DEVELOPMENT AND QUALITY CHARACTERISTICS OF PROTEIN ENRICHED WHEAT-SOYBEAN BISCUITS DURING STORAGE

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ABSTRACT

Protein - Energy Malnutrition (PEM) is the most serious nutritional problem in third world countries. This research study was conducted to evaluate the nutritional and sensory qualities of protein enriched biscuits which could be used as a protein supplemented cereal snack foods. The use of soy flour from 0 – 25 % as the substitute to wheat flour for the production of biscuits was investigated. The various ratios of wheat to soybean flour used were 100:00, 95:05, 90:10, 85:15, 80:20 and 75:25. The nutritional qualities such as protein, fat, moisture and total soluble carbohydrate of the biscuit were analyzed. The protein and fat of soy flour supplemented biscuits increased with progressive increase in proportion of soy flour whereas the moisture and carbohydrate content were decreased with corresponding increase in the percentage of soy flour. Organoleptic assessment was conducted for biscuit's colour, texture, flavour and overall acceptance for all treatments. In organoleptic assessment, the mean scores for the assessed sensory characters decreased with increase in the soybean blend.

Based on the nutritional and sensory analysis the most preferred protein enriched biscuits were subjected for storage studies. The quality of the biscuits was assessed in two weeks interval throughout the experimental period. The declining trend was observed in protein, fat and total sugars whereas an increasing trend was observed in moisture with storage period for all the tested treatments. From the overall acceptance rating, the 10% soybean flour added biscuit had the highest mean value compared to other combinations and had the stable shelf life up to 6 weeks at the storage conditions of 30ºC and 75-80% RH.

Key words : Biscuit, Consumer Acceptability, Protein Enrichment, Quality, Soybean, Wheat

1.INTRODUCTION

Biscuits are nutritivesnacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven. They are ready-to-eat, convenient and inexpensive food product, containing digestive and dietary principles of vital importance (Kulkarni, 1997). The principal ingredients are flour, fat, sugar and water; while other ingredients include milk, salt, flouring agent and aerating agent. Biscuits are a rich source of fat and carbohydrate, hence are energy giving food and they are also a good source of protein and minerals.

Soyabean (*Glycine max)* is an excellent source of protein (35-40%); hence the seed is the richest in food value of all plant foods consumed in the world (Kure*et al.*, 1998). It is used in the fresh, fermented or dried form. Soybean can play a vital role in balancing the protein deficiency of our diet. It is rich in calcium, iron, phosphorus and vitamins. It is the only source that contains all the essential amino acids. Its use in the production of bread as composite flourhas been reported (Basman *et al*., 2003). Wheat (*Triticum aestivum* L.) is one of the important cereal grains because of its use for the preparation of many baked products. Unfortunately, lysine is the first limiting amino acid in wheat flour. Enrichment of cereal-based foods with other protein sources such as oil seeds and legumes has received considerable attention (Ayo and Olawale, 2003). This is because of oil seed and legumes proteins are high in lysine, an essential limiting amino acid in most cereals. The use of any food raw material in processing depends on its availability. The main problem facing the bakery industry in Sri Lanka is the total dependence on importation of wheat to sustain it. Sri Lanka has unfavorable climatic condition for wheat cultivation, but suitable for other cereal (sorghum, maize, millet) and legumes (soybean, groundnut, cowpeas). Therefore, any effort made to substitute part of the wheat flour by other kinds of available flours e.g. sorghum, millet will contribute to lowering the cost of production.

In this present study, efforts have been made to supplement wheat flour with soybean flour to develop

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nutritionally protein enriched functional food biscuit. This research also explains the changes in nutritional and sensory characteristics of the biscuits during storage.

2. MATERIALS AND METHODS

A research was carried out to develop and assess the quality characteristics of protein enriched wheat - soybean biscuit.

PREPARATION OF SOYBEAN FLOUR

The Soybean seeds were processed into flour; using the method of IITA (1990) are shown in Figure 1. The process ensures effective removal of most anti-nutritional factors.

