 3.14 Making sticks from dough

3.4 Chemical Analysis

The fresh potato, potato flour, wheat, wheat flour, rice, rice flour, prepared rice and noodles were analyzed for their moisture, ash, fat, protein and total carbohydrate contents. All the determinations were done in triplicate and the results were expressed as average value.

3.4.1 Moisture

Moisture content was determined using AOAC (2004) method as describe below;

Procedure

Moisture content was determined by oven drying method. An empty crucible was washed, dried, cooled and weighed. Then definite quantity (5gm) of sample was taken in the crucible and weighed. The crucible was placed in the oven and dried at a temperature of 102^0C for 24 hours. After drying, the crucible was removed from the oven and cooled in desiccators and weighed. Crucible was again placed in the oven, dried for 30 minutes, taken out of the dryer, cooled in desiccators and weighed. Drying, cooling and weighing were repeated until 2 consecutive weights were same. For accuracy, at least 3 samples were dried in the oven and average moisture content was then calculated as follows:

$$\% \text{ Moisture content} = \frac{\text{loss in weight}}{\text{weight of samples}} \times 100$$

3.4.2. Ash

AOAC method (2004) was used to determine the total ash content.

Procedure

The samples (2-3) were weighed in clean dry crucible. The sample was then placed in a muffle furnace at 550^0C and ignited until light gray ash resulted (or to constant weight). The sample was then cooled in desiccators and weighed. The ash content was expressed as

$$\% \text{ Ash} = \frac{\text{wt. of residue}}{\text{wt. of sample}} \times 100$$

3.4.3 Fat

AOAC method (2004) was used to determine crude fat content of the sample.

Procedure

The dried sample remaining after moisture determination was transferred to a thimble and plugged the top of the thimble with a wad of fat free cotton. The thimble was dropped into the extraction tube attached to a Soxhket flask. Approximately 75 ml or more of anhydrous ether was poured into the flask. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hr or longer on water bathe at 70-80 ^{0}C. At the end of the extraction period, the thimble was removed from the apparatus and most of the ether was distilled off by allowing it or collected in soxhlet tube. The ether was poured off when the tube was nearly full. When the ether reached a small volume, it was poured into a small, dry (previously weighed) beaker through a small funnel containing a plug of cotton. The flask was rinsed and filtered thoroughly using ether. The ether was evaporated on a steam bath at low heat, dried at 100 ^{0}C for 1hour, cooled and weighed. The difference in the weights gave the ether soluble material present in the sample. The presence of crude fat was expressed as follows:

$$\% \text{ Crude fat} = \frac{\text{wt. of ether soluble materials}}{\text{wt. of sample}} \times 100$$

3.4.4 Protein

Protein content was determined using AOAC (2000) method. The accepted method was as follows:

Reagent required

Sulphuric acid (nitrogen-free); digestion mixture -100gm potassium sulphate, 20 gm copper sulphate and 2.5 gm selenium powder, well mixed in a mortar and kept in a dry place; NaOH, appx. 10 N; 0.05N HCl; Indicator solution-one column of a 0.05% solution of methylene blue is mixed in alcohol with 2 volumes of a 0.05% aqueous solution of methyl red; Boric acid solution-a 2.00% solution in water.

Procedure

An 11.1gm digestion mixture was weighed accurately and transferred into a dry 300 ml Kjeldahl flask. A suitable quantity of the sample (1 gm for each case) was transferred into the flask.25 ml of sulphuric acid was added and heated continuously until frothing

ceased, and then simmered briskly . The solution became clear in 15-20 min; continued heating for 45 minutes. After cooling, 100 ml water was added and transferred quantitatively to a 1 litre round bottom flask; the final volume was about 500 ml. NaOH solution was added gently down the side enough to form a precipitate of cupric-hydroxide and immediately connected the flask to steam-trap condenser. To a 500ml conical receiving flask 50 ml of Indicator solution was added positioning the condenser. Distillation was carried out for 40-45 min or until about 250 ml distillate was titrated with 0.05N HCl, the end point was marked by a brown colour. A reagent blank was also determined and deducted from the titration. 1 ml of 0.05N HCl is equivalent to 1 ml gm of nitrogen.

A protein conversion factor of 6.5 was used to calculate the percent protein from nitrogen determination percentage of nitrogen and protein calculated by the following equation.

$$\% \text{ Nitrogen} = \frac{(TS-TB)\times Normality\ \ of\ Acid\ \times 14\times Volume\ made\ up\ of\ the\ digest}{Aliqout\ of\ the\ digest\ taken\times wt.of\ sample\ taken\times 1000}\times 100$$

Where,

TS = Titre volume of the sample (ml)

TB = Titre volume of the blank (ml)

% Protein = % Nitrogen x Protein factor

3.4.5 Carbohydrate

Total carbohydrate contents of samples were calculated by difference, that the percentage of moisture, protein, fat and ash was subtracted from 100 (Pearson, 1976).

3.5 Cooking of Prepared Rice and Noodles

3.5.1 Cooking of prepared rice

Prepared rice was cooked in boiled water for 15 minutes. The cooked rice was rinsed and washed with cold water. The form of rice grains did not change (i.e. dissolve or disintegrate) after cooking. Then the boiled rice was cooked with oil and others spices and served to panellist for sensory evaluation.

3.5.2 Cooking of Noodles

Noodle was cooked in boiled water for 12 minutes. The cooked noodle was rinsed and washed with cold water. The form of noodle did not change (i.e. dissolve or disintegrate) after cooking. Then the boiled noodles were cooked with oil, taste maker, spices, egg etc. Noodles were served to panellist for sensory evaluation.

