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Improvement of Nutritional and Sensory Qualities of Traditional Maize Porridge using Locally Available Plant Sources

Inthujaa Yogarajah
Department of Agricultural Chemistry
Faculty of Agriculture
Eastern University, Sri Lanka

Thevaki Mahendran
Department of Agricultural Chemistry
Faculty of Agriculture
Eastern University, Sri Lanka

***Abstract*— Germinated green gram flour, in the amounts of 10, 20, 30 and 40 g and moringa leaves as constant amount of 10 g were incorporated with maize flour for 100 g of porridge mixture (PM). These formulated PMs were subjected to nutritional, microbial and sensory assessment. On the basis of nutritional analysis of the developed products, protein, fiber and iron increased and moisture decreased when increasing GG flour from 10 to 40%. The sensory assessment revealed that, there were significant differences between the treatments. Based on the quality characteristics, most preferred PMs were selected and stored at 30˚C and 70 – 80% RH. Quality assessments were carried out for 14 weeks. The results of storage studies revealed, declining trends in protein, fiber and iron and an increasing trend in moisture of the PMs. There was no total plate counts observed in the formulated PMs during storage. The results indicated that the PMs formulated with 70% MF, 20% GG flour and 10% ML contained 18.04% protein, 2.42% fiber, 4.25% iron 0.132% calcium and 3.49% moisture which could be stored for 14 weeks without any significant changes in the quality characteristics.**

Keywords*— Germinated green gram flour; iron enrichment; nutritional quality; porridge

I. INTRODUCTION

Enrichment of cereals-based foods with other protein sources such as legumes has received considerable attention [1]. Legumes are normally consumed after processing, which not only improves palatability of goods but also increases the bioavailability of nutrients [2]. Porridge is a traditional food product in many countries and commonly porridges are prepared traditionally using maize. Maize (*Zea mays)*, sprouted green gram (*Vigna radiate*) and moringa leaves (*Moringa oleifera*) combination has not been used for porridge. Maize is belonging to family Poacea and a major source of calories and nutrients [3]. Germinated green gram is an outstanding source of protein, vitamins, minerals, phyto-chemicals, enzymes and amino acids and these are most useful in respect of human health. During the germination the amount of the anti-nutritive materials such as trypsin inhibitors, phytic acid, pentosan, and tannin decreases. Moringa oleifera is the most known and widely cultivated variety of the genus Moringa. It is packed with nutritional potential can be used as a dietary supplement and may even contribute to fight against malnutrition [4].

The level of under nutrition among children and adults remains unacceptable throughout the world including large number of developing countries as Sri Lanka. Men are more likely to be underweight compared to women [5]. As well as the under nutrition due to major nutrients, micronutrient deficiencies also remains in Sri Lanka. Therefore, the present study was carried out to develop and evaluate the shelf life of a protein and iron enriched porridge mixture by using maize and germinated green gram at different combinations and constant amount of moringa leaves.

II. MATERIALS AND METHODS

Maize (variety Ruwan) and green grams (variety MI-1) seeds were obtained from the commercial growers in Sri Lanka. The seeds were cleaned, air dried for 48 hours at 40±1°C, roasted ground and screened through 0.3 mm sieve to obtain flour. Green grams were soaked for 8 hours, allowed to germinate in 30°C for 3 days, air dried for 48 hours at 40±1°C, the testa and roots were removed, roasted, ground and sieved through 1 mm sieve to obtain flour. Moringa leaves (variety Local) were cleaned, steam blanched, air dried for 48 hours at 40±1°C, ground and sieved through 5 mm sieve to obtain leaves. Porridge mixtures of each combination was packed separately in polypropylene bags and labeled individually and stored at ambient condition of 30˚C and 70 - 75% RH. The most preferred three treatments were selected for the storage studies and the sensory and nutritional qualities were assessed in 2 weeks interval to determine the shelf life of the formulated mixtures. The porridge mixtures were prepared according to the following treatments:

T_1 – 100% MF

T_2 – 80% MF + 10% GG flour + 10% ML

T_3 – 70% MF + 20% GG flour + 10% ML

T_4 – 60% MF + 30% GG flour + 10% ML

T_5 – 50% MF + 40% GG flour + 10% ML

A. Nutritional Analysis

Protein, fiber, moisture and iron content of PMs were determined according to the standard methods [6]. Iron and calcium content was determined by Atomic Absorption Spectrophotometer (PHOENIX-986 AA). Three replicates were used from each treatment during the nutritional assessment. Nutritional studies were analyzed by Analysis of Variance (ANOVA) and the difference between means was compared using Duncan's Multiple Range Test (DMRT), through Statistical Analysis System (SAS) software.

