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Storage Condition Evaluation of Biscuits Prepared by Composite Flour.

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Abstract

This study was aimed to analyze the nutritional and sensory quality variations of biscuits prepared from composite flour which consist of sprouted sorghum, soybean and finger millet during 12 weeks (3 months) of storage period. Based on the physical, nutritional and sensory analysis of preliminary studies, most preferred biscuit samples were selected for storage studies. Three replications were prepared for each treatment for the evaluation. Those were, T1 – 70% Sprouted Sorghum + 20% Soybean + 10% Finger millet, T2 – 60% Sprouted Sorghum + 30% Soybean + 10% Finger millet, T3 – 50% Sprouted Sorghum + 40% Soybean + 10% Finger millet. These treatments were packed in sealed laminated aluminium foil for storage studies. Packed biscuits were stored under ambient condition of 30^0C average temperature and 70% - 80% relative humidity for 12 weeks. Nutritional analyses of the biscuits were carried out at two weeks' interval throughout the storage period. The results of nutritional analysis showed that, there were significance differences ($p<0.05$) between the tested treatments. These results revealed the declining trends in protein, fat, fiber, ash and total sugar and an increasing trend in moisture content of the biscuits. The organoleptic analysis carried out at the end of 12 weeks revealed that there were significant ($p<0.05$) differences for the organoleptic characters between the formulations. From the overall acceptability rating, the biscuit sample prepared from composite flour with 60% sprouted sorghum flour, 30% soybean flour and 10% finger millet flour had the highest mean value compared with other treatments. There were no remarkable changes in organoleptic qualities observed up to 12 weeks of storage at 30^0 C and RH of 70%-80% in this treatment. Microbial Analysis was done after 12 weeks of storage. Products were not affected by any microbial activities. There was no harmful effect during storage on the quality of the product due to microbial growth at ambient temperature. Therefore, it is safe for the consumption upon 12 weeks of storage. Based on the nutritional, organoleptic and microbial qualities, the biscuit sample prepared from composite flour with 60% Sprouted Sorghum flour, 30% Soybean flour and 10% Finger millet was the best treatment compared to other combinations at the end of storage period.

Keywords: Composite Flour; Biscuit; Sprouted Sorghum; Soybean; Finger Millet; Organoleptic Evaluation; Microbial Evaluation.

1. Introduction

The consumption of cereal snack foods such as biscuits, cookies and short bread has become very popular in Sri Lanka especially among children. Among these biscuits possess several attractive features including wider consumption, relatively long shelf-life and good eating quality. The principal ingredients are flour, fat, sugar and water; while other ingredients include milk, salt, flouring agent and aerating agent. Biscuit is a primarily flour-based baked food product. It can be called either a "cookie" or a "cracker" in most countries. Biscuits are hard and may be savory or sweet, such as chocolate biscuits, ginger nuts and custard creams. Those are easy-to-store, easy-to-carry, and long-lasting foods on long journeys. Biscuits are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven. The principal ingredients are flour, fat, sugar and water; while other ingredients include milk, salt, flouring agent and aerating agent.
Composite flour is a mixture of different flour from cereal, legume or root crops that is created to satisfy specific functional characteristics and nutrient composition. It could be a mixture of cereals with legumes or cereals with tubers. The use of composite flour based on wheat and other cereals including minor millets in bakery products is becoming popular because of the economic and nutritional advantages of composite flour. The biscuit produced from sprouted Sorghum (sorghum bicolor), Soybean (Glycine max) and Finger millet (Eleusine coracana) is nutritionally, healthy and tasty product. The composite flour, including above three types of flour is fulfilled with protein, fiber and minerals (Calcium and Iron) specially. Biscuits are such products with low moisture content thus have longer shelf life. But storage conditions have huge impact on Nutritional quality, Microbial growth and Sensory evaluation of biscuits prepared by composite flour.

Therefore, present study was undertaken to assess the nutritional qualities and consumer acceptability of biscuits prepared from composite flour of Sprouted Sorghum, Soybean and Finger Millet after formulation and during 12 weeks of storage period.

2. Materials and method

2.1. Preparation of Sprouted Sorghum, Roasted Soy Bean and Finger Millet Flour

Water soaked sorghum grains were allowed to germinate for 4 days. The sprouted grains were ground by a grinder into fine flour. Soybeans were cleaned and sundried to achieve uniform moisture content. Soybeans were roasted and ground into fine flour using a grinder and sieved through a sieve. Finger millets were washed well and dried in sun. Dried grains were ground by a grinder and sieved to get fine flour by a sieve.