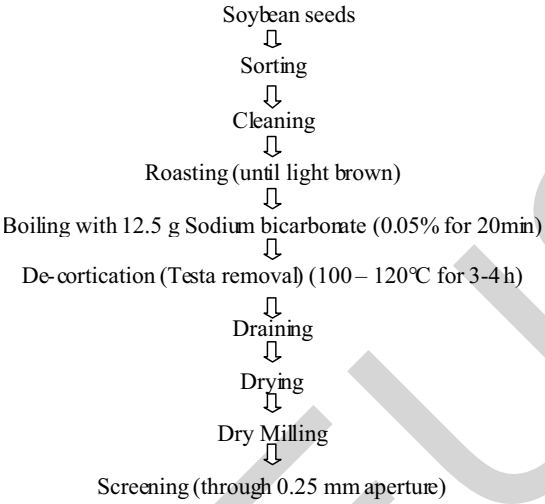

Figure 1: Flow chart for the production of Soy flour

The soybean flour was kept under refrigerated temperature (4-6°C) to prevent spoilage particularly rancidity until usage. Commercially available wheat flour was procured from whole sale trader in Batticaloa. Wheat flour was added with soy flour and biscuits were prepared as per following treatments using the recipe describe below. The same amount of sugar, margarine, egg and baking powder were added during preparation.

Treatments are given below;

T_1 - Biscuit made by 100% wheat flour.
T_2 - 5 g Soybean flour /100 g mixture (5+95 g)
T_3 - 10 g Soybean flour /100 g mixture (10+90 g)
T_4 -15 g Soybean flour /100 g mixture (15+85 g)
T_5 - 20 g Soybean flour /100 g mixture (20+80 g)
T_6 - 25 g Soybean flour /100 g mixture (25+75 g)

DEVELOPMENT OF BISCUITS

Hydrogenated fat (margarine) of 50 g and powdered sugar of 50 g were creamed together by electric beater. All purpose wheat flour and baking powder of 3 g were sieved twice together. These sieved flour and egg were added to creamed paste. Different amount of soybean flour were also added to the mixture. Firm dough was prepared from every mixture. The dough was rolled out to 2.5 mm thickness in a baking tray and cut into round having 5 cm diameter with a biscuit cutter. The biscuits were placed on greased aluminum trays and baked in a pre-heated oven at 150ºC for 4 minutes to produce biscuits. These biscuits were assessed for nutritional and sensory qualities.

NUTRITIONAL ANALYSIS

The moisture, protein and fat content of the biscuits were determined according to the standard AOAC (2000) while the total sugar was determined by Lane and Eynon method. The carbohydrate content was determined by simple difference {100 – (protein % + fat % moisture % + ash %)}

SENSORY ANALYSIS

The sensory attributes including texture, colour, flavour and overall acceptability were evaluated by a trained 20-member panel. The Nine-point hedonic scale was used to evaluate the degree of liking and disliking for preference. The mean scores were analyzed using analysis of variance (ANOVA) method and mean difference separated using Turkey's test.

3. RESULTS AND DISCUSSION

PHYSICO-CHEMICAL CHARACTERISTICS OF SOY FLOUR

The chemical composition of studied soy flour were moisture content 11.54 %, protein 40.20%, fat 19.65%, ash 4.56% and total soluble carbohydrate 24.05%. Similar result was also reported by Gopalan *et al.,* (1991).

NUTRITIONAL COMPOSITION OF PROTEIN ENRICHED WHEAT - SOYBEAN BISCUITS

The nutritional analysis of the biscuits indicated that all the biscuits contained favorable proportion of protein and fat. The nutritional qualities of the soybean mainly contributed to the protein and fat content of the biscuits.

Table1: Nutritional Composition of Biscuits Incorporated with Soy Flour

Treatments	Protein (%)	Fat (%)	Total soluble Carbohydrate (%)	Moisture (%)
T_1 (0%)	5±0.18 f	14.56±0.08 d	66.53±0.64 a	2.9±0.10 a
T_2 (5%)	6.48±0.04 e	15.3±0.11 d	65.35±0.31 a	2.87±0.0 a
T_3 (10%)	9.9±0.15 d	20±0.11 c	58.53±0.41 b	2.57±0.0 b
T_4 (15%)	11.51±0.15 c	22±0.57 b	56.85±0.24 c	2.47±0.0 b
T_5 (20%)	12.02±0.09 b	22.3±0.05 b	55.27±0.16 d	1.83±0.0 c
T_6 (25%)	14.19±0.11 a	24±0.15 a	55.08±0.54 d	1.53±0.0 d

The values are means of triplicates ± standard error.
Mean scores in rows with same letters are not significantly different ($p<0.05$)

Table 2: Sensory Attributes of Biscuits Incorporated with Different Levels of Soy Flour

