Development and Quality Evaluation of a Protein Enriched Instant Noodle

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ABSTARCT. *The instant food products play a major role in the market and there is a good demand for these products due to the variety of products and their convenience in preparation. Protein enriched, wheat-based food is a promising alternative for people prone to Protein Energy Malnutrition (PEM). The research was conducted to formulate a nutritious, protein enriched and convenient instant noodle product. The main objective was to develop protein enriched instant noodles (PEIN) using soy flour, green gram flour and whole egg powder. The formula selected was used in industrial scale production. Physiochemical analysis, sensory evaluation and storage study were conducted on the developed product, enriched with proteins. The formula with 10 kg of green gram flour, 10 kg of soy flour, 5 kg of whole egg powder and 75 kg wheat flour (Formula V) was selected as the best combination for PEIN. A protein enriched noodle piece (85 g) provides a minimum of 14.9% protein. There was a significant difference in protein and ash content in Formula V PEIN and the control ($p<0.05$). Moisture content and peroxide values after six months storage were within the Sri Lankan standards and microbiological analyses during six months assured the safety of the product. The storage study reveled that the developed PEIN product possessed six months shelf life.*

INTRODUCTION

The food consumption pattern has changed during the past decade due to urbanization and industrialization. Popularity of instant food is being increased because of the varieties of products with unique sensory attributes and convenience in preparation (Ranjani *et al.*, 2000).

Although, extensive studies on enriched cereal-based foods have been carried out, studies on protein enrichment in wheat-based snack foods were scanty (Rao *et al*., 1995). Incorporation of either plant or animal protein with cereals improves the amino acid balance and protein content. Protein enriched wheat-based foods is one of the best alternatives to prevent widely prevailing Protein Energy Malnutrition (PEM) in South Asian countries.

In developing countries, nearly 80% of the protein in the diet is supplied by the plant protein sources such as pulses. The pulses are rich source of minerals and vitamins in daily diets, especially among the low-income group (Singh, 1999).

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The instant noodles is a product made from a dough prepared from wheat flour and water, with or without other optional ingredients, kneaded, extruded through an extrusion press fitted with a die of the desired size, pre-cooked in boiling edible oil, cooled and packed (SLS 420, 1989). The product should be in the form of solid rods with a minimum length of 200 mm and a diameter of 1-2 mm or ribbon with minimum length of 200 mm, width of 1.5-15 mm and thickness of 1-2 mm (SLS 420, 1989). The information on final product quality and the factors affecting quality are extremely limited in the scientific literature (Kruger *et al*., 1998).

The research was conducted to formulate a nutritious, protein enriched, and convenient instant noodle product. The objectives of the research were; (i) to increase the protein content and amino acid balance of the final product by utilizing soy flour, green gram flour, whole egg powder and wheat flour, (ii) to minimize the cost of production to provide affordable and convenient diet for low income, and malnourished local consumers.

MATERIALS AND METHODS

Formulation of protein enriched instant noodle

The experiments were conducted on six Protein Enriched Instant Noodle (PEIN) formulations in order to select the best combination for the industrial process. The best formula was determined using the process parameters and physicochemical analysis. Raw materials and ingredients of the experimental formulas are given in Table 1.

During the processing, structure, size of dough crumbs in the mixer, dampness of dough crumbs and sheet, color of dough sheet before and after resting, stickiness of dough sheet, cooking properties of noodle strands, color and tensile of the strands, appearance and texture after frying were considered to select the best formula.

Table 1. Protein enriched instant noodle formulations.

Ingredients (kg)	Experimental Formulations					
	I	II	III	IV	V	VI
Wheat flour	90.00	85.00	81.00	80.00	75.00	70.00
Soy flour	3.50	5.00	7.00	10.00	10.00	10.00
Green gram flour	3.50	5.00	7.00	5.00	10.00	10.00
Whole egg powder	3.50	5.00	5.00	5.00	5.00	10.00
Water	32.00	32.00	32.00	32.00	32.00	32.00
Salt	1.00	1.00	1.00	1.00	1.00	1.00
Sugar	0.65	0.65	0.65	0.65	0.65	0.65
Sodium bicarbonate	0.10	0.10	0.10	0.10	0.10	0.10
Potassium carbonate	0.15	0.15	0.15	0.15	0.15	0.15
Sodium tripolyphosphate	0.12	0.12	0.12	0.12	0.12	0.12

Production process of protein enriched instant noodles

The production process line is fully automated and the electronic control devices control the continuous feeding of raw materials. The production process consists of mixing of flour, rolling, slitting, steaming, and cutting (one serving size), molding, frying, cooling and packing of PEIN.