2.2. Preparation of Biscuit

Biscuits were prepared by using the creaming method. After the preparation of biscuits, were packed separately in laminated aluminium foil according to the treatments and labeled individually. Different combinations of biscuits were assessed for organoleptic, physical, microbial and nutrition qualities.

2.3. Quality Analysis of Storage Biscuit

Biscuits were analyzed for nutritional qualities such as moisture, ash, protein, fat and fiber by proximate analysis. Physical parameters such as diameter, thickness, volume, density and spread ratio and thirty trained panel of judges carried out organoleptic evaluation of quality factors such as color, taste, texture, flavor and overall acceptability by seven-point hedonic structure scale. Total plate count was done for the biscuit samples and the plates were observed after four days for plate count.

2.4. Statistical Analysis

Data of the quality analysis and storage study were analyzed by Analysis of Variance (ANOVA) ($\alpha = 0.05$) and mean separation was done with Duncan's Multiple Range Test (DMRT). Data related to sensory evaluation were analyzed using the Turkey's test.

3. Results and Discussion

Based on the nutritional and organoleptic analysis of freshly made biscuits, the most preferred three treatments and control treatment were selected for storage studies. They were packed in laminated aluminum foil and stored at ambient condition of 30°C and 70 - 80% RH. Most preferred treatments are as follows:

T_0 - 100% Wheat flour (control)

T_1 - 70% Sprouted sorghum + 20% Soybean + 10% Finger millet

T_2 - 60% Sprouted sorghum + 30% Soybean + 10% Finger millet

T_3 - 50% Sprouted sorghum + 40% Soybean + 10% Finger millet

3.1. Protein Changers during Storage

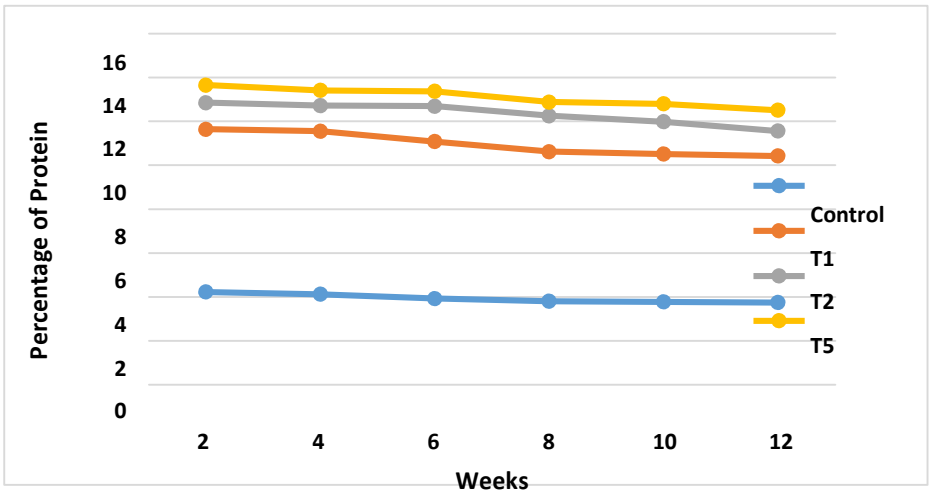

Figure: 1. Changes in Protein Content during Storage Period

The various flour proteins present in Sprouted sorghum-soybean-finger millet flour can undergo changes such as protein cross linking, protein-carbohydrate interaction, and non-enzymatic browning and protein denaturation during processing and storage condition. Changes that occur in proteins during processing and storage are endogenous and exogenous enzymatic activities, chemical reactions and modifications, pH changes, salt effects, storage-fungi contamination, and temperature. Proteins undergo denaturation by reaction with hydro peroxides and produce objectionable odors and off-flavor developed during storage.