B. Sensory Analysis

Sensory attributes including colour, texture, taste, aroma and overall acceptability were evaluated by 30 trained panelist using seven-point hedonic scale to evaluate the degree of liking (7) and disliking for preference (1). Porridge mixture of 100 g was heated with 25 g sugar, 100 ml of coconut milk and small amount of salt for 5 minutes. Means were analyzed by Analysis of Variance (ANOVA) and the difference between means was compared using Friedman test, through Statistical Analysis System (SAS) software

C. Microbial Test

The aerobic plate count was carried out for the porridge mixtures using the method of Fawole and Oso [7]. 10 g of each mixture were taken and homogenized in 90 ml sterile distilled water; in a blender (Philips Type HR 2815i) for about 2 min. Serial dilutions (using 1 ml of homogenates) were made in 9 ml sterile distilled water, dispensed in test tubes. One milliliter of each dilution was pour plated in sterile Petri dishes, using the plate count agar (PCA, oxoid), incubated at 37ºC for 24 - 36 h. Counts of visible colonies were made and expressed as log CFU/g sample.

III. RESULTS AND DISSCUSSION

A. Composition of Roasted Germinated Green Gram Flour and Moringa Leaves

The roasted germinated green gram flour consisted of 21.1% protein, 3.98% fiber, 3.48% moisture, 1.43mg% iron and calcium 0.009%. The blanched moringa leaves consisted of 8.26% protein, 6.23% 3.23% fiber, 3.23% moisture, 4.36 mg% iron and 1.3%.

B. Nutritional qualities of Fresh Porridge Mixtures

Nutritional parameters of the porridge mixtures are presented in Table 1.

Table 1: Nutritional parameters of fresh porridge mixtures

Nutrients	Treatments				
	T_1	T_2	T_3	T_4	T_5
Protein (%)	10.43 ±0.2^{e}	16.57 ±0.21^{d}	17.70 ±0.4^{c}	19.54 ±0.09^{b}	20.71 ±0.18^{a}
Fiber (%)	1.87 ±0.04^{e}	2.37 ±0.09^{d}	2.62 ±0.08^{c}	2.8 ±0.12^{b}	3.08 ±0.09^{a}
Moisture (%)	3.51 ±0.04^{a}	3.34 ±0.06^{b}	3.22 ±0.06^{c}	3.11 ±0.06^{d}	3.03 ±0.08^{e}
Iron (mg %)	0.94 ±0.10^{e}	4.25 ±0.06^{d}	4.49 ±0.07^{c}	4.68 ±0.08^{b}	4.92 ±0.11^{a}
Calcium (%)	0.009 ±0.0002	0.144 ±0.001	0.153 ±0.003	0.166 ±0.007	0.168 ±0.004

The values are means of triplicates ± standard error
The means with the same letters are not significantly different at 5% level.

The protein content increased with the increase in the proportion of germinated green gram flour level in the porridge mixtures because germinated green gram is an excellent source of protein than the non-geminated green gram. It contains about 23 – 25% protein which is almost three times that of cereals [8]. Fiber content of porridge mixture followed the same trend as protein because germinated green gram and moringa leaves are rich in fiber content. There was an increase in crude fiber in pea, lentil and green gram at the 120 h of germination [9].