3.6 Sensory evaluation

A test panel evaluated the consumer's acceptability of developed products. The test panels (10) were selected from the students, officers and teachers of the Faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The panelists were requested to assign score for characteristics color, flavour, texture and overall acceptability of prepared rice and noodles.

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.

The results were evaluated by analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) procedures of the Statistical Analysis System (SAS, 1985).

3.7 Data analysis

Analysis of variance (ANOVA) was carried out using MSTAT-C statistical software packages (MSTAT-C, 1991). Means were compared using least significant differences (LSD). Correlations between parameters were made when appropriate. As suggested by Watts et al. (1989), in analyzing the sensory data, the 5 point scale and the 9 point hedonic scales were used and the numerical values for each sample were tabulated and analyzed by ANOVA to determine whether significance differences in mean degree of scoring points exist among the samples or not.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Composition of potato, rice and wheat

4.1.1 Composition of fresh potato

The fresh potatoes were analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.1. The fresh potato contained moisture 80.5%, ash 0.98%, fat 0.1%, protein 2.04 % and total carbohydrate 16.38 % .

Kroner and Volksen (1950) showed that potato contained 77.5 %, 1%, 19.4%, 0.1% and 2% moisture, ash, carbohydrate, oil and protein respectively. These values are very close to those found in this study. The slight variation in composition of fresh potato might be due to varietals differences, variation in stage of maturity, time elapsed between harvesting and analysis and the growing conditions of the crop.

4.1.2 Composition of rice

The rice was analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.1. The rice contained moisture 12.9%, ash 0.5%, fat 0.6%, protein 6.8 % and total carbohydrate 79.2 %.

The composition of rice under study was more or less similar to those reported in USDA Nutrient Data Base. The reported nutrient content of rice as follows: moisture 12%, ash 0.52%, fat 0.66%, protein 7.1%, and total carbohydrate 80%
(wikipedia, 2012)

4.1.3 Composition of wheat

The fresh wheat was analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.1. The wheat contained moisture 12%, ash 1.5%, fat 2.3%, protein 13.0 % and total carbohydrate 71.2%.

USDA Nutrient Data Base showed that wheat contained moisture 11%. ash 1.83%, fat 2.47%, protein 13.7 % and total carbohydrate 71.0%.

Table 4.1 Composition of fresh potato, rice, wheat

Components	Fresh potato	Rice	Wheat
Moisture (%)	80.5	12.9	12.0
Ash (%)	0.98	0.5	1.5
Protein (%)	2.04	6.8	13.0
Fat (%)	0.1	0.6	2.3
Total carbohydrate (%)	16.38	79.2	71.2

4.2 Composition of potato flour, rice flour, and wheat flour

4.2.1 Composition of potato flour

Potato flour was analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.2. Potato flour contained moisture 10%, ash 2.5%, fat 0.86%, protein 5 % and total carbohydrate 81.64%.

4.2.2 Composition of rice flour

Rice flour was analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.2. Rice flour contained moisture 11.0%, ash 0.7%, fat 0.8%, protein 7.5 % and total carbohydrate 80.0%.

4.2.3 Composition of wheat flour

Wheat flour was analyzed for moisture, ash, protein, fat, and total carbohydrate. The results are presented in table 4.2. Wheat flour contained moisture 13%, ash 0.70%, fat 1.0%, protein 11.5% and total carbohydrate 73.80%.

Table 4.2 Composition of potato flour, rice flour and wheat flour

Components	**potato flour**	**rice flour**	**wheat flour**
Moisture (%)	10.0	11.0	13.0
Ash (%)	2.5	0.7	0.70
Protein (%)	5.0	7.5	11.5
Fat (%)	0.86	0.8	1.0
Total carbohydrate (%)	81.64	80.0	73.80

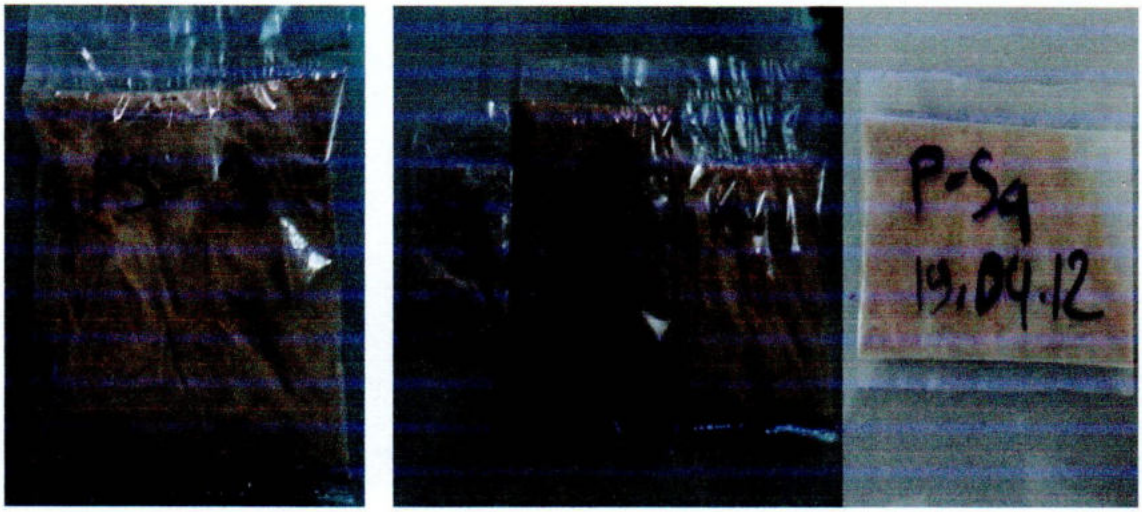


Fig. 4.1 Potato flour prepared from potato with various treatments.