Treatments	Colour	Texture	Flavour	Overall Acceptability
T_1	6.95±0.34 bc	7.05±0.19 a	6.95±0.29 a	6.55±0.21 dc
T_2	6.20±0.34 c	6.85±0.27 a	6.90±0.22 a	6.95±0.21 bc
T_3	7.80±0.25 a	6.75±0.27 a	6.85±0.31 a	7.85±0.23 a
T_4	6.90±0.26b c	6.65±0.30 ab	6.40±0.29 a	7.30±0.21 ab
T_5	7.10±0.21 ab	6.40±0.34 ab	6.20±0.25 ab	6.25±0.26 dc
T_6	6.50±0.26 bc	5.75±0.42 b	5.45±0.26 b	6.05±0.28 d

The values are means of triplicates ± standard error.
Mean scores in rows with same letters are not significantly different ($p<0.05$)

The protein content of the biscuit increased from 5.0 to 14.19% with increase in the percentage (0 - 25%) of soybean flour as shown in Table 1. The increase in the protein content could be due to the increase in the proportion of soybean in the flour blended. This is in agreement with works that soybean flour has high protein (38 – 40%), fat (18 – 20%) and lysine (5 – 6%) content which have great potential in overcoming protein-calorie malnutrition (Rastogi and Singh, 1989). The fat increased from 14.56 to 24% with increase in the percentage (0 - 25%) of soybean flour as presented in Table 1.The increase in the fat content could be due to the increase in the proportion of soybean in the flour blended. This is due to the fact that soy flour contained higher percentage of fat than wheat flour. Kawamura (1997) reported that Soy flourcontained 21% fat whereas wheat flour contains 0.9%. The highest moisture content of 2.9 % was observed in 100% wheat flour. Then the moisture content decreased gradually with the incremental addition of soy flour (0 - 25%) as shown in Table 1. This might be due to the fact that soy flour contained higher amount of solid matters compared to wheat flour. The moisture content of the biscuit is low, which high percentage of soy flour blended because soybean is an excellence source of protein (Kure *et al.*, 1998). The soluble carbohydrate content decreased with increase in the percentage (0 - 25%) of soybean flour as shown in Table 1. The variations in carbohydrate content among the biscuit samples may results from the difference in the level of protein, fat, ash and moisture content of wheat flour and soy flour. The decrease could be due to the low content of carbohydrate in the added flour which agreed with the finding of Iwe (2004) that soybean are poor sources of carbohydrate.

ORGANOLEPTICEVALUATIONOFFRESHLYMADE WHEAT-SOYBEAN BISCUITS

The sensoryevaluation of the biscuit revealed that, there were observed significant differences between the treatments and the organoleptic attributes of texture, colour, flavour and overall acceptability in Table 2.

The colour of the biscuit changed from creamy to dark brown, with a decrease in the mean scores (6.95 to 6.5). The crust texture was related to the external appearance of the biscuit top, which is the smoothness or roughness of the crust. Crust texture score decreased (7.05 to 5.75) with increase in the substitution of soybean flour. The control treatment (T_1) had the highest mean value and 25% soy flour added biscuit (T_6) had the least mean value. Flavour of biscuit decreased (6.95 to 5.45) with increasing in the substitution of soybean flour (0-25%). This is due to the beany flavour of soybean flavour (Grewal, 1992). Overall acceptability includes many implications, which is the important parameter in sensory estimation. The 10% Soy flour added biscuit (T_3) had the highest mean value and 25% Soy flour added biscuit (T_6) had the least mean value.

CHANGESIN QUALITY CHARACTERISTICS OF PROTEINENRICHED WHEAT-SOYBEANBISCUITS DURING STORAGE

NUTRITIONAL QUALITIESOF PROTEIN ENRICHED WHEAT - SOYBEAN BISCUITSDURINGSTORAGE

Based on the nutritional and sensory analysis of freshly made protein enriched biscuits, the most preferred biscuits were selected for storage studies. These biscuits were packed in sealed laminate packaging material of aluminum foil which is used commercially. Biscuit packs were stored under ambient conditions of average temperature 30ºC and RH of 75-80% for the shelf life evaluation.