Mixing is done to distribute the ingredients uniformly and for hydrolysis. Wheat flour (75 kg), soy flour (10 kg), green gram flour (10 kg) and whole egg powder (05 kg) were weighed and added to a horizontal mixer. Ingredients such as salt, potassium carbonate, sodium bicarbonate, sodium tripolyphosphate (STPP) and sugar were pre-dissolved in potable water and stored in a storage tank. STPP is a GRAS (generally recognized as safe) compound and performs water holding properties during the production process. The solution is referred as alkaline water in which pH of 7.2-7.5 and temperature of 20-30^{0}C were maintained during the storage. Alkaline water (32%) was fed into the mixer through the automatic feeder. Mixing time was 15-20 min.

Further development of gluten takes place at the rolling to obtain an extremely uniform protein matrix. The folded sheet was successively reduced to the desirable thickness (0.85-0.90 mm) and cut into noodles. The reduction in thickness of sheet was controlled with a gap setting of a series of smooth metal rolls. The cut noodle strands were continually fed into a traveling net conveyor, which moves slower than the cutting rolls above it. The speed difference between noodle feeding and net traveling results in a unique wave to the noodle strands.

During steaming, starch on the surface of noodle is gelatinized and dissolved completely and the surface of noodle is covered with a thin film of dissolved starch. This thin film of starch gives smoothness to noodles and inhibits the oil absorption during frying.

The cut and wavy noodle strands were conveyed to the closed steam chamber (4 bar pressure) and cooked for 90 s at 100ºC. After steaming, these noodles strands were fed into the cutter. Cutting length of the noodles strands was adjusted according to the final weight of the product. Continuous rotating cutter was used with a cutting speed of 25-30 cuts per min. Cooked noodles were cooled with a cooling fan, extended to separate the strands and cut into one serving size (based on the final weight). The noodle strands folded and placed in a square molds and conveyed to the tunnel fryer. Excess water in noodles was removed and oil incorporated during frying. Refined Bleached and Deodorised (RBD) palm olein was used for frying at 155-165^{0}C for 90 s. Since the fried noodles temperature is 80-100^{0}C, it requires immediate cooling to avoid rapid fat oxidation. Cooling tunnel was used to reduce the temperature and excess oil was drained. The cooled noodles were automatically conveyed and passed through a metal detector. Finally the products were weighed and fed into the wrapping machine, hermetically sealed with oriented poly propylene (OPP) printed pouches.

Protein requirement (%) in the PEIN piece

The recommended daily protein allowance for a moderately working man (65 kg body weight) is 37 g. In order to claim on the label as a food is a sufficient source of one or more nutrients, the food should be contained one or more nutrients equivalent to 1/3 of the quantity of such nutrient/s recommended as daily allowance (SLS 467: Part 2, (1994).

The required protein content per diet is 12.3 g (assumed 3 diets/day). The minimum protein content, 14.4% should be maintained in the develop product to satisfy the recommended daily allowance for protein per diet, as a piece (85 g) of PEIN.

Physicochemical analysis

The best formulated sample was analyzed for moisture content (oven drying method), total ash (muffle furnace), fat (soxhlet apparatus) and crude protein (Kjeldhal distillation apparatus) using the standard methodology (AOAC, 2000). Carbohydrate quantity available in the sample was estimated [Carbohydrate (%) = Total Solid (%) - (Protein (%) + Fat (%) + Ash (%))].

Determinations of free fatty acid and peroxide value were conducted after extraction of oil from noodles using chloroform. About 200 g of the prepared noodle sample was soaked in 300 ml of chloroform in a beaker for one hour. It was filtered through a dry, fluted filter paper and the first few milliliters were rejected and rest of the filtrate was kept in a stoppered flask. Free fatty acid was determined using a 25 ml of filtrate pipetted into a conical flask. A 25 ml of neutralized ethanol was added and titrated with sodium hydroxide solution using phenolphthalein as indicator (AOAC, 2000).