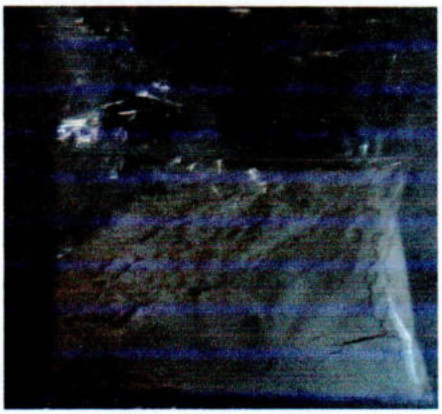
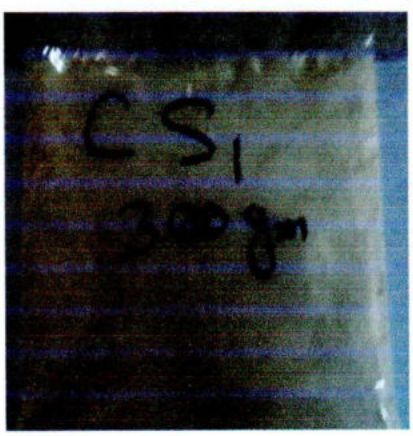
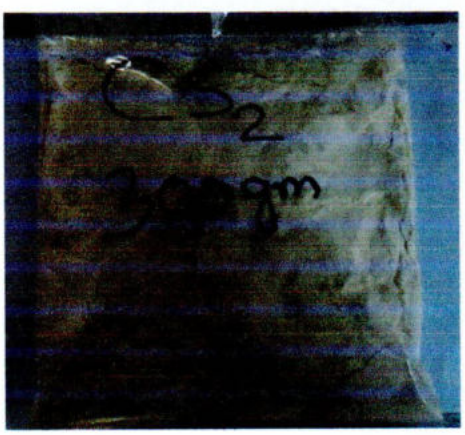


Fig. 4.2 Rice flour prepared from rice

4.3 Preparation of composite flour from potato, rice and wheat flour

Composite flour was prepared which include the ingredients potato, rice and wheat flour as shown in figure 4.3. The proportion is mentioned in table 3.1.





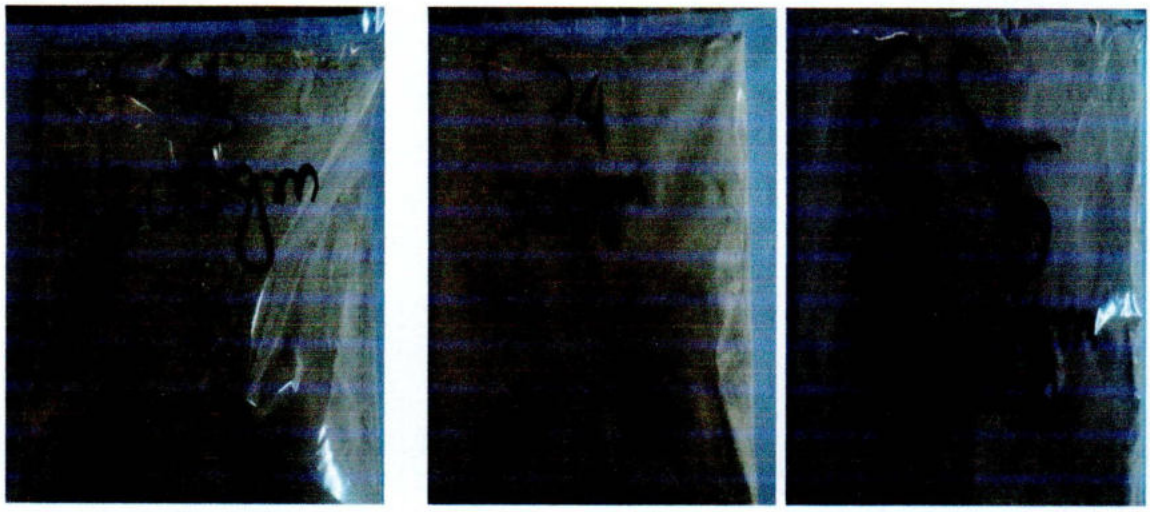


Fig. 4.3 Composite flour prepared from various proportion of potato, rice and wheat flour.

4.3.1 Composition of prepared rice and noodles

In the present study five samples of prepared rice and noodles, one containing no potato flour and four samples with various levels of potato flour, were prepared and analyzed for their composition. The results are shown in table 4.3.

Table 4.3 Composition of prepared rice / Noodles

Type of products		Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Total carbohydrate (by difference) %
prepared rice/ noodles	CS1 (0%)	10.57	0.71	10.50	0.90	77.32
	CS2 (10%)	11.25	0.89	10.05	0.85	76.96
	CS3 (20%)	11.70	1.07	9.60	0.82	76.81
	CS4 (30%)	11.25	1.27	9.25	0.92	77.38
	CS5 (40%)	11.00	1.40	9.01	0.82	76.77

The proportion is mentioned in table 3.1. CS1= Composite flour sample 1, CS2= Composite flour sample 2, CS3= Composite flour sample 3, CS4= Composite flour sample 4, CS5= Composite flour sample 5.

Moisture content of prepared rice and noodles sample with different levels of potato flour was higher than that of controlled sample. But fat content of 30% potato flour was higher than different level of potato flour and noodles. With the increasing level of potato flour, the prepared rice and noodles had increasing level of ash and decreasing protein.