The most preferred treatments;

T_2 5 g Soybean flour /100 g mixture (5+95 g)
T_3 10 g Soybean flour /100 g mixture (10+90 g)
T_4 15 g Soybean flour /100 g mixture (15+85 g)

PROTEIN

Soybean is an excellent source of protein (Kure *et al.*, 1998). During processing and storage of foods, non-enzymatic reaction may cause food deterioration and reduce the shelf life. The changes in protein of the biscuits during storage are shown in Figure 1.

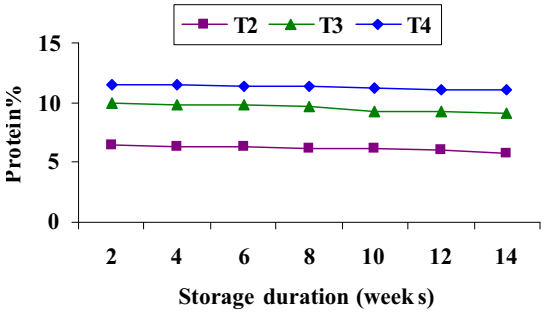

Figure 1 : Changesin proteincontentofwheat-soybean biscuits during the storage

Protein decreased significantly (p<0.05) throughout the storage period. This is occurs due to the Maillard reaction between reducingsugarsand amino acids which is a major cause of quality change and degradation of nutritional content in many foods. The maillard reaction impairs nutritional value of the protein and also this reactions result in the loss of protein solubility (Fennema, 2000). Treatment 2 (5% soy flour added biscuit) had the slow rate of decreasing trend than T_3 and T_4 treatments and there was no significant difference in protein content from the 1st week up to 9th weeks of storage. However, in the T_3 and T_4, there was no significant difference from1 st to 7th weeks and from1 st to 5th weeks respectively.

FAT

Soybean is a protein rich oil seed, which is presently number one edible oil source globally (Reddy, 2004). Fat can help to leaven a product due to incorporation of air (Brooker, 1998). Shortening of fat or oil contribute to the tenderization of baked products throughinhibition of gluten development and starch gelatinization. This is through a water proofing effect, possibly due to the complexing with the carbohydrate and/or protein. The changes in fat of the biscuits during storage are shown in Figure 2.

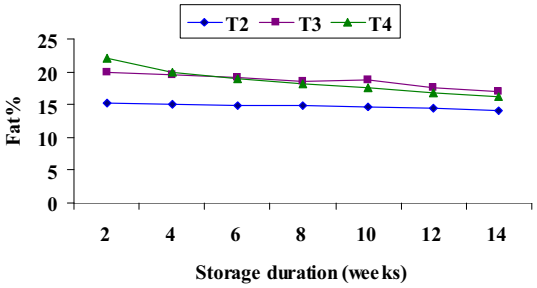

Figure 2 : Changes in fat content of wheat - soybean Biscuits during the Storage

The major unsaturated fatty acids in soybean oil triglycerides are 7% linolenic acid 51% linoleic acid

and 23% oleic acid. This will leads to oxidation reaction and can reduce the nutritional quality of food (Fennema, 2000). Treatment T_2 (5% soy flour added biscuit) had the very slow rate of decreasing trend than other treatments. This is due to in the T_2; there was no significant difference during storage period of 14th weeks and T_3; there was no significant difference upto 11th week during the storage period but in the T_4, there was no significant difference only from 1st to 3rd week.

TOTAL SUGAR

Total sugar decreased significantly (p<0.05) throughout the storage period (Figure 3). This was caused by the thermal degradation of sugars during baking due to polymerization reaction.

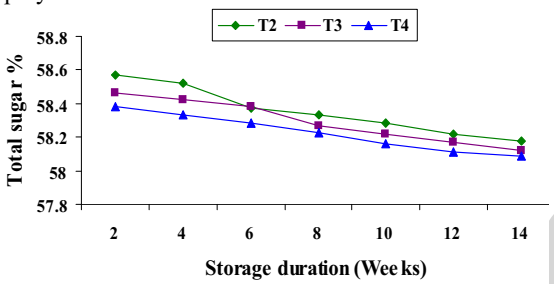

Figure 3 : Changes in Total Sugar of wheat-soybean biscuits during the Storage

Treatment 2 (5% soy flour added biscuits) had the slower rate of decreasing trend than the T_3 and T_4. Iwe (2004) reported that, soybean is poor sources of carbohydrate due to this 15% soy flour added biscuit (T_4) has low sugar content and also the Maillard reaction was reduce the sugar content of the biscuit during storage.