Finot (1997) considers that the loss of amino acids during storage is largely the result of the Maillard reaction leading to formation of complexes resistant to enzymatic digestion. According to DMRT, the protein content of biscuits was decreased significantly ($p < 0.05$) through the storage period. This may be due to interaction between reducing sugars and amino acids (Millard reaction). Also it is a major course of quality and degradation of many nutrients in food. Millard reaction makes the loss of protein stability. (Fennema, 1996)

3.2. Fiber Content during Storage

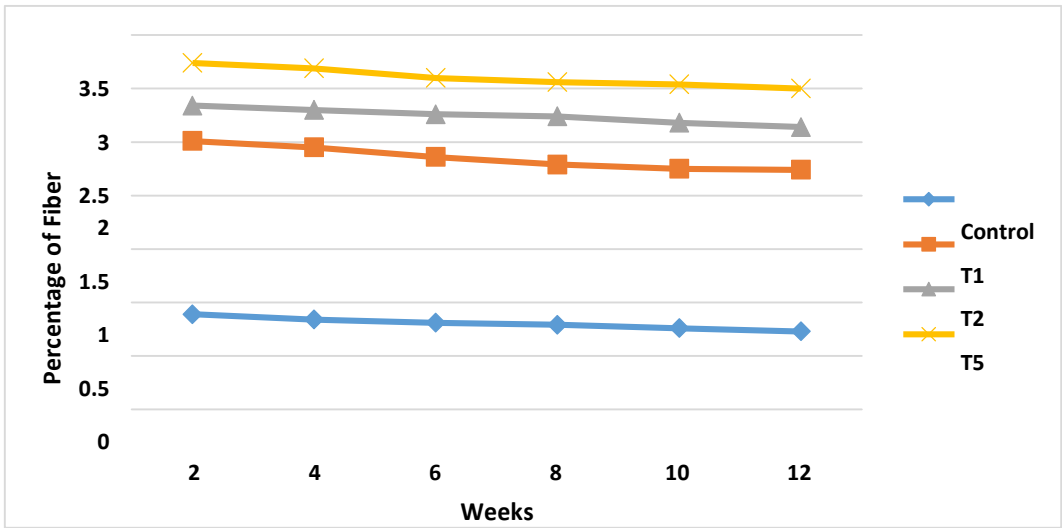

Figure: 2. Changes in Fiber Content during Storage Period

According to DMRT, there was a slow decrease in T2 and T3 treatments. In T1, there was a significant difference between 4th, 6th and 8th weeks during storage. There was a slight change in fiber content of all treatments during storage.

Dietary fiber is that part of plant material in the diet which is resistant to enzymatic digestion which includes cellulose, non-cellulosic polysaccharides such as hemicellulose, pectic substances, gums, mucilages and a non-carbohydrate component lignin. Processing of the cereals and legumes affects to the fiber content. Thermal effect leads to degradation of bonds in polysaccharide chains.

3.3. Fat Content during Storage

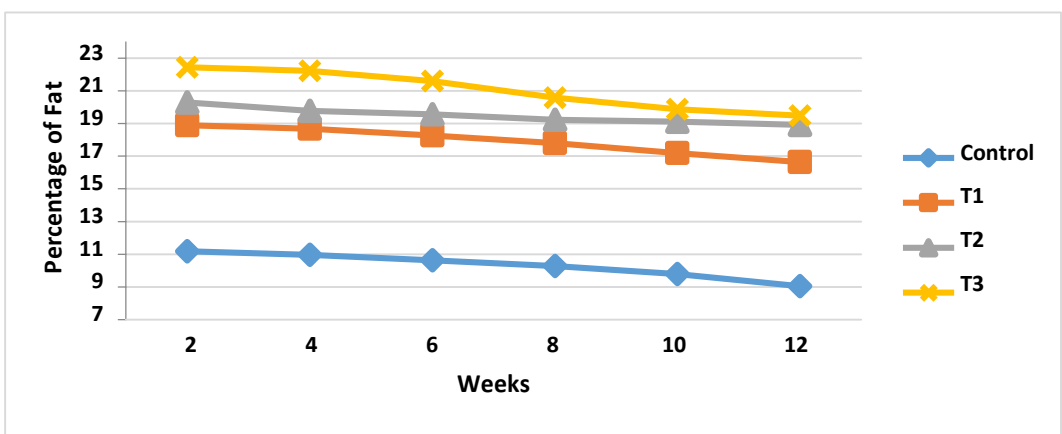

Figure: 3. Changes in Fat Content during Storage Period

Lipid molecules undergo different chemical reactions during processing starting from separation from their raw sources to storage. These changes in lipids occurring during processing and storage can be desirable and undesirable such as Hydrolytic Rancidity, Oxidative Rancidity, Cis –Tran's isomerization and Colour fixation. (Ekezie, 2015)

According to DMRT, there was slight change of fat in T2 treatment. Fat content in T1 and T3 treatments were significantly decreased throughout the storage period. Reduction was due to the oxidation of unsaturated fatty acids with atmospheric oxygen and moisture uptake.