4.4 Sensory evaluation of products

4.4.1 Sensory evaluation of prepared rice

The prepared rice was substituted with 0, 10, 20, 30 and 40% potato flour and subjected to sensory evaluation by a panel of 10 panellists. The mean scores for colour, flavour, texture and overall acceptability of the prepared rice are presented in table 4.4. A two way analysis of variance indicated that all these sensory attributes of different prepared rice were significantly ($P<0.05$) different and thus the prepared rice samples showed varied degrees of acceptability in terms of colour, flavour, texture and overall acceptability.

Table 4.4 Mean sensory scores of prepared rice Duncan's Multiple Range Test (DMRT) for colour, flavour, texture and overall acceptability of prepared rice

Product type	*Mean scores on sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
prepared rice with wheat flour only (Control)	6.5^{bc}	6.2^{bc}	6.9^{b}	6.3^{c}
prepared rice with 10% rice and 10% potato flour	6.6^{bc}	6.6^{abc}	7.3^{ab}	6.7^{bc}
prepared rice with 10% rice and 20% potato flour	7.1^{b}	7.2^{ab}	6.5^{b}	7.4^{ab}
prepared rice with 10% rice and 30% potato flour	7.9^{a}	7.5^{a}	7.9^{a}	7.8^{a}
prepared rice with 10% rice and 40% potato flour	6.3^{c}	5.8^{c}	6.6^{b}	6.6^{c}
LSD (P <0.05)	0.6329	0.9852	0.8123	0.7008

*Means with different superscripts within a column are significantly different at $P< 0.05$

As shown in Table 4.4, the DMRT test revealed that the prepared rice containing 30% potato flour was most preferred for colour than the prepared rice containing various levels of potato flour and controlled prepared rice. Potato rice with 40% potato flour had least colour acceptability. The flavour, texture and overall acceptability of prepared rice containing 30% potato flour were significantly different from that of others and secured the highest scores in terms of all quality attributes and ranked as 'like moderately' to 'like very much'.

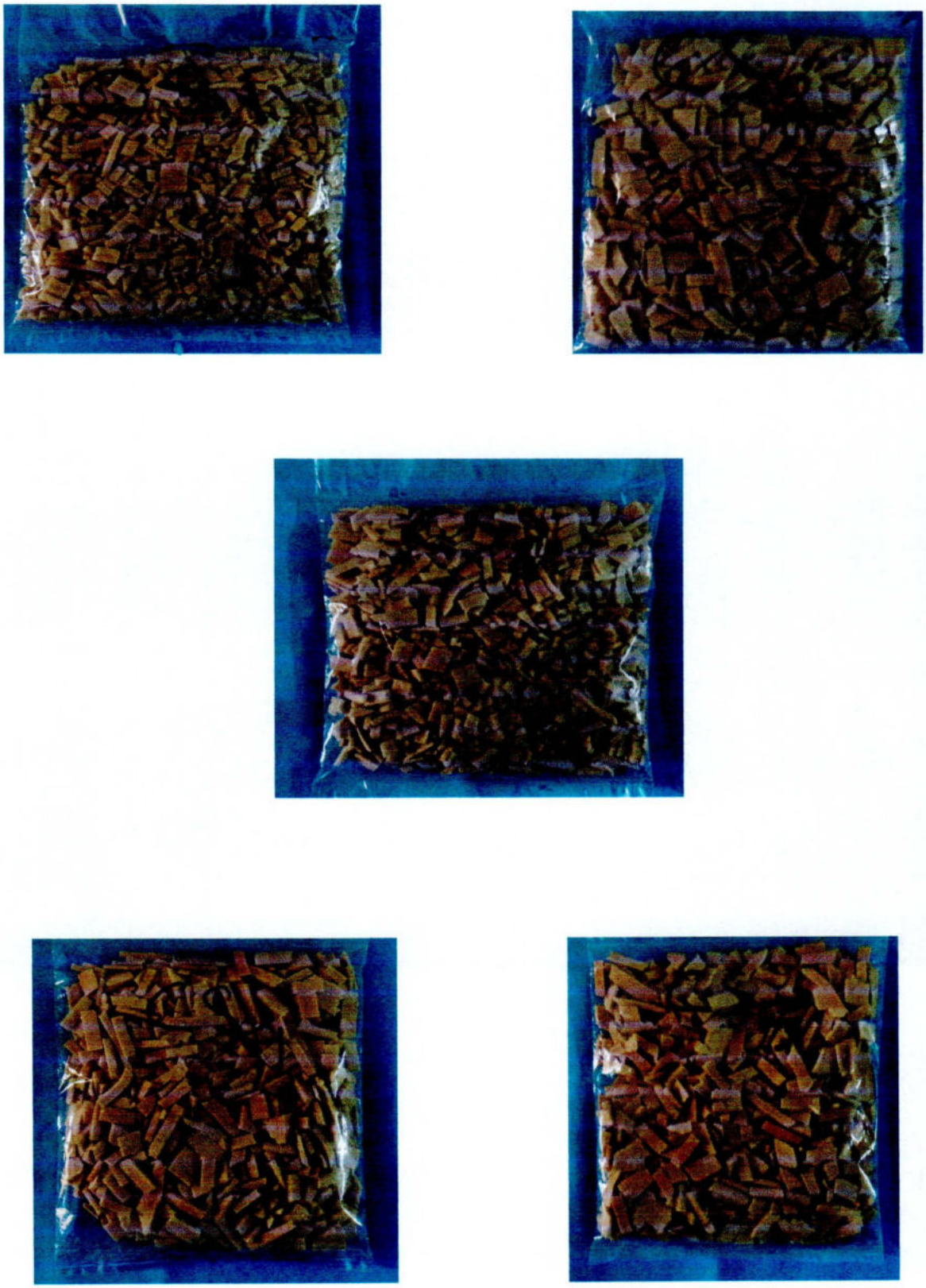


Fig 4.4 Rice prepared from composite flour

4.4.2 Sensory evaluation of noodles

The noodles substituted with 0, 10, 20, 30 and 40% potato flour were subjected to sensory evaluation by a panel of 10 panellists. The mean scores for colour, flavour, texture and overall acceptability of the noodles are presented in table 4.5. A two way analysis of variance indicate that all these sensory attributes of different noodles were significantly ($P<0.05$) different and thus the noodles showed varied degrees of acceptability in terms of colour, flavour, texture and overall acceptability.