The peroxide value was determined with the pipetted 25 ml of filtrate into a 150 ml conical flask. Glacial acetic acid (35 ml) and 0.5 ml of saturated potassium iodide (0.5 ml) were added and shaked for 1 min. Then, 30 ml of water was added and titrated with Sodium thiosulfate solution using starch as an indicator (AOAC, 2000).

Sensory evaluation

Sensory evaluation was conducted to determine the most preferred sample. Formulas III, IV and V were evaluated by preference-ranking test using 30 semi-trained panelists (Khan *et al*., 1973).

The sensory attributes; appearance, texture, taste, aroma and overall acceptability were evaluated using scores 1 to 5 (1 - extremely poor and 5 - extremely good). Based on the previous experiments, the best PEIN formula was selected and compared with the control using the Hedonic scale (5 points) with 30 semi-trained panelists (Merck Technical Bulletin, 1973). The tabulated data was analyzed by non-parametric analysis, Friedman test (Minitab statistical package).

Storage study and microbiological tests

Moisture content, peroxide value and free fatty acid value were determined during the storage (AOAC, 2000). Microbiological tests; total plate count (SLS 516: Part I, 1991), detection and enumeration of yeast and moulds **(**SLS 516: Part I, 1991), *E. coli* (SLS 516: Part III, 1991) and enumeration of *Staphylococcus aureus* (SLS 516: Part VI, 1991) were conducted on the stored sample.

Cost of production and market survey

The variable costs on raw material, packing material, labor and electricity were considered to calculate the cost of production. Similarly, depreciation, insurance, uniforms

and other overheads were estimated to calculate the fixed cost. A consumer survey was conducted by randomly selected sample of 200 consumers.

RESULTS AND DISCUSSION

Formulation of protein enriched instant noodles

The protein contents of Formulas I and II were 13.7 and 14.1%, respectively. The minimum protein content should be 14.4% and therefore, Formula I and II were rejected. The dough sheet of the Formula VI was highly fragile at the rollers. Formulas III, IV and V were selected as good formulas and further evaluated on production parameters and protein content. Finally, the Formula V was selected because of the best appearance, texture and taste of the products (Plate 1). Formula V consisted with 10 kg soy flour, 10 kg green gram flour, 5 kg egg powder and 75 kg wheat flour. Addition of higher quantities of soy and green gram flour was resulted in breakages of the dough sheet and noodle strands due to under development of gluten network during the sheeting process.

Physicochemical analysis

There was no significant difference ($P<0.05$) in moisture content in developed PEIN, Formula V (2.73 ± 0.07) and the control (2.5 ± 0.142) (Table 2). The moisture content was below the SLS product specification on pasta products of 12% maximum (SLS 420, 1989). Therefore, the low moisture of the samples has extended the shelf life. Low water activity (a_w) has been reduced the microorganisms growth and oxidative rancidity. There was a significant difference ($P<0.05$) in ash content in PEIN Formula V (2.35 ± 0.188) and control (1.90 ± 0.073) (Table 2). The average ash content of prepared sample was 2.35%, which was higher than the control and lower than the SLS standards of 3.50%. The higher value of ash is due to addition of soy flour and green gram flour rich in minerals. The new product consists of high levels of potassium, magnesium, phosphorus and other important minerals.

Table 2. Proximate composition of developed PEIN and the control.

Constituents	Formula V	Control	SLS Standards
Moisture (%)	2.73 ± 0.070^a	2.50 ± 0.142^a	12.0, Max
Ash (%)	2.35 ± 0.188^a	1.90 ± 0.073^b	3.5, Max
Crude protein (%)	14.90 ± 0.200^a	9.55 ± 0.880^b	9.0, Min
Fat (%)	1.70 ± 0.125^a	1.50 ± 0.043^a	-
Free fatty acid (%)	0.60 ± 0.020^a	0.42 ± 0.030^a	0.8, Max
Peroxide value*	5.43 ± 0.298^a	5.68 ± 0.305^a	10.0, Max