3.4. Moisture Content during Storage

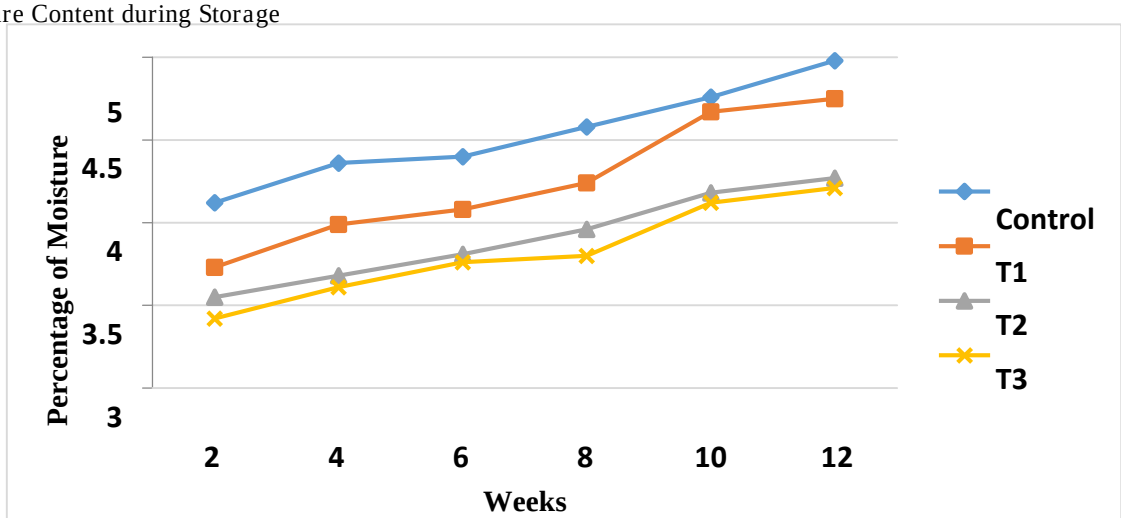

Figure: 4. Changes in Moisture Content during Storage Period

According to the DMRT, moisture content was increased significantly ($p<0.05$) throughout the storage period. There was no change significantly in moisture content of T2 and T3 from 4th week to 12th week and there was a significant change in T1 during the storage period.

Biscuits are very hygroscopic in nature. Therefore, they must be protected from the atmosphere to prevent or delay the moisture pick up. The moisture content of food products is changed when there is a moisture gradient outside and inside of the product. Fennema (1996), stated that low and intermediate moisture foods, such as bakery products, the ability of proteins to bind water is critical to the acceptability

3.5. Ash Content during Storage

Ash content of the product is related to mineral composition of that product. The changes in ash content of the biscuits during storage are shown in Figure 5. The ash content of all the treatments was slightly decreased during the storage period. According to DMRT, there were no significant differences in T1, T2 treatments throughout the storage period.

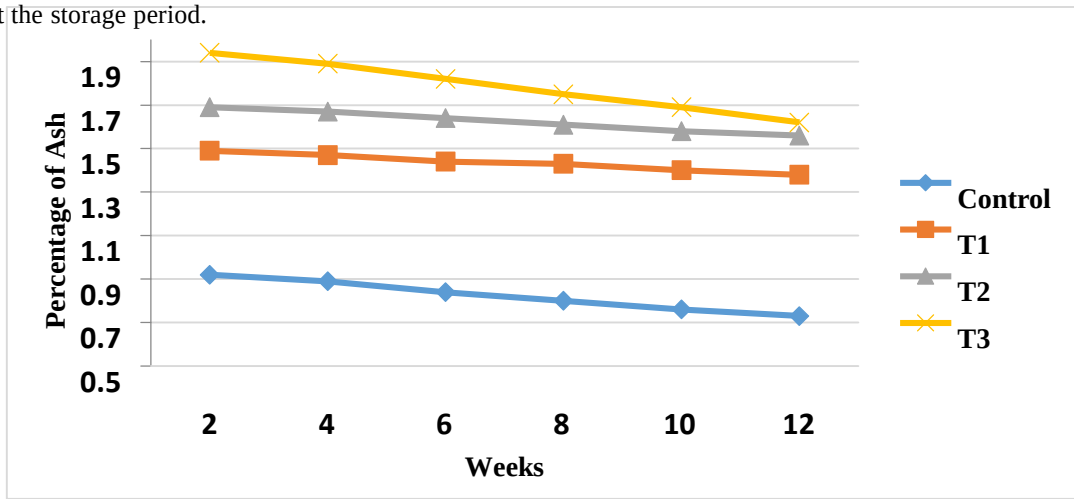

Figure: 5. Changes in Ash Content during Storage Period

3.6. Total Sugar Content during Storage

Considerable amount of sugar was added to dough mixture during preparing of biscuits. The changes in total sugars of biscuits are shown in figure 6. According to DMRT, there was a significant ($p<0.05$) decrease in total sugar content throughout the storage period.