Table 4.5 Mean sensory scores of noodles Duncan's Multiple Range Test (DMRT) for colour, flavour, texture and overall acceptability of noodles

Product type	*Mean scores on sensory attributes			
	Colour	Flavour	Texture	Overall acceptability
Noodles with wheat flour only (Control)	6.0^{c}	6.8^{ab}	6.7^{b}	7.0^{b}
Noodles with 10% rice and 10% potato flour	6.4^{bc}	6.7^{ab}	6.5^{b}	7.1^{ab}
Noodles with 10% rice and 20% potato flour	6.8^{abc}	7.8^{a}	7.8^{a}	7.8^{a}
Noodles with 10% rice and 30% potato flour	7.6^{a}	7.0^{ab}	6.2^{b}	6.4^{b}
Noodles with 10% rice and 40% potato flour	7.0^{ab}	6.4^{b}	7.0^{ab}	6.7^{b}
LSD (P <0.05)	0.8657	1.233	0.8951	0.7250

*Means with different superscripts within a column are significantly different at $P< 0.05$

As shown in Table 4.5, the DMRT test revealed that the noodles containing 30% potato flour were most preferred for colour than the noodles containing various levels of potato flour and controlled noodles. Noodles with (control) 0% potato flour had least colour acceptability. The flavour, texture and overall acceptability of noodles containing 20% potato flour were significantly different from that of others and secured the highest scores in terms of all quality attributes and ranked as 'like moderately' to 'like very much'.

Fig. 4.5 Noodles prepared from composite flour

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

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SUMMARY AND CONCLUSION

The present study reports on the preparation of potato flour with various treatments and formulation of products incorporating potato flour as supplement to wheat flour and rice flour. The study was conducted in the laboratories of the Department of Food Engineering and Technology, Food Science and Nutrition, Food Processing and Preservation and Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

The raw potato was procured, cleaned, sliced and treated with different treatments. Four types of potato flours were prepared by treating the raw potato slices as blanched, blanched plus KMS, blanched plus smashed and another one as control without treatment. The treated potato samples were dried in cabinet drier at 60^0 C for 8 hours and 45^0 C for 4 hours to dry fully and then ground to powder in a blender to prepare potato flour. Blanched plus KMS treated potato flour was used only. The study was also conducted to find out the best level of potato flour supplementation in the preparation of rice and noodles; hence 0, 10, 20, 30, and 40% of potato flour was supplemented in formulation of rice and noodles.

The fresh potato, potato flour, rice, rice flour, wheat and wheat flour were analyzed for their moisture content, ash, protein, fat and total carbohydrate. Composite flour was prepared which include the ingredients potato, rice and wheat flour in different proportion. The prepared rice and noodles were analyzed for their composition.

Five samples of prepared rice and five samples of noodles were prepared by the incorporation of various levels of potato flour (0-40%) in the standard formulations and the products were evaluated for their physico-chemical properties and sensory analysis.

Statistical analysis of prepared rice containing 30% of potato flour was mostly preferred for colour, flavour, texture and overall acceptability than the prepared rice containing other levels of potato flour and controlled prepared rice. The colour, flavour, texture and overall acceptability of prepared rice containing 30% potato flour were significantly different from that of others.

Statistical analysis of noodles containing 30% of potato flour was mostly preferred for colour than the noodles containing various levels of potato flour and controlled noodles.

The noodles containing 20% potato flour was mostly preferred for flavour, texture and overall acceptability than the noodles containing various levels of potato flour and control noodles. The flavour, texture and overall acceptability of noodles containing 20% potato flour were significantly different from that of others.

This study demonstrates that it is possible to prepare potato flour from potato and preserve as flour. The study also demonstrates that potato flour can be incorporated with rice and wheat flour to develop composite flour. The study also reveals that rice, wheat, potato composite flour can be used to prepare grains like rice and also stick noodles that can be cooked as rice and noodles and consumed. Then the study opens a bright area of using potato as flour and use of potato as a supplement to rice and alike products. This will ensure the good price of potato for the growers and supply of potato and preservation throughout the year.

The findings of the present study may help in developing commercial processing technology for effective utilization of potato flour, especially for manufacturing of rice and noodles.

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APPENDICES

APPENDICES

APPENDIX I

1. Sensory evaluation of prepared rice made from blanched + KMS treated potato flour

Table 1.1.1 Rating score for colour of prepared rice containing (0-40%) potato flour

No. of Panellist	Prepared rice with wheat flour only (Control)	Prepared rice with 10% rice and 10% potato flour	Prepared rice with 10% rice and 20% potato flour	Prepared rice with 10% rice and 30% potato flour	Prepared rice with 10% rice and 40% potato flour	Total
1	7	8	8	9	8	35
2	7	8	7	6	7	34
3	8	6	7	8	7	32
4	6	8	7	6	7	34
5	8	7	7	8	6	36
6	8	7	9	8	7	38
7	6	7	7	8	7	36
8	6	7	6	8	6	31
9	7	7	8	7	8	34
10	6	8	7	8	6	34
Total	65	66	71	79	63	344
Mean	6.5	6.6	7.1	7.9	6.3	

* Hedonic scale used: 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.