The moisture content of the porridge mixture decreased with the increase in germinated green gram flour as the germinated green gram flour contained higher amount of solid matter compared to maize flour. The moisture content for the dried and powdered products should less than of 3.5% and exceeding the limit would directly impact on shelf life of the product [10]. The iron and calcium contents increased with the increase in the proportion of germinated green gram flour and addition of moringa leaves. Germinated green gram flour contain considerable amount of iron and moringa leaves might provide high amount of iron and calcium to the porridge mixture except the treatment T_1 (100% MF). Calcium content of dried moringa leaves powder is 95mg/5g [11].

C. Sensory Qualities of Fresh Porridge Mixtures

Table 2: Sensory parameters of fresh porridge mixtures

Treatments	Colour	Texture	Flavour	Overall acceptability
T_1	6.63±0.09^{a}	6.10±0.11^{ab}	5.93±0.10^{bc}	5.93±0.08^{b}
T_2	5.93±0.12^{b}	5.87±0.10^{ab}	6.13±0.11^{b}	6.10±0.11^{b}
T_3	6.33±o.12^{ab}	6.30±0.12^{a}	6.70±0.08^{a}	6.60±0.10^{a}
T_4	6.00±0.12^{ab}	5.57±0.18^{b}	5.63±0.14^{c}	5.23±0.11^{c}
T_5	4.43±0.12^{c}	4.93±0.22^{c}	4.43±0.17^{d}	4.10±0.17^{d}

The values are means of 30 replicates ± standard error.
The means with the same letters are not significantly different from each other at 5% level based on Friedman Test. Sensory parameters were measured using seven point hedonic scale. 1: Dislike very much, 7: like very much.

Results of sensory evaluation showed that, there were significant differences (p<0.05) between treatments for all attributes of colour, texture, flavour and overall acceptability. Treatments T_2 (80% MF + 10% GG flour + 10% ML), T_3 (70% MF + 20% GG flour + 10% ML) and T_4 (60% MF + 30% GG flour + 10% ML) received higher consumer acceptance for all attributes. Treatment T_5 (50% MF + 40% GG flour + 10% ML) received the lowest acceptability when compared to other four treatments. The treatment with T_3 (70% MF + 20% GG flour + 10% ML) had the highest scores for all the attributes. Germination also improves the consistency, mouth feel and taste of the product [12].

D. Nutritional Qualities of Porridge Mixtures during storage

Based on the chemical and sensory analysis of freshly made protein and iron enriched porridge mixtures, the most preferred three porridge mixtures were selected for storage studies. They were packed in polypropylene bags (100 µ thickness) and stored at ambient condition of 30˚C and 70 - 75% RH.

The most preferred treatments are:

T_2 - 80% MF + 10% GG flour + 10% ML

T_3 - 70% MF + 20% GG flour + 10% ML

T_4 - 60% MF + 30% GG flour + 10% ML

E. Protein Content

Protein is essential for synthesis of new cells, body maintenance and growth. Green gram is a rich source of protein and amino acid especially lysine and thus can be blended with cereal-based human diets. During the processing and storage of foods, non-enzymatic browning my cause deterioration and reduce the shelf life. According to the DMRT, the protein content decreased significantly (p<0.05) throughout the storage period. This is due to the interaction between reducing sugars and amino acids. This is called non-enzymatic browning (Millard reaction) and this reaction impairs protein nutritional value. Green gram protein was rich in essential amino acids triptophan, threonine, leucine, isoleucine and valine. Dry moringa leaves contained 18 amino acids [13].

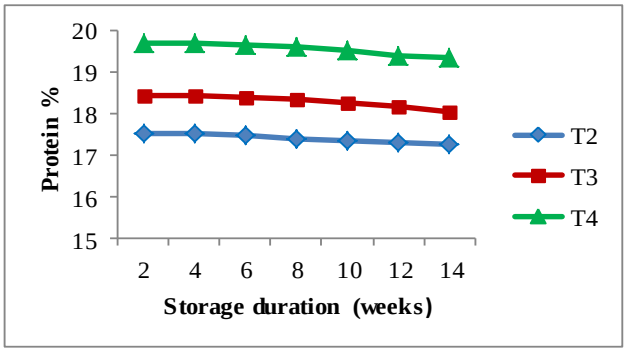

Figure 01: Changes in Protein content of PMs during storage

Combining cereal-based foods with legume for the production of porridge will improve their nutrient quality. [14]. This is because legume are high in lysine, an essential limiting amino acid in most cereals. Cereals on the other hand, are high in methionine and cystine which are deficient in legumes [15]. Therefore combining legume with cereal will provide desirable protein pattern that would enhance nutritional status of the population.