Moisture

Biscuits are very hygroscopic in ambient conditions. Therefore, in most cases must be protected from the atmosphere to prevent the moisture picks up. The changes in moisture of the biscuits during storage are shown in Figure 4.

Manley (1986) reported that moisture content in baked goods vary from 4 to 7%. In low and intermediate moisture foods, such as bakery products, the ability of proteins to bind water is critical to the acceptability of these foods. Moisture increased significantly (p<0.05) throughout the storage period. T_3 (10% soy flour added biscuit) and T_2 had the slow rate of decreasing trend than T_4. This is due to in the T_3 and T_2; there was no significant difference from the 1st week up to 7weeks during the storage. But in the T_4 there was no significant difference from 1st to 5th week.

SENSORY ANALYSIS OF PROTEIN ENRICHED WHEAT-SOYBEAN BISCUITS FOLLOWING STORAGE

Organoleptic characters of the biscuits stored at room temperature did not change during the storage period (Table 3). Following storage period, the changes were noticed in some sensory attributes. This is due to the non- enzymatic browning reaction and fat oxidation developed off flavours and odours as a result of auto-oxidation in fats. Berger (2000) reported that moisture uptake and gas exchange were cause of off odour development in biscuits. During the storage of food, Maillard reaction has great impact on sensory qualities of biscuits (Fennema, 2000).

The 10% soy flour added biscuit (T_3) has the best shelf life in nutritional and organoleptical point of view compared to other combinations. From the overall acceptance rating, the 10% soybean flour was added biscuit had the highest mean value as shown in Table 3 and no remarkable changes in organoleptic characters were observed up to 6 weeks of storage in ambient condition (average temperature 30ºC and RH. of 75-80%) indicating that the 10% soy flour added biscuits could be stored up to 6 weeks.

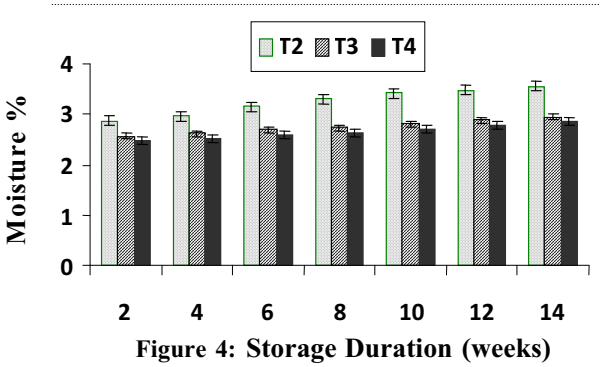

Figure 4: Changes in moisture content of protein enriched wheat-soybean biscuit during the Storage

Table 3: Sensory Attributes of stored wheat-soybean biscuits following storage

Treatments	Colour	Texture	Flavour	Overall acceptability
T_2	6.20 ± 0.34^b	6.85 ± 0.27^a	6.90 ± 0.22^b	6.95 ± 0.21^c
T_3	7.80 ± 0.25^b	6.75 ± 0.27^a	6.85 ± 0.31^a	7.85 ± 0.23^a
T_4	6.90 ± 0.26^a	6.65 ± 0.30^a	6.40 ± 0.29^a	7.30 ± 0.21^b

The values are means of 20 replicates ± standard error.
The means with the same letters are not significantly different from each other at 5% level.

4. CONCLUSION

The research was conducted to solve the Protein – Energy Malnutrition (PEM) problem of the third world country's children through the development of protein enriched wheat-soybean biscuits and to increase protein nutrient consumption in human diet. The storage study revealed that the 10% soy flour added biscuits had the best shelf life and had highly acceptable nutritional and organoleptic characters compared to other combinations. From the overall acceptability rating, the 10% soybean flour added biscuit had the highest mean value and there is no remarkable changes in organoleptic characters were observed upto 6 weeks of storage at the average temperature of 30ºC and 75-80% of RH. The biscuits made from 10% soy flour could provide needed nutrient to the diet because they contain good proportion of protein 9.17%, fat 17.0% and energy value 464.52kcal. Protein enriched wheat based food is one of the best alternatives to prevent widely prevailing protein energy malnutrition in the world. Biscuit consumption is high among the children, therefore wheat - soybean biscuit will serve as a vehicle for increasing intake of protein, fat and calories in the children's diet. At the same time the utilization of soybean increase which may encourage the farmers to grow more soybean. Thus, the malnutrition problem may be solved and the country's poverty reduced to a certain level.

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