Table 1.1.2 ANOVA (Analysis of variance) for colour of prepared rice

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	16.48	4.12	**8.46**	**2.63**
Panellists	9	7.28	0.809		
Errors	36	17.52	0.487		
Total	49	41.28			

Table 1.1.3 Duncan's Multiple Range Test (DMRT) for colour of prepared rice

LSD value = 0.6329; S_x = 0.2207; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Prepared rice with wheat flour only (Control)	**6.5^{bc}**	Prepared rice with 10% rice and 30% potato flour	**7.9^{a}**
Prepared rice with 10% rice and 10% potato flour	**6.6^{bc}**	Prepared rice with 10% rice and 20% potato flour	**7.1^{b}**
Prepared rice with 10% rice and 20% potato flour	**7.1^{b}**	Prepared rice with 10% rice and 10% potato flour	**6.6^{bc}**
Prepared rice with 10% rice and 30% potato flour	**7.9^{a}**	Prepared rice with wheat flour only (Control)	**6.5^{bc}**
Prepared rice with 10% rice and 40% potato flour	**6.3^{c}**	Prepared rice with 10% rice and 40% potato flour	**6.3^{c}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX II

Table 1.2.1 Rating score for flavour of prepared rice containing (0-40%) potato flour

No. of Panellist	Prepared rice with wheat flour only (Control)	Prepared rice with 10% rice and 10% potato flour	Prepared rice with 10% rice and 20% potato flour	Prepared rice with 10% rice and 30% potato flour	Prepared rice with 10% rice and 40% potato flour	Total
1	6	7	7	9	7	34
2	7	8	6	8	7	34
3	4	6	7	8	7	33
4	6	7	7	8	7	29
5	7	4	6	8	5	33
6	7	6	5	8	7	34
7	6	5	7	7	6	33
8	4	7	6	8	5	34
9	5	6	7	9	6	32
10	7	7	8	8	6	37
Total	62	66	72	75	58	333
Mean	6.2	6.6	7.2	7.5	5.8	

* Hedonic scale used: 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.

Table 1.2.2 ANOVA (Analysis of variance) for flavour of prepared rice

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	19.52	4.88	**4.13**	**2.63**
Panellists	9	7.22	0.80		
Errors	36	42.48	1.18		
Total	49	69.22			

Table 1.2.3 Duncan's Multiple Range Test (DMRT) for flavour of prepared rice

LSD value = **0.9852**; S_x **= 0.3435; P< 0.05**

Product type	Original order of means	Product type	Ranked order of means
Prepared rice with wheat flour only (Control)	**6.2^{bc}**	Prepared rice with 10% rice and 30% potato flour	**7.5^{a}**
Prepared rice with 10% rice and 10% potato flour	**6.6^{abc}**	Prepared rice with 10% rice and 20% potato flour	**7.2^{ab}**
Prepared rice with 10% rice and 20% potato flour	**7.2^{ab}**	Prepared rice with 10% rice and 10% potato flour	**6.6^{abc}**
Prepared rice with 10% rice and 30% potato flour	**7.5^{a}**	Prepared rice with wheat flour only (Control)	**6.2^{bc}**
Prepared rice with 10% rice and 40% potato flour	**5.8^{c}**	Prepared rice with 10% rice and 40% potato flour	**5.8^{c}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX III

Table 1.3.1 Rating score for texture of prepared rice containing (0-40%) potato flour

No. of Panellist	Prepared rice with wheat flour only (Control)	Prepared rice with 10% rice and 10% potato flour	Prepared rice with 10% rice and 20% potato flour	Prepared rice with 10% rice and 30% potato flour	Prepared rice with 10% rice and 40% potato flour	Total
1	8	8	7	9	9	41
2	8	9	6	7	7	35
3	7	8	7	8	6	35
4	8	7	8	7	8	31
5	8	6	6	8	6	33
6	9	7	8	9	8	36
7	8	8	7	8	8	36
8	8	8	7	8	8	36
9	7	8	7	6	7	35
10	8	7	8	7	9	34
Total	69	73	65	79	66	352
Mean	6.9	7.3	6.5	7.9	6.6	

- Hedonic scale used: 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.

Table 1.3.2 ANOVA (Analysis of variance) for texture of prepared rice

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	13.12	3.28	**4.08**	**2.63**
Panellists	9	11.92	1.32		
Errors	36	28.88	0.802		
Total	49	53.92			

Table 1.3.3 Duncan's Multiple Range Test (DMRT) for texture of prepared rice

LSD value =0.8123; S_x = 0.2832; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Prepared rice with wheat flour only (Control)	**6.9^b**	Prepared rice with 10% rice and 30% potato flour	**7.9^a**
Prepared rice with 10% rice and 10% potato flour	**7.3^{ab}**	Prepared rice with 10% rice and 10% potato flour	**7.3^{ab}**
Prepared rice with 10% rice and 20% potato flour	**6.5^b**	Prepared rice with wheat flour only (Control)	**6.9^b**
Prepared rice with 10% rice and 30% potato flour	**7.9^a**	Prepared rice with 10% rice and 40% potato flour	**6.6^b**
Prepared rice with 10% rice and 40% potato flour	**6.6^b**	Prepared rice with 10% rice and 20% potato flour	**6.5^b**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX IV

Table.1.4.1 Rating score for overall acceptability of prepared rice containing (0-40%) potato flour

No. of Panellist	Potato rice with wheat flour only (Control)	Potato rice with 10% rice and 10% potato flour	Potato rice with 10% rice and 20% potato flour	Potato rice with 10% rice and 30% potato flour	Potato rice with 10% rice and 40% potato flour	Total
1	6	7	8	9	6	35
2	7	8	6	8	8	35
3	5	6	7	8	7	33
4	6	7	5	7	7	33
5	5	7	7	8	6	33
6	8	7	8	9	5	36
7	7	5	6	7	6	32
8	6	7	8	8	6	35
9	7	6	7	8	7	36
10	6	7	8	9	8	37
Total	63	67	74	78	66	348
Mean	6.3	6.7	7.4	7.8	6.6	

* Hedonic scale used: 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.