F. Moisture content

Dry foods are normally hygroscopic in nature. Therefore, most cases they must be protected from moisture pickup because studies have shown that moisture content in food products facilitate the growth of microorganisms, which in turns causes spoilage and low nutritional qualities of the food products [16]. In low and intermediate moisture foods, the ability of proteins to bind water is critical to the acceptability of these foods [17]. Higher water absorption capacity indicates higher protein content in the formulations, which absorbs and binds with more water.

According to the DMRT, moisture content increased significantly (p<0.05) throughout the storage period.

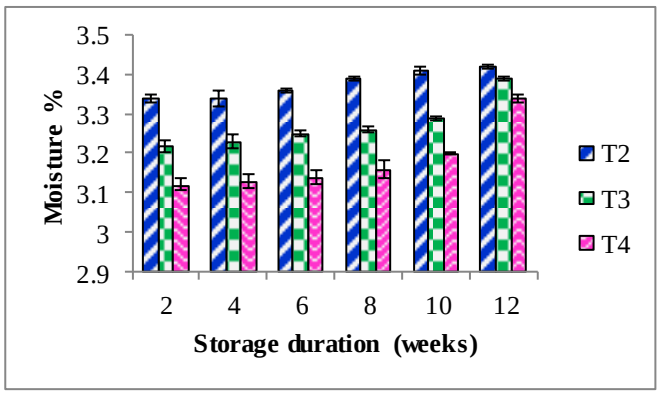

Figure 02: Changes in Moisture content of PMs during storage

G. Fiber content:

The crude fiber content is important to maintain healthy gastro intestinal tract through facilitating bowel emptying. According to the DMRT, fiber content decreased significantly (p<0.05) throughout the storage period. At the end of 14weeks storage T_2 (80% MF + 10% GG flour + 10% ML) showed lowest mean value of 2.24% and T_4 (60% MF + 30% GG flour + 10% ML) showed higher mean value of 2.51%. According to DMRT, fiber decreased significantly, (p <0.05) throughout the storage period as fiber also a type of carbohydrate and which undergoes some hydrolysis by several factors and the quality and quantity reduce slightly.

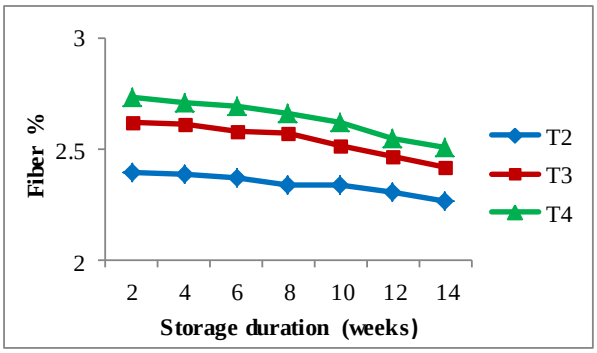

Figure 03: Changes in Fiber content of PMs during storage

H. Iron and Calcium Content

A large quantity of moringa could increase this value of iron and calcium present and the nutrient content of the porridge, but may have influenced in organoleptic quality of food such as porridge color and taste. Therefore, the addition of 10% for the porridge mixture improved the iron and calcium content as well as maintained the organoleptic qualities in desirable level. The mineral content of the porridge mixtures increased significantly (p<0.05) as the levels of germinated green gram increased. This could be due to the effect caused by the high levels of Iron (Fe) and Calcium (Ca) contents in *Moringa* leaf. The iron content of moringa leaves is 26.20 mg/100g [18] and calcium content is 454.00 mg/100g [19]. Minerals such as iron and zinc are low

in cereals but the addition of legumes can improve the iron and calcium content [20].