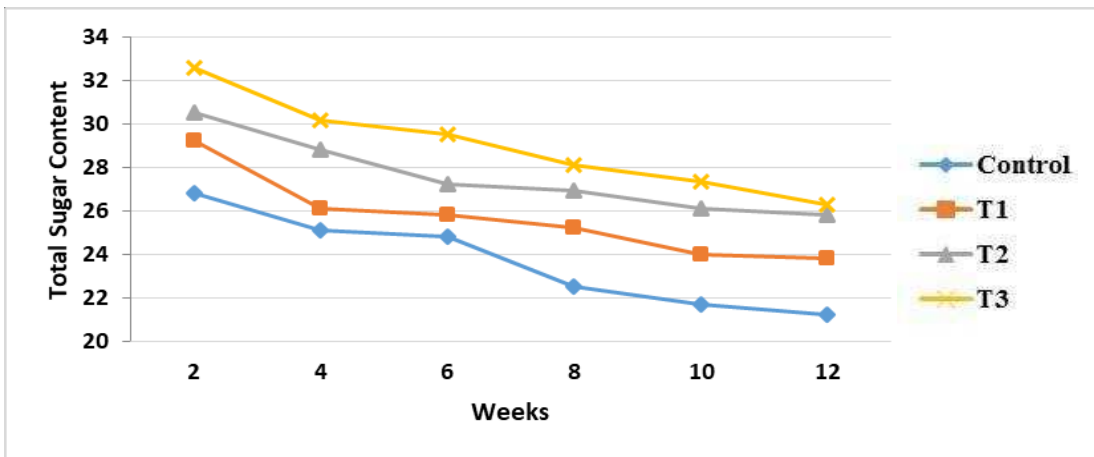

Figure: 6. Changes in Total Sugar Content during Storage Period

There was a significant difference in T1 and T3 during the storage period. This was caused by thermal degradation of total sugars and sugar polymerization reaction during roasting. Maillard reaction is also one of the reasons for the reduction of total sugar content of biscuits.

4. Organoleptic Analysis of Biscuits during Storage

Organoleptic qualities analysis for the biscuits prepared from sprouted sorghum-soybean and finger millet flour was done after 12 weeks of storage period by the panel of 30 semi-trained judges. The panel evaluated colour, texture, taste, flavour and overall acceptability. A seven-point hedonic scale was used for this purpose. Sensory characters of biscuits stored at ambient temperature were changed slightly than freshly made biscuits. Because Maillard reaction, lipid oxidization, reduction in total sugar content, moisture uptake and other chemical reaction may change the sensory qualities of the biscuits during the storage period. Berger (1970) reported that moisture uptake and gas exchange were cause of off odour development in biscuits. Maillard reaction has impact on sensory qualities (Fennema, 1996).

Table: 1. Organoleptic Characteristics of Biscuits after 12 weeks of Storage at Ambient Temperature

Treatments	Texture	Flavor	Taste	Colour	Overall Acceptability
T1	4.70 ± 0.54^{b}	6.16 ± 0.26^{a}	5.80 ± 0.29^{b}	4.36 ± 0.63^{b}	5.10 ± 0.35^{b}
T2	5.96 ± 0.25^{a}	5.06 ± 0.36^{b}	6.33 ± 0.26^{a}	5.66 ± 0.34^{a}	5.90 ± 0.38^{a}
T3	4.56 ± 0.54^{b}	3.50 ± 0.46^{c}	5.66 ± 0.32^{b}	6.26 ± 0.28^{a}	4.50 ± 0.56^{b}

The means with the same letters are not significantly different from each other at 5% level based on Tukey's Test

4.1. Texture

Texture is one of the most important parameter connected to product quality. The crust texture of biscuits was related to the external appearance of biscuit, which is smoothness or roughness of the biscuit. Biscuit`s texture analysis revealed that there was a significant change in texture when increasing the percentage of soybean.