Table 1.4.2 ANOVA (Analysis of variance) for overall acceptability of prepared rice

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	15.32	3.83	**6.41**	**2.63**
Panellists	9	7.12	0.79		
Errors	36	21.48	0.597		
Total	49	43.92			

Table 4.1.2 Duncan's Multiple Range Test (DMRT) for acceptability of prepared rice

LSD value = 0.7008 ; Sx = 0.2443; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Prepared rice with wheat flour only (Control)	**6.3^{c}**	Prepared rice with 10% rice and 30% potato flour	**7.8^{a}**
Prepared rice with 10% rice and 10% potato flour	**6.7^{bc}**	Prepared rice with 10% rice and 20% potato flour	**7.4^{ab}**
Prepared rice with 10% rice and 20% potato flour	**7.4^{ab}**	Prepared rice with 10% rice and 10% potato flour	**6.7^{bc}**
Prepared rice with 10% rice and 30% potato flour	**7.8^{a}**	Prepared rice with 10% rice and 40% potato flour	**6.6^{c}**
Prepared rice with 10% rice and 40% potato flour	**6.6^{c}**	Prepared rice with wheat flour only (Control)	**6.3^{c}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX V

2. Sensory evaluation of noodles made from blanched + KMS treated potato flour.

Table 2.1.1 Rating score for colour of noodles containing (0-40%) potato flour

No. of Panellist	Noodles with wheat flour only (Control)	Noodles with 10% rice and 10% potato flour	Noodles with 10% rice and 20% potato flour	Noodles with 10% rice and 30% potato flour	Noodles with 10% rice and 40% potato flour	Total
1	7	8	8	7	8	35
2	8	6	6	5	4	33
3	8	8	7	7	8	33
4	6	8	6	6	6	30
5	8	7	7	8	6	32
6	8	6	5	6	7	34
7	6	8	9	9	7	38
8	8	8	7	6	8	35
9	7	7	7	7	8	35
10	6	7	7	8	7	35
Total	65	67	77	69	62	340
Mean	6.5	6.7	7.7	6.9	6.2	

* Hedonic scale used: 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.

Table 2.1.2 ANOVA (Analysis of variance) for colour of noodles

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	12.80	3.2	**3.51**	**2.63**
Panellists	9	8.4	0.933		
Errors	36	32.80	0.911		
Total	49	54.00			

Table 2.1.3 Duncan's Multiple Range Test (DMRT) for colour noodles

LSD value = 0.8657; Sx = 0.3018 ; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Noodles with wheat flour only (Control)	**6.0^{c}**	Noodles with 10% rice and 30% potato flour	**7.6^{a}**
Noodles with 10% rice and 10% potato flour	**6.4^{bc}**	Noodles with 10% rice and 40% potato flour	**7.0^{ab}**
Noodles with 10% rice and 20% potato flour	**6.8^{abc}**	Noodles with 10% rice and 20% potato flour	**6.8^{abc}**
Noodles with 10% rice and 30% potato flour	**7.6^{a}**	Noodles with 10% rice and 10% potato flour	**6.4^{bc}**
Noodles with 10% rice and 40% potato flour	**7.0^{ab}**	Noodles with wheat flour only (Control)	**6.0^{c}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX VI

Table 2.2.1 Rating score for flavour of noodles containing (0-40%) potato flour

No. of Panellist	Noodles with wheat flour only (Control)	Noodles with 10% rice and 10% potato flour	Noodles with 10% rice and 20% potato flour	Noodles with 10% rice and 30% potato flour	Noodles with 10% rice and 40% potato flour	Total
1	7	8	8	8	8	39
2	7	6	6	7	5	31
3	7	8	7	8	8	38
4	7	8	6	6	6	32
5	7	7	7	8	6	35
6	8	7	6	5	8	33
7	7	8	9	9	8	38
8	8	9	8	8	9	32
9	7	7	8	7	7	36
10	7	8	7	8	7	33
Total	68	67	78	70	64	347
Mean	6.8	6.7	7.8	7.0	6.4	

* Hedonic scale used: 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.

Table 2.2.2 ANOVA (Analysis of variance) for flavour of noodles

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	11.12	2.78	**1.5**	**2.63**
Panellists	9	15.22	1.69		
Errors	36	66.48	1.84		
Total	49	92.82			

Table 2.2.3 Duncan's Multiple Range Test (DMRT) for flavour of noodles

LSD value = 1.233; Sx = 0.4298; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Noodles with wheat flour only (Control)	**6.8^{ab}**	Noodles with 10% rice and 20% potato flour	**7.8^{a}**
Noodles with 10% rice and 10% potato flour	**6.7^{ab}**	Noodles with 10% rice and 30% potato flour	**7.0^{ab}**
Noodles with 10% rice and 20% potato flour	**7.8^{a}**	Noodles with wheat flour only (Control)	**6.8^{ab}**
Noodles with 10% rice and 30% potato flour	**7.0^{ab}**	Noodles with 10% rice and 10% potato flour	**6.7^{ab}**
Noodles with 10% rice and 40% potato flour	**6.4^{b}**	Noodles with 10% rice and 40% potato flour	**6.4^{b}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX VII