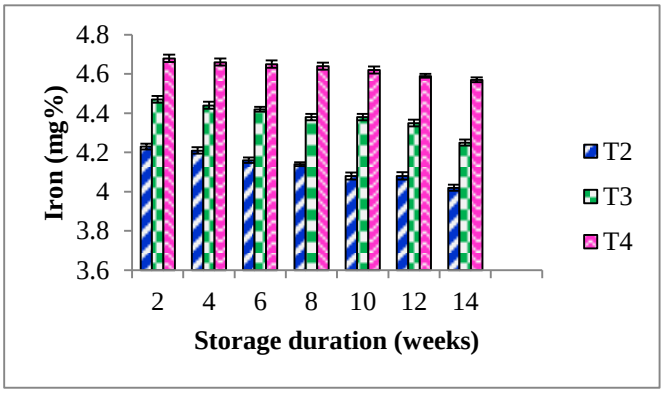

Figure 04: Changes in Iron content of PMs during storage

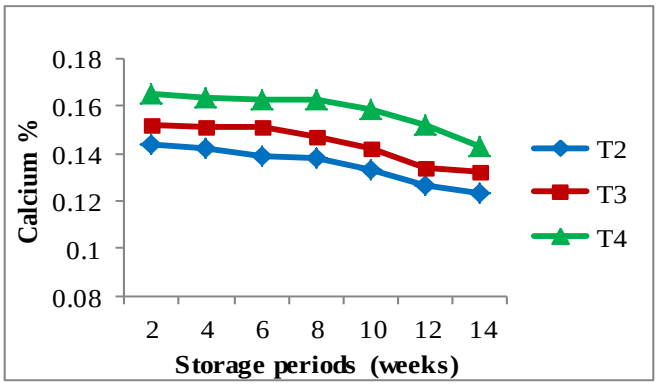

Figure 05: Changes in calcium content of PMs during storage

I. Sensory qualities of Porridge Mixtures during storage

Porridge mixture of 100 g of each was mixed with 25 g sugar, 100 ml of hot coconut milk and small amount of salt and the mixtures were heated in pans for 55˚C and served to the panelists as hot.

Table 3: Sensory parameters of porridge mixtures at 14 weeks of storage

Treatments	Colour	Texture	Flavour	Overall acceptability
T_1	5.00±0.21^b	4.80±0.23^b	4.90±0.21^b	5.07±0.29^a
T_2	5.80±0.22^a	5.80±0.2^a	5.80± 0.19^a	5.8o±0.19^a
T_3	3.90±0.24^c	3.87±0.23^c	4.20±0.26^b	4.0o±0.24^b

The values are means of 30 replicates ± standard error.
The means with the same letters are not significantly different from each other at 5% level based on Friedman Test.
Sensory parameters were measured using seven point hedonic scale. 1: Dislike very much, 7: like very much.

Organoleptic characters of protein and iron enriched porridge mixtures stored at ambient temperature were changed slightly apart from freshly made porridge mixtures. During the storage period, Millard reaction, lipid oxidization, reduction in total sugar content, moisture uptake and other chemical reactions occurred in the mixture would have changed the sensory qualities of the porridge. The best combination was observed to be porridge mixture made with 70% maize flour, 20% germinated green gram flour and 10% moringa leaves (T_3) for every sensory attributes.

J. Microbial Analysis

The microbial examination, in terms of aerobic plate counts (APC, CFU/g), ranged from 1.00 to 1.5. The counts were minimal and are within acceptable limits after the period of three months of storage [7]. Due to the preliminary processes such as air drying and roasting at high temperature eliminated a large number of micro-organisms. Therefore, the population of micro-organisms in relation to moisture content was not high enough to produce any harmful effect in the porridge mixtures.

IV. CONCLUSIONS

The finding of the storage study revealed that, 70% Maize flour + 30% Green gram flour + 10% Moringa leaves (T_3) porridge mixture was selected as most preferred treatments at the end of preparation based on the chemical and organoleptic point of view. The formulated porridge mixtures could be stored for 14 weeks without any significance changes of quality parameters at ambient condition of 30˚C and 70 - 75% RH.

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