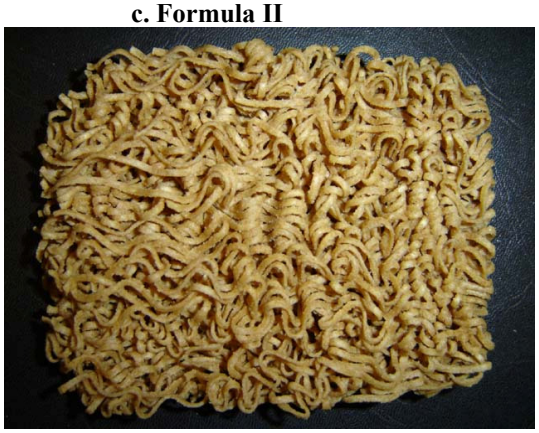
Note: (n = 3) Mean in the same row sharing the same letter are not significantly different at 95 % probability level;
* Miliequivalent peroxide/kg.

a. Control

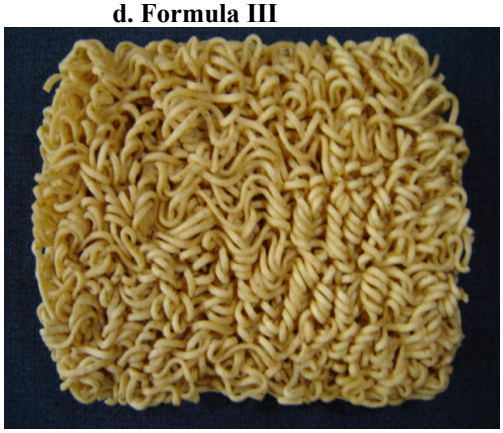
b. Formula I

c. Formula II

d. Formula III



e. Formula IV



f. Formula V

Plate 1. The PEIN Formulas I - V and the control.

As shown in Table 2, there was a significant difference in protein content in PEIN Formula V, 14.90±0.20% and the control, 9.55±0.88 % ($P<0.05$). The protein is higher than the SLS product specification of 9.00% minimum (SLS 420, 1989) by 5.90%.

The fat content of 1.70% was favorable to avoid oxidative rancidity during storage. The recommended food grade antioxidants (BHA, BHT, and TBHQ) could be used with instant noodles to extent the shelf life. Estimated carbohydrate content of the PEIN was 63.30%.

Free fatty acid value was 0.60, which is lower than the SLS standards of 0.8 maximum. The peroxide value of prepared sample was 5.43 that is extremely low compared to the SLS standard of 10 maximum (Table 2). The low free fatty acid and peroxide values were good indicators to ensure the extended shelf life of the product.

Sensory evaluation

Preference - ranking test

The numerical scores of samples were tabulated and analyzed by using Friedman test in Minitab statistical package. Difference of the products was identified using the sums of ranks. Figure 1 shows the average panel scores of the selected formulas. Formula V was selected as the best formulation among three PEIN formulas.

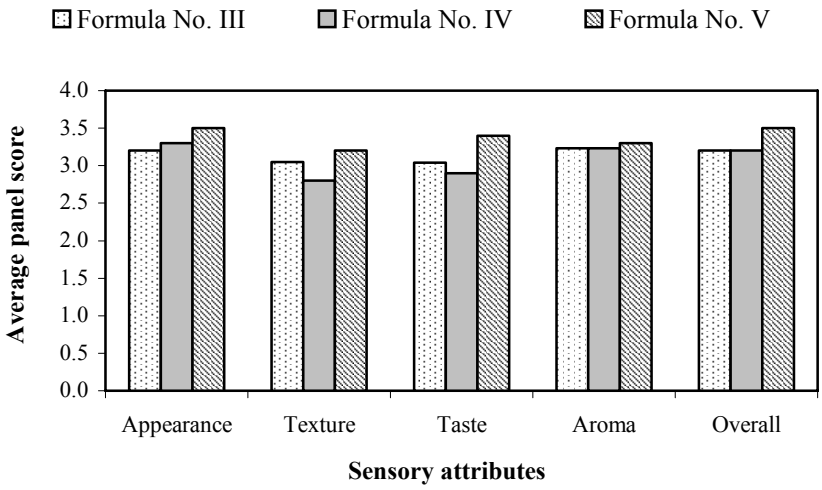


Fig. 1. Sensory attributes of PEIN formulas.