Table 2.3.1 Rating score for texture of noodles containing (0-40%) potato flour

No. of Panellist	Noodles with wheat flour only (Control)	Noodles with 10% rice and 10% potato flour	Noodles with 10% rice and 20% potato flour	Noodles with 10% rice and 30% potato flour	Noodles with 10% rice and 40% potato flour	Total
1	7	8	8	7	8	38
2	7	6	6	6	5	32
3	8	8	7	7	7	27
4	7	8	7	7	7	33
5	8	8	8	8	8	40
6	7	7	4	6	7	35
7	7	8	8	9	8	31
8	8	9	8	6	6	35
9	6	7	7	6	8	33
10	8	7	8	7	8	38
Total	67	65	78	62	70	342
Mean	6.7	6.5	7.8	6.2	7.0	

- Hedonic scale used: 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.

Table 2.3.2 ANOVA (Analysis of variance) for texture of noodles

Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	14.92	3.73	**3.82**	**2.63**
Panellists	9	26.72	2.96		
Errors	36	35.08	0.974		
Total	49	76.72			

Table 2.3.3 Duncan's Multiple Range Test (DMRT) for texture of noodles

LSD value = 0.8951 ; Sx = 0.3121; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Noodles with wheat flour only (Control)	**6.7^{b}**	Noodles with 10% rice and 20% potato flour	**7.8^{a}**
Noodles with 10% rice and 10% potato flour	**6.5^{b}**	Noodles with 10% rice and 40% potato flour	**7.0^{ab}**
Noodles with 10% rice and 20% potato flour	**7.8^{a}**	Noodles with wheat flour only (Control)	**6.7^{b}**
Noodles with 10% rice and 30% potato flour	**6.2^{b}**	Noodles with 10% rice and 10% potato flour	**6.5^{b}**
Noodles with 10% rice and 40% potato flour	**7.0^{ab}**	Noodles with 10% rice and 30% potato flour	**6.2^{b}**

Means with same superscripts within a column are not significantly different at P< 0.05

APPENDIX VIII

Table.2.4.1 Rating score for overall acceptability of noodles containing (0-40%) potato flour

No. of Panellist	Noodles with wheat flour only (Control)	Noodles with 10% rice and 10% potato flour	Noodles with 10% rice and 20% potato flour	Noodles with 10% rice and 30% potato flour	Noodles with 10% rice and 40% potato flour	Total
1	7	8	8	7	8	38
2	8	7	6	6	6	35
3	8	7	7	7	8	35
4	7	8	7	7	7	36
5	7	7	8	7	7	36
6	7	8	5	8	7	38
7	7	8	9	9	8	36
8	8	9	7	5	6	32
9	6	7	8	7	7	33
10	8	7	8	8	8	31
Total	70	71	78	64	67	350
Mean	7.0	7.1	7.8	6.4	6.7	

* Hedonic scale used: 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.

Table 2.4.2 ANOVA (Analysis of variance) for overall acceptability of noodles

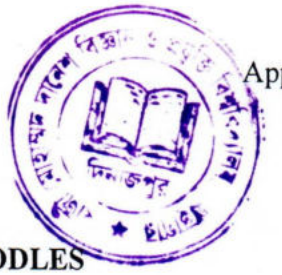
Sources of variance	Degree of freedom	Sum of squares	Mean scores	Calculated value F_C	Tabulated value (5%) F_T
Products	4	11.00	2.75	4.30	2.63
Panellists	9	10.00	1.11		
Errors	36	23.00	0.639		
Total	49	44.00			

Table 2.4.3 Duncan's Multiple Range Test (DMRT) for acceptability of noodles

LSD value = 0.7250; Sx= 0.2528; P< 0.05

Product type	Original order of means	Product type	Ranked order of means
Noodles with wheat flour only (Control)	**7.0^{b}**	Noodles with 10% rice and 20% potato flour	**7.8^{a}**
Noodles with 10% rice and 10% potato flour	**7.1^{ab}**	Noodles with 10% rice and 10% potato flour	**7.1^{ab}**
Noodles with 10% rice and 20% potato flour	**7.8^{a}**	Noodles with wheat flour only (Control)	**7.0^{b}**
Noodles with 10% rice and 30% potato flour	**6.4^{b}**	Noodles with 10% rice and 40% potato flour	**6.7^{b}**
Noodles with 10% rice and 40% potato flour	**6.7^{b}**	Noodles with 10% rice and 30% potato flour	**6.4^{b}**

Means with same superscripts within a column are not significantly different at P< 0.05



APPENDIX IX

A PANEL TASTE OF RICE /NOODLES

Name of tester:..... Date:.....

Please taste these samples and check how much you like or dislike each one on four sensory attributes such as Colour, Flavour, Texture and Overall Acceptability. Use the appropriate scale to show your attitude by checking at the point that best describe your feeling about the sample. Please give a reason for this attitude. Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help me.

HEDONIC	COLOUR					FLAVOUR					TEXTURE					OVERALL ACCEPTABILITY				
	SAMPLE					SAMPLE					SAMPLE					SAMPLE				
	CS_1	CS_2	CS_3	CS_4	CS_5	CS_1	CS_2	CS_3	CS_4	CS_5	CS_1	CS_2	CS_3	CS_4	CS_5	CS_1	CS_2	CS_3	CS_4	CS_5
Like extremely																				
Like very much																				
Like moderately																				
Like slightly																				
Neither like nor dislike																				
Dislike slightly																				
Dislike moderately																				
Dislike very much																				
Dislike extremely																				

Extra comments on each sample if any:

Signature:.....

N.B. Overall Evaluation:
Hedonic scale used: 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.