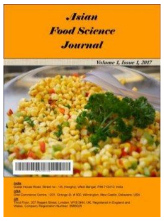

Asian Food Science Journal

9(3): 1-12, 2019; Article no.AFSJ.49078
ISSN: 2581-7752

Effect of Storage Conditions (Relative Humidity, Packaging Materials and Time) on the Chemical Properties of Maize-soy Flour Blend

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Authors' contributions

This work was carried out in collaboration among all authors. Author SOA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JKI and DIG managed the analyses of the study. Author DIG managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2019/v9i330015
Editor(s):
(1) Dr. Kresimir Mastanjevic, Associate Professor, Faculty of Food Technology, University in Osijek, Franje Kuhaca, Croatia.
Reviewers:
(1) Maurilio Gustavo Nespeca, São Paulo State University, Brazil.
(2) Adeyeye, Samuel Ayofemi Olalekan, Ton Duc Thang University, Vietnam.
(3) Jaime Cuauhtemoc Negrete, Autonomous Agrarian Antonio Narro University, Mexico.
Complete Peer review History: http://www.sdiarticle3.com/review-history/49078

Original Research Article

Received 05 March 2019
Accepted 21 May 2019
Published 28 May 2019

ABSTRACT

Aims: The aim of this study was to examine the effect of storage conditions on the of maize-soy flour blend.

Study Design: Preliminary studies were conducted using ratio blends of 70:30, 75:25, 80:20, 85:15, 90:10, 95:5 and 100:0 of maize flour to soy flour. This was to ascertain the best blend formulation for the study. The sensory attributes showed that the ratio 85:15 of maize-soy flour blend was preferred. It was packaged in low density polyethylene (LDPE), high density polyethylene (HDPE) and stored at 30.5 ± 3°C with relative humidity of 57% and 82% for 4 months. Analysis of proximate composition, pH, total titratable acidity (TTA), thiobarbuturic acid (TBA) was carried out on the samples at a monthly interval respectively.

Results: Packaging significantly ($p > 0.05$) affected the chemical qualities of "soy-fermented maize" flour during storage. Moisture content, titratable acidity (TTA) and thiobarbuturic acid (TBA) increased with the storage period (9.46% - 23.5%, 0.12% - 0.21%, and 0.06 - 0.12 respectively)

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while all other chemical qualities of the soy-fermented maize flour decreased significantly (p > 0.05) (pH: 5.18 - 3.45, protein: 15.21% - 12.18% fat: 7.45% - 5.36%, fibre: 3.27% - 1.65%, ash: 1.12% - 0.89% and carbohydrate: 62.97% - 56.87%.

Conclusion: The samples packaged in HDPE were more acceptable than those in other packaging materials due to its considerable maintenance of the flour's quality during and after storage.

Keywords: Storage; Agidi; maize-soy flour; low density polyethylene and high density polyethylene.

1. INTRODUCTION

Agidi is a local West African dish (mostly in Nigeria) made from fermented maize, sorghum or millet known as *Ogi*. *Ogi* is one of the popular products consumed widely in Nigeria. It is a fermented starchy mash obtained by soaking, wet milling, wet extraction (filtering) and decanting of surface water to obtain *Ogi* [1]. O*gi* is cooked with water to produce a semi-solid product called *Agidi* which is also known as *Eko* [1]. *Agidi* could be eaten alone or with vegetable soup and/or stew as well as with *Moi-moi* or *Akara* (steamed or fried bean cake) by both infants and adults. *Agidi* has added advantage over *Ogi*, as it could be eaten cold or warm. It could also be prepared and kept for later use, unlike *Ogi*, which should be eaten warm, thereby requiring fresh preparation. Traditionally, the maize grains are soaked in water for up to three days, before wet milling and sieving to ferment for three days until sour. It is then boiled as pap, or cooked into a semi-solid product called *Agidi*. It's appearance or color depends on the type of cereal used for production [2].

Earlier attempts made tends to improve the nutritional quality of these maize based products including "*Ogi"* but not much were found for *Agidi* [3]. *Agidi* is quite low in protein since it is mostly composed of starch. Over consumption of such product could lead to problems generally associated with protein [4]. Due to its low protein content, soybean was added to improve the nutritional composition and also add value to *Agidi*, because it is a cheap and available source of protein. Soybean is a versatile crop with many uses. Among the products are soymilk, soy-cake, ice cream, and soybean vegetable oil. As a proteinous food, soybean is much better than any other legume in terms of protein quality. The protein content of other legumes varies from 20 – 25% while that of soybean is about 39% [5]. The meal is rich in mineral element and vitamins such as thiamin riboflavin and niacin.