Hedonic test

The ANOVA indicated that there was a significant difference in taste and overall acceptability in PEIN formula and the control. There was no significant difference in appearance, texture and aroma of prepared noodle sample ($P \leq 0.05$) (Fig. 2).

Both noodle samples were free from any flavor, except the saltiness. The prepared PEIN Formula V was highly accepted by the evaluators. The reason was the firm, chewy and elastic nature of noodles due to addition of soy, green gram flour and whole egg powder.

Nevertheless, according to the ANOVA, there was no significant difference between appearance, texture and aroma of the prepared PEIN noodles and the control.

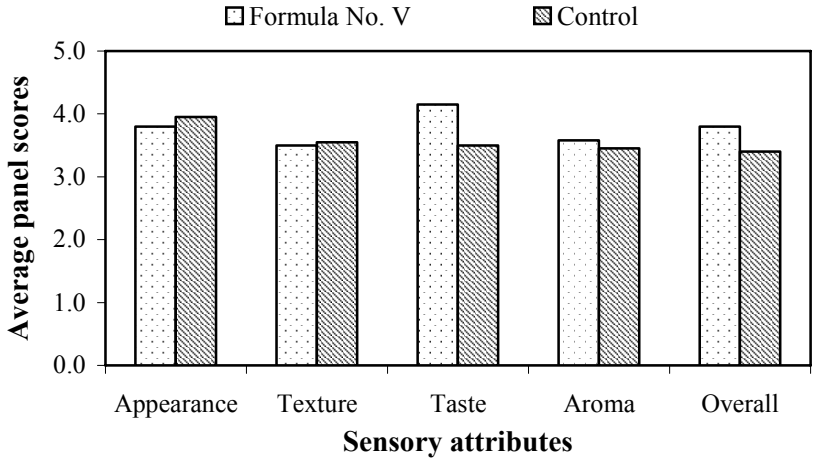


Fig. 2. Sensory attributes of Formula V of PEIN and the control.

Storage study

The changes of moisture content and peroxide value of PEIN sample (Formula V) are given in Figures 3 and 4, respectively.

Moisture content of prepared samples at storage was gradually increased. During the storage, PEIN moisture content has been increased from 2.73 to 3.78% and the control from 2.5 to 3.6% (Fig. 4). There was a tendency to commence the growth of microorganisms, yeast, mold and oxidation of lipids. The texture, appearance and taste of the prepared samples were changed due to increase of moisture content.

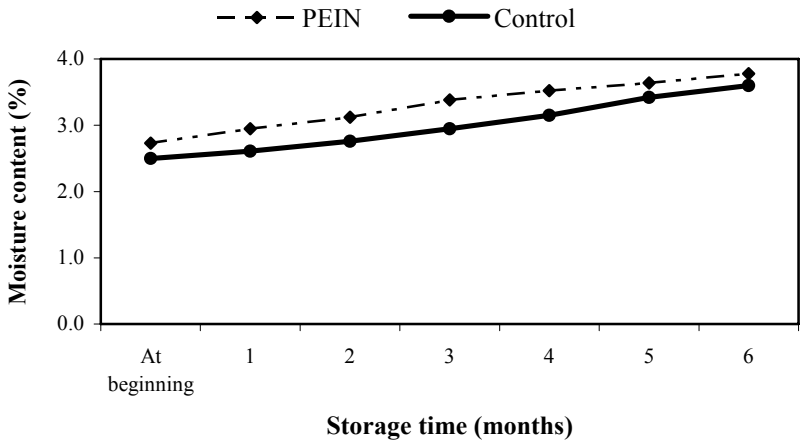


Fig. 3. Moisture (%) of PEIN (Formula V) and the control during the storage period.

However, after six months of storage, the prepared samples contained very low moisture content, which gives positive indication for longer keeping quality of the product. The peroxide value was rapidly changing during six months of storage, but the peroxide value was less than the SLS standards of 10 maximum. After 6 months from the production, peroxide value was close to the SLS standard. Shelf life of the developed PEIN could be predicted observing the peroxide value. Therefore, shelf life of this product was 6 months and thereafter the product was degraded by autoxidation reaction.