4.2. Colour

Color is very important parameter in judging the properly baked biscuits not only reflects the suitable raw material used for the preparation but also provide information about the quality product. An attractive color leads to the good demand for the product. The color of biscuits was changed to light brown to some amount of slightly dark brown when increasing the proportion of soybean flour. According to Tukey`s test, there was a no significant difference between control and other treatments.

4.3. Taste

Taste is the primary factor which determines the acceptability of any product which has the highest impact as far as market success of product impact. According to Tukey`s test, 100% wheat flour biscuit had highest mean value (5.40) of taste and the biscuit prepared from 60% sprouted sorghum, 30% soybean and 10% finger millet (T2) had the highest mean value (6.33) for taste.

4.4. Flavor

Sensory impression of food and is determined primarily by the chemical senses of taste and smell. There was a no significant difference in control treatment and treatments. According to Tukey`s test, 100% wheat flour added biscuit had highest mean value for flavor followed by the biscuit prepared from 50% sprouted sorghum, 40% soybean and 10% finger millet flour had the least mean value for flavor.

4.5. Overall Acceptability

Overall acceptability includes many implications, which is important parameter in sensory evaluation. There was no significant difference among control and treatments. According to Tukey`s test, T2 had the highest mean value and T3 had lowest mean value.

5. Microbial Analysis of Biscuits during Storage

Microorganisms play a significant role in determination of shelf life. They are mainly caused to food spoilage. A high aerobic plate count indicates the presence mixed population of micro-organisms which may consist of spoilage types. The microbiological examination after 12 weeks`s storage period, in terms of total plate count revealed that there was no evidence for any microbes observed in the stored biscuit samples. Processes such as roasting and baking at high temperature destroyed large number of micro-organisms. Therefore, these biscuits were suitable for consumption. Total Plate Count (TPC) of cookies was examined on 1, 2 and 3 months' period (Chandru et al. 2010). Limits of microbial counts have been recommended in most foods to keep them safe for consumption (Ogunjobi and Ogunwolu, 2010). The product should however be well kept after processing in suitable packaging materials capable of preventing contamination and the subsequent proliferation of spoilage microorganisms.

6. Conclusion

Production of biscuits by using composite flour including cereals and legumes provides better nutrition and healthy value for the children and adults in developing countries like Sri Lanka. A biscuit prepared from such composite flour provides valuable contribution to the diet. Even though biscuits have low moisture percentage compared to other nutritive products, it needs to store well in order to conserve the nutritive, sensory and microbial properties. So this study was carried out to find such quality changers during 12 weeks of storage period under ambient environmental condition.

Based on the nutritional and organoleptic quality characteristics of preliminary studies, most preferred treatments of nutritionally enriched biscuit samples such as T1-70% Sprouted Sorghum + 20% Soybean + 10% Finger millet, T2 - 60% Sprouted Sorghum + 30% Soybean + 10% Finger millet,T3 - 50% Sprouted Sorghum + 40% Soybean + 10% Finger millet with control treatment were selected and subjected to storage studies in ambient conditions at 30^0C and 70 - 75% RH for 12 weeks to evaluate the shelf life of the biscuits.

Nutritional analysis of the biscuits was carried out at two weeks' interval throughout the storage period. During the storage periods, the nutritional parameters vz: protein, fat, fiber, ash and total sugar contents were decreased and moisture content was increased in the biscuit samples. The organoleptic analysis carried out at the end of
12 weeks revealed that there were significant ($p<0.05$) differences for the organoleptic characters between the formulations. From the overall acceptability rating, the biscuit sample prepared from composite flour with 60% sprouted sorghum flour, 30% soybean flour and 10% finger millet flour had the highest mean value compared with other treatments. There were no remarkable changes in organoleptic qualities observed up to 12 weeks of storage at 30^0C and RH of 70%-80% in this treatment. Microbial analysis was done after 12 weeks of storage.

Biscuits were not affected by any microbial activities because of low moisture content. There was no harmful effect during storage on the quality of the product due to microbial growth at ambient temperature. Processes such as roasting and baking at high temperature destroy large number of micro-organisms. Therefore, it is safe for the consumption upon 12 weeks of storage. The biscuit with 60% Sprouted Sorghum flour, 30% Soybean flour and 10% Finger millet was the best treatment based on nutritional and organoleptic qualities compared to biscuits prepared from the composite flour of other combinations at the end of storage period.

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