Storage of maize-soy flour is necessary due to the tedious and cumbersome unit operation methods required for the production of the flour. Storage of the maize-soy flour for the production of *Agidi* was probably not done in most research articles of *Agidi* production. This was done to ascertain the quality of the storage flour over time in production of *Agidi* with respect to its nutritional and sensory properties as these nutrients depreciate over time.

This study was geared towards finding the effects of storage on the quality of maize-soy flour blends and the *Agidi* product.

2. MATERIALS AND METHODS

2.1 Procurement of Materials

Maize (*Zea mays*) and Soybean (*Glycine max*) seeds used in this study were purchased from the Teaching and Research Farm of the College of Agronomy, University of Agriculture Makurdi, Benue State Nigeria.

2.1.1 Preparation of fermented maize flour

The fermented maize flour was prepared by the wet milling process with slight modification [6-8]. As shown in Fig. 1.

2.1.2 Preparation of soy flour

The soy flour was prepared according to the method reported by [9,10] with slight modification. As shown in Fig. 2. The flour was stored in a refrigerator (4°C) until used.

2.1.3 Preparation of soy-*Agidi*

Agidi was prepared according to the method reported by Akpapunam et al. [11] with slight modification. As shown in Fig. 3.

2.1.4 Storage studies

The samples (85:15 maize-soy flour blend) were packaged in low density polyethylene film and high density polyethylene film, then stored in two desiccators with relative humidity of 82% and 57% and placed in a room at ambient temperature (32 ± 2°C) for 24 weeks. Samples were withdrawn at four (4) weeks interval to check for chemical analysis.

2.2 Proximate Composition

The protein, moisture, fat, fibre, ash, carbohydrate, pH and titratable acidity were determined according to AOAC 2012 [12].

2.3 Statistical Analysis

All analyses were carried out in triplicate unless otherwise stated. Statistical significance was established using one-way analysis of variance (ANOVA), and data were reported as the mean and standard deviation. Mean comparison and separation were done using Fisher's Least Significant Difference test (LSD) at $p \leq 0.05$. Statistical analysis was carried out using the SPSS version 25 statistical package.

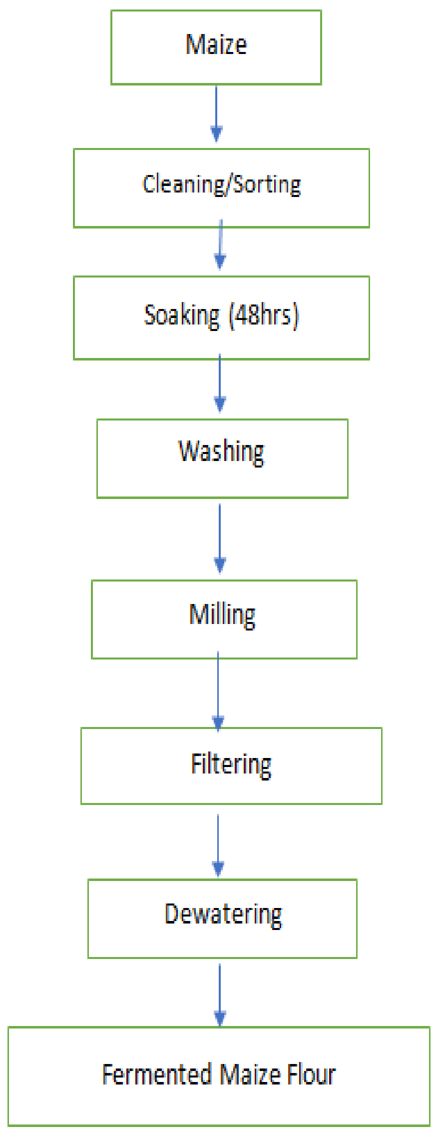

Fig. 1. Flow chart for the preparation of *Ogi* flour (Fermented maize flour)
Source: Osungbaro (1998) modified