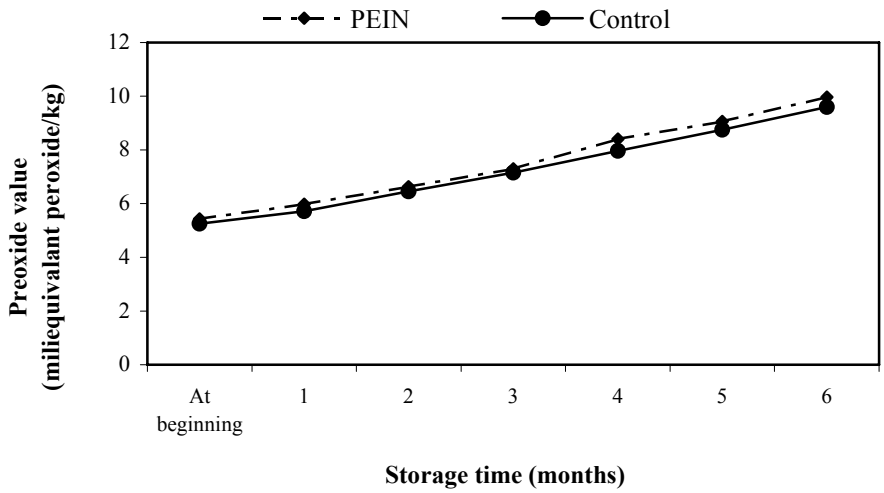


Fig. 4. Peroxide value of PEIN (Formula V) and the control during the storage period.

Microbiological analysis during storage

Table 3. Tabulated results of microbiological analysis.

Microbes	Time (months)						Reference standard
	1	2	3	4	5	6	
Total plate count/g	$<1.0x10^2$	$<1.0x10^2$	$<1.0x10^2$	$<1.0x10^2$	$<1.0x10^2$	$<1.0x10^2$	$<1.6x10^2$
E. Coli (MPN/g)	<0.3x10	<0.3x10	<0.3x10	<0.3x10	<0.3x10	<0.3x10	<0.3x10
Staphylococcus aureus/g	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Yeast and mould/g	<1.0x10	<1.0x10	<1.0x10	<1.0x10	<1.0x10	<1.0x10	<1.0x10

Note: n = 3.

The investigated noodle samples were starch-based products with low moisture content. The reduction of moisture level is a well-recognized method of food preservation. The primary purpose of this is to inhibit the growth of microorganism by limiting the water activity (a_w). The result revealed that due to low moisture content, product was not affected by the microbial growth and occurrence, the tested microbiological parameters were below the reference standards (Table 3). Therefore, contributes to extend of the shelf life of the noodles.

Cost of production and market survey

Cost of production of existing noodle piece (control) was Rs. 7.10. The total cost of PEIN was Rs. 8.60 where the difference was only Rs. 1.50. Therefore, ordinary consumers would be able to afford the price Rs. 8.60 for a PEIN packet. The survey revealed that there was a good potential for the developed PEIN as there are no protein enriched instant noodle products in the local market.

The consumer survey revealed that 74% of consumers prefer the developed PEIN products than the control due to high nutritional value. The rest 26% of consumers refused the product and most consumers highlighted that their willingness for seasoning sachet (taste maker) and the cost factor.

CONCLUSIONS

The research was conducted to develop a nutritious, protein enriched, and convenient instant noodle product at a lower price, targeted to the malnourished local consumers. Green gram flour, soy flour, whole egg powder, wheat flour and other ingredients were used to formulate PEIN product with minimum 14.4% protein content to satisfy the recommended daily allowance of protein.

Green gram flour 10 kg, soy flour 10 kg, whole egg powder 5 kg and wheat flour 75 kg with 32 kg of alkaline water (experimental Formula V) was selected as the best formula for the production of PEIN in the industrial scale. The protein percentage of the developed PEIN was 14.9% and the value was 5.9% higher than the control.

Moisture content and peroxide values after six months of storage were within the SLS standards. The product safety was assured on tested microbiological parameters on total plate count, yeast and mold, *Staphylococcus aureus* and *E. coli* during the storage. The developed product was possessed 6 months shelf life. The PEIN is a promising alternative to satisfy the protein requirement for the malnourished and vulnerable groups in Sri Lanka.

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