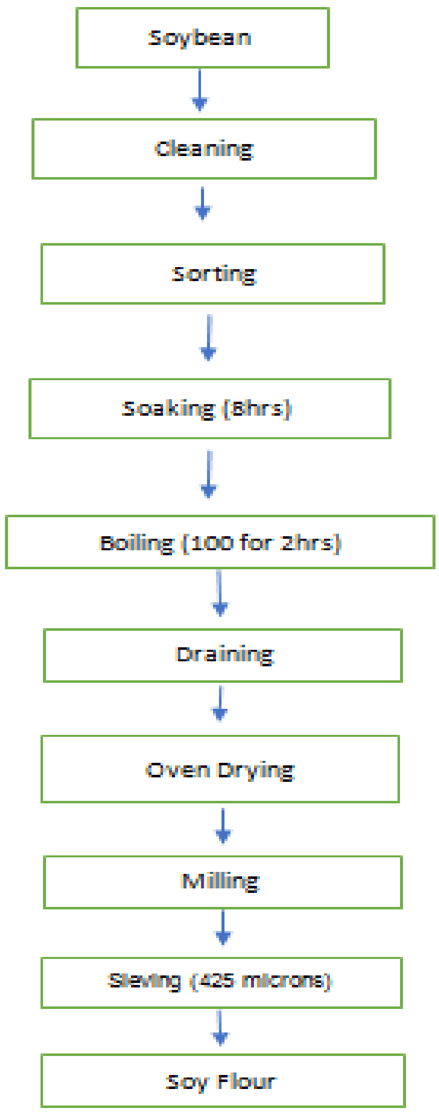

Fig. 2. Flow chart for the preparation of soy flour
Source: Amadou et al. [9] modified

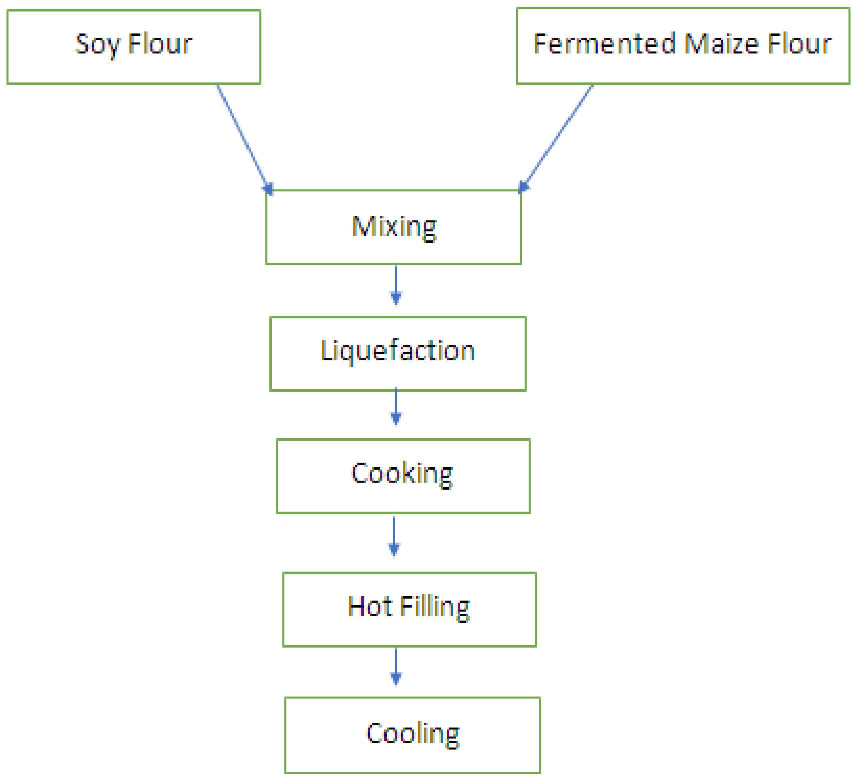

Fig. 3. Flow chart for the production of soy-*Agidi*
Source: Akpapunam et al. [11] – modified

3. RESULTS AND DISCUSSION

3.1 Effect of Storage on the Protein Quality of Soy Supplemented Maize Flour Blend

The results of protein for fresh and stored samples of maize-soy flour are shown in Table 1. The protein content decreased significantly ($p < 0.05$) across the four months for samples in low density polyethylene (15.70 - 13.16), in high density polyethylene (15.56 - 13.44) and no package (15.56 - 12.87) at relative humidity of 57%. In addition there was no significant difference ($p > 0.05$) of samples between packages (Table 1). Also at relative humidity of 82% there was significant difference for samples in low density polyethylene, high density polyethylene and no package ($p < 0.05$) as show in Table 1. But there was no significant difference for samples between packages. There was a decrease in crude protein content for all samples without package for both relative humidity of 57% and 82%. The result agrees with earlier studies by Garima and Anand [13].

3.2 Effect of Storage on the Moisture Content of Soy Supplemented Maize Flour Blend

The result of moisture for fresh and stored maize-soy flour is shown in Table 2. The moisture content increased significantly ($p < 0.05$) as the storage period increased independently of the packaging material or the relative humidity. Moisture content was highest in samples without packaging for both relative humidity of 57% and 82% (9.64 - 17.46 and 9.64 - 23.75) and lowest values in high density polyethylene film (9.60 - 15.56 and 9.56 - 15.59) during the 4 months of storage at ambient condition (Table 2). The increase in the percentage moisture content of stored flour can be attributed to the hygroscopic properties of the flour [14] and might be due to the fact that at a high humidity the vapour pressure may have increased which aids water absorption into the samples [15]. Polyethylene films generally have good barrier against moisture [16], but low density polyethylene had higher water vapour permeability compared with high density polyethylene. The result agrees with the earlier studies by [17], who observed higher moisture in low density polyethylene than in high density polyethylene during the storage of African Breadfruit seed flour at room temperature for 12 weeks. The results also agree with [18], who also found higher moisture in low density polyethylene than in high density polyethylene during the storage of pupuru for 24 weeks.

3.3 Effect of Storage on the Fat Content of Soy Supplemented Maize Flour Blend

The results of crude fat for fresh and stored samples of maize-soy flour are shown in Table 3. There was a progressive decrease in the fat content for all samples during storage at ambient conditions. The highest decrease in fat was seen in samples without package in both relative humidity of 57 % and 82 % as seen in Table 3. The lowest decrease was found in samples in High density polyethylene. The result agrees with the earlier studies of [19], where a steady decrease in fat during storage of cassava chips, cassava flour, yam chips and yam flour for three months was reported. The decrease may be attributed to the lipolytic activity of enzymes i.e. lipase and lipoxidase [20].

3.4 Effect of Storage on the Fiber Content of Soy Supplemented Maize Flour Blend

The results of crude fiber for fresh and stored samples of maize-soy flour are shown in Table 4. There was a significant difference ($p < 0.05$) for samples in low density polyethylene, high density polyethylene, and no package across the four months for relative humidity of 57% and 82%. Also, there was no significant difference ($p > 0.05$) for samples between packages. There was a decrease in fiber content in samples without packaging material with decrease observed in both relative humidity of 57% and 82%. (3.32 - 1.86 and 3.23 - 1.62 respectively). While samples in low density polyethylene had the lowest decrease for relative humidity of 57% (3.29 - 2.03) and samples in high density polyethylene had the highest decrease for relative humidity 82% (3.27 - 1.86).

These results were contrary to the result obtained by [19], where there was an increase in fiber during storage of cassava chips, cassava flour, yam chips and yam flour for three months. But were in agreement with [21] where it was observed that the fiber content decreased during the storage of soup thickener *Brachystegia enrycoma* (Achi) for 12 weeks.

3.5 Effect of Storage on the Ash Content of Soy Supplemented Maize Flour Blend

The results of ash for fresh and stored samples of maize-soy flour are shown in Table 5. There was a significant difference ($p < 0.05$) for samples in low density polyethylene, high density polyethylene, and no package for relative humidity of 57% and 82% across the four months. Moreover, there was no significant difference ($p > 0.05$) for samples between packages. There was a decrease in ash with samples without packaging resulting in the highest decrease for both relative humidity of 57% and 82% (1.12 - 0.99 and 1.13 - 0.95 respectively). The lowest decrease in ash was recorded in samples with low density polyethylene for both relative humidity (1.13-1.04 and 1.13-1.05). The results agreed with by [21].

3.6 Effect of Storage on the Carbohydrate Content of Soy Supplemented Maize Flour Blend

The carbohydrate results for fresh and stored samples of maize-soy flour are shown in Table 6. There was a significant difference ($p < 0.05$) for samples in low density polyethylene, high density polyethylene, and no package for Relative humidity of 57% and 82% across the four months. There was also significant difference ($p < 0.05$) for samples between packages. There was a decrease in the carbohydrate content for samples with no packaging materials with the lowest decrease for both relative humidity 57% and 82% (62.86 - 60.42 and 62.99 - 56.87).The highest results for relative 57% was found in samples in low density polyethylene (62.9 - 61.51) while the highest results for relative humidity of 82% was observed in high density polyethylene (62.96 - 58.87) (Table 8). The result agrees with the earlier findings of [19], where a steady decrease in the carbohydrate content of the samples during storage of cassava chips, cassava flour, yam chips and yam flour for three months was reported, but was contrary to the report of [22] where an increase after the storage of yam chips and flour was observed. Carbohydrate content of the samples might have decreased because of its utilization for growth by microorganisms [19].

Table 1. Effect of storage conditions (Relative humidity, packaging material and time) on the crude protein of maize- soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	1	2	3	4	
57	LDPE	$15.61^{a}_{a}\pm0.03$	$15.70^{a}_{a}\pm0.03$	$15.53^{a}_{a}\pm0.09$	$14.76^{b}_{a}\pm0.15$	$13.16^{c}_{a}\pm0.08$	0.56
	HDPE	$15.61^{a}_{a}\pm0.03$	$15.56^{a}_{a}\pm0.14$	$15.44_{a}\pm 0.06$	$14.79^{b}_{c} \pm 0.07$	$13.44^{c}_{a}\pm0.48$	0.56
	No Packaging	$15.61^{a}_{a}\pm0.03$	$15.56^{a}_{a}\pm0.08$	$15.57^{a}_{a}\pm0.18$	$14.68^{b}_{a}\pm0.04$	$12.87^{c}_{a}\pm0.26$	0.56
82	LDPE	$15.61^{a}_{a}\pm0.03$	$15.55^{a}_{a}\pm0.07$	$15.57^{a}_{a}\pm0.08$	$14.76^{b}_{a}\pm0.09$	$13.54^{c}_{a}\pm0.12$	0.56
	HDPE	$15.61^{a}_{a}\pm0.03$	$15.52^{a}_{a}\pm0.16$	$15.64^{a}_{a}\pm0.08$	$14.73^{b}_{a}\pm0.11$	$13.33^{c}_{a}\pm0.67$	0.56
	No Packaging	$15.61^{a}_{a}\pm0.03$	$15.56^{a}_{a}\pm0.08$	$15.57^{a}_{a}\pm0.18$	$14.68^{b}_{a}\pm0.04$	$12.87^{c}_{b}\pm0.26$	0.56
LSD		0.65	0.65	0.65	0.65	0.65	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE = Low density polyethylene,
HDPE: High density polyethylene

Table 2. Effect of storage conditions (Relative humidity, packaging material and time) on the moisture of maize-soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	1	2	3	4	
57	LDPE	$9.61^{d}_{a}\pm0.16$	$9.46^{d}_{a}\pm0.03$	$10.89^{c}_{a}\pm0.15$	$13.50^{b}_{a}\pm0.14$	$16.33^{a}_{b} \pm0.07$	0.92
	HDPE	$9.61^{d}_{a}\pm0.16$	$9.60^{d}_{a}\pm0.14$	$11.72^{c}_{a}\pm0.05$	$13.63^{b}_{a}\pm0.09$	$15.56^{a}_{c} \pm0.59$	0.92
	No Packaging	$9.61^{d}_{a}\pm0.16$	$9.64^{d}_{a}\pm0.21$	$11.66^{c}_{a}\pm0.06$	$14.27^{b}_{a}\pm0.18$	$17.46^{a}_{a}\pm0.35$	0.92
82	LDPE	$9.61^{d}_{a}\pm0.16$	$9.57^{d}_{a}\pm0.16$	$11.10^{c}_{b}\pm0.59$	$13.60^{b}_{b}\pm0.06$	$16.18^{a}_{b}\pm0.43$	0.92
	HDPE	$9.61^{d}_{a}\pm0.16$	$9.56^{d}_{a}\pm0.23$	$12.77^{c}_{a}\pm0.06$	$13.19^{b}_{c}\pm0.70$	$15.59^{a}_{c}\pm0.59$	0.92
	No Packaging	$9.61^{d}_{a}\pm0.16$	$9.64^{d}_{a}\pm0.23$	$12.77^{c}_{a}\pm0.23$	$18.16^{b}_{a}\pm0.54$	$23.75^{a}_{a}\pm0.49$	0.92
LSD		1.06	1.06	1.06	1.06	1.06	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE = Low density polyethylene
HDPE: High density polyethylene

Table 3. Effect of storage conditions (Relative humidity, packaging material and time) on the crude fat of maize-soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	**1**	**2**	**3**	**4**	
57	LDPE	$7.55^{a}_{a}\pm0.08$	$7.53^{a}_{a}\pm0.03$	$7.21^{b}_{a}\pm0.2$	$6.76^{c}_{a}\pm0.08$	$6.58^{c}_{a}\pm0.03$	0.29
	HDPE	$7.55^{a}_{a}\pm0.08$	$7.56^{a}_{a}\pm0.08$	$7.16^{b}_{a}\pm0.06$	$6.65^{c}_{a}\pm0.08$	$6.37^{c}_{a}\pm0.22$	0.29
	No Packaging	$7.55^{a}_{a}\pm0.08$	$7.51^{a}_{a}\pm0.02$	$7.17^{b}_{a}\pm0.06$	$6.67^{c}_{a}\pm0.07$	$6.38^{d}_{a}\pm0.19$	0.29
		$7.55^{a}_{a}\pm0.08$	$7.49^{a}_{a}\pm0.01$	$7.20^{b}_{a}\pm0.11$	$6.79^{c}_{a}\pm0.03$	$6.64^{c}_{a}\pm0.14$	0.29
82	LDPE	$7.55^{a}_{a}\pm0.08$	$7.56^{a}_{a}\pm0.07$	$7.25^{b}_{a}\pm0.05$	$6.63^{c}_{a}\pm0.18$	$6.61^{c}_{a}\pm0.19$	0.29
	HDPE	$7.55^{a}_{a}\pm0.08$	$7.45^{a}_{a}\pm0.06$	$7.16^{b}_{a}\pm0.08$	$5.69^{c}_{b}\pm0.08$	$5.00^{d}_{b}\pm0.01$	0.29
	No Packaging	$7.55^{a}_{a}\pm0.08$	$7.53^{a}_{a}\pm0.03$	$7.21^{b}_{a}\pm0.2$	$6.76^{c}_{a}\pm0.08$	$6.58^{c}_{a}\pm0.03$	0.29
LSD		0.33	0.33	0.33	0.33	0.33	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE = Low density polyethylene
HDPE: High density polyethylene

Table 4. Effect of storage conditions (Relative humidity, packaging material and time) on the crude fiber of maize-soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	**1**	**2**	**3**	**4**	
57	LDPE	$3.30^{a}_{a}\pm0.06$	$3.29^{a}_{a}\pm0.02$	$2.54^{b}_{a}\pm0.07$	$2.16^{c}_{a}\pm0.06$	$2.03^{c}_{a}\pm0.11$	0.30
	HDPE	$3.30^{a}_{a}\pm0.06$	$3.27^{a}_{a}\pm0.04$	$2.29^{b}_{a}\pm0.01$	$1.95^{c}_{a}\pm0.12$	$1.89^{c}_{a}\pm0.19$	0.30
	No Packaging	$3.30^{a}_{a}\pm0.06$	$3.32^{a}_{a}\pm0.04$	$2.38^{b}_{a}\pm0.18$	$1.89^{c}_{a}\pm0.06$	$1.86^{c}_{a}\pm0.15$	0.30
82	LDPE	$3.30^{a}_{a}\pm0.06$	$3.27^{a}_{a}\pm0.02$	$2.43^{b}_{a}\pm0.04$	$1.94^{c}_{a}\pm006$	$1.77^{c}_{a}\pm0.16$	0.30
	HDPE	$3.30^{a}_{a}\pm0.06$	$3.27^{a}_{a}\pm0.01$	$2.45^{b}_{a}\pm0.04$	$1.91^{c}_{a}\pm0.15$	$1.86^{c}_{a}\pm0.27$	0.30
	No Packaging	$3.30^{a}_{a}\pm0.06$	$3.23^{a}_{a}\pm0.04$	$2.27^{b}_{a}\pm0.08$	$1.75^{c}_{a}\pm0.00$	$1.65^{c}_{a}\pm0.14$	0.30
LSD		0.35	0.35	0.35	0.35	0.35	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE: Low density polyethylene
HDPE: High density polyethylene

Table 5. Effect of storage conditions (Relative humidity, packaging material and time) on the ash of maize-soy flour blend

Relative Humidity	**Packaging**	**Storage time (in Months)**					**LSD**
		0	**1**	**2**	**3**	**4**	
57	LDPE	1.14^{a}_{a}±0.01	1.13^{a}_{a}±0.06	1.07^{a}_{a}±0.08	1.06^{a}_{b}±0.09	1.04^{a}_{a}±0.92	0.23
	HDPE	1.14^{a}_{a}±0.01	1.14^{a}_{a}±0.01	1.06^{a}_{a}±0.08	1.09^{a}_{a}±0.00	1.00^{a}_{a}±0.01	0.23
	No Packaging	1.14^{a}_{a}±0.01	1.12^{a}_{a}±0.42	1.09_{a}a±0.21	1.01^{a}_{a}±0.01	0.99^{a}_{a}±0.01	0.23
82	LDPE	1.14^{a}_{a}±0.01	1.13^{a}_{a}±0.02	1.28^{a}_{a}±0.24	0.99^{a}_{a}±0.04	1.05^{a}_{a}±0.14	0.23
	HDPE	1.14^{a}_{a}±0.01	1.14^{a}_{a}±0.04	1.15^{a}_{a}±0.07	1.00^{a}_{a}±0.01	0.88^{b}_{a}±0.17	0.23
	No Packaging	1.14^{a}_{a}±0.01	1.13^{a}_{a}±0.02	1.12^{a}_{a}±0.16	1.03^{a}_{a}±0.00	0.98^{a}_{a}±0.28	0.23
LSD		0.26	0.26	0.26	0.26	0.26	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE: Low density polyethylene
HDPE: High density polyethylene

Table 6. Effect of storage conditions (Relative humidity, packaging material and time) on the carbohydrate of maize-soy flour blend

Relative humidity	**Packaging**	**Storage time (in Months)**					**LSD**
		0	**1**	**2**	**3**	**4**	
57	LDPE	62.97^{a}_{a}±0.06	62.9^{a}_{a}±0.014	62.57^{a}_{a}±0.07	61.91^{b}_{a}±0.09	61.51^{b}_{a}±0.05	0.80
	HDPE	62.97^{a}_{a}±0.06	62.87^{a}_{a}±0.13	62.31^{a}_{a}±0.01	61.96^{b}_{a}±0.17	60.92^{c}_{a}±0.67	0.80
	No Packaging	62.97^{a}_{a}±0.06	62.86^{a}_{a}±0.06	62.08^{a}_{a}±0.13	61.52^{b}_{a}±0.03	60.42^{c}_{b}±0.13	0.80
82	LDPE	62.97^{a}_{a}±0.06	63.01^{a}_{a}±0.11	61.92^{b}_{a}±0.11	61.86^{b}_{a}±0.11	60.83^{c}_{a}±0.25	0.80
	HDPE	62.97^{a}_{a}±0.06	62.96^{a}_{a}±0.92	62.42^{a}_{a}±0.65	62.59^{a}_{a}±0.21	61.67^{b}_{a}±0.25	0.80
	No Packaging	62.97^{a}_{a}±0.06	62.99^{a}_{a}±0.01	61.19^{b}_{a}±0.26	58.80^{c}_{b}±0.66	56.87^{d}_{b}±0.47	0.80
LSD		0.92	0.92	0.92	0.92	0.92	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE: Low density polyethylene
HDPE: High density polyethylene

Table 7. Effect of storage conditions (Relative humidity, packaging material and time) on the pH of maize-soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	1	2	3	4	
57	LDPE	$5.21^{a}_{a}\pm0.01$	$5.05^{a}_{a}\pm0.07$	$4.86^{ab}_{c}\pm0.02$	$3.45^{c}_{c}\pm0.00$	$3.45^{c}_{c}\pm0.01$	0.56
	HDPE	$5.21^{a}_{a}\pm0.01$	$5.18^{a}_{a}\pm0.03$	$5.14^{a}_{a}\pm0.07$	$4.15^{b}_{b}\pm0.12$	$3.80^{c}_{b}\pm0.09$	0.56
	No Packaging	$5.21^{a}_{a}\pm0.01$	$5.14^{a}_{a}\pm0.35$	$5.01^{b}_{b}\pm0.10$	$4.26^{b}_{a}\pm0.08$	$4.26^{b}_{a}\pm0.03$	0.56
82	LDPE	$5.21^{a}_{a}\pm0.01$	$5.13^{a}_{a}\pm0.21$	$4.72^{ab}_{c}\pm0.01$	$3.81^{c}_{b}\pm0.06$	$3.71^{c}_{a}\pm0.01$	0.56
	HDPE	$5.21^{a}_{a}\pm0.01$	$5.20^{a}_{a}\pm031$	$5.07^{a}_{a}\pm0.14$	$3.99^{b}_{c}\pm0.01$	$3.64^{b}_{b}\pm0.12$	0.56
	No Packaging	$5.21^{a}_{a}\pm0.01$	$5.18^{a}_{a}\pm0.01$	$4.90^{a}_{b}\pm0.02$	$3.75^{b}_{c}\pm0.35$	$3.66^{b}_{b}\pm0.07$	0.56
LSD		0.07	0.07	0.07	0.07	0.07	

Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
Key: LDPE: Low density polyethylene
HDPE: High density polyethylene

Table 8. Effect of storage conditions (Relative humidity, packaging material and time) on the titrable acidity of maize-soy flour blend

Relative humidity	Packaging	Storage time (in Months)					LSD
		0	1	2	3	4	
57	LDPE	$0.12^{c}_{a}\pm0.01$	$0.12^{c}_{b}\pm0.00$	$0.13^{cb}_{b}\pm0.01$	$0.15^{b}_{c}\pm0.02$	0.18 ± 0.01	0.02
	HDPE	$0.12^{c}_{a}\pm0.01$	$0.13^{c}_{a}\pm0.01$	$0.13^{c}_{b}\pm0.01$	$0.17^{ab}_{b}\pm0.01$	$0.19^{a}_{a}\pm0.02$	0.02
	No Packaging	$0.12^{c}_{a}\pm0.01$	$0.11^{c}_{c}\pm0.02$	$0.14^{b}_{a}\pm0.01$	$0.18^{a}_{a}\pm0.00$	$0.19^{a}_{a}\pm0.01$	0.02
82	LDPE	$0.12^{c}_{a}\pm0.01$	$0.13^{b}_{a}\pm0.02$	$0.14^{b}_{a}\pm0.03$	$0.16^{a}_{b}\pm0.01$	$0.18^{a}_{c}\pm0.01$	0.02
	HDPE	$0.12^{c}_{a}\pm0.01$	$0.13^{c}_{a}\pm0.00$	$0.13^{c}_{a}\pm0.01$	$0.16^{b}_{b}\pm0.01$	$0.19^{a}_{b}\pm0.01$	0.02
	No Packaging	$0.12^{c}_{a}\pm0.01$	$0.11^{b}_{b}\pm0.01$	$0.14^{b}_{a}\pm0.12$	$0.19^{a}_{a}\pm0.00$	$0.21^{a}_{a}\pm0.02$	0.02
LSD		0.01	0.01	0.01	0.01	0.01	

Key: Superscript: Separation of mean for months (across the rows) Subscript: Separation of means for packaging (down the columns)
LDPE: Low density polyethylene
HDPE: High density polyethylene

3.7 Effect of Storage on the pH Content of Soy Supplemented Maize Flour Blend

The pH values of the fresh and stored samples are shown in Table 7. There was a steady decrease in pH value during the storage months (samples became more acidic). The lowest decrease for pH in relative humidity of 57 % was recorded in samples in low density polyethylene and highest in samples with no packaging material. The lowest results for pH in relative humidity of 82% was recorded in samples with no packaging material and highest in sample with high density polyethylene. These results are in agreement with earlier studies by [18], where higher pH value in low density polyethylene than in high density polyethylene during the storage of pupuru for 24 weeks was reported.

The samples in low density polyethylene, at relative humidity of 57% had the lowest pH values after storage while samples stored at relative humidity of 82% had higher pH values.

For samples in high-density polyethylene, the samples at relative humidity of 82 % were recorded as samples with the lowest pH values after storage while samples stored under Relative humidity of 57% had higher pH values.

For samples without Packaging material, the samples at relative humidity of 82% were recorded as samples with the lowest pH values after storage while samples stored under relative humidity of 57% had higher pH values.

In general there was a steady decrease in pH value in all samples. This is in agreement with [19], who reported a steady decrease in pH value during storage of cassava chips, cassava flour, yam chips and yam flour for three months. The pH value observed could help in the control of microbial load in the flour as it is an indication of microbial proliferation [23].

3.8 Effect of Storage on the Titratable Acidity Content of Soy Supplemented Maize Flour Blend

The titratable Acidity values of the fresh and stored samples are shown in Table 8.

There was a steady increase in titratable acidity value during the storage months (samples became more acidic). The lowest increase for titratable acidity in relative humidity of 57% was recorded in samples in no packaging materials and highest score in samples in high density polyethylene. The lowest score for titratable acidity in relative humidity of 82 % was recorded with samples in high density polyethylene and highest score was observed in samples with no packaging material. These finding are in agreement with [18], where higher titratable acidity value in low density polyethylene than in high density polyethylene during the storage of pupuru for 24 weeks was reported.

For samples with low-density polyethylene, the samples at relative humidity of 57% was recorded as samples with the lowest titratable acidity values after storage while samples stored at relative humidity of 82% had the higher titratable acidity values.

For samples with high-density polyethylene, the samples at relative humidity of 82% was recorded as samples with the lowest titratable acidity values after storage while samples stored at relative humidity of 57% had higher titratable acidity values.

For samples with no packaging material, the samples at relative humidity of 82% was observed as samples with the lowest titratable acidity values after storage while samples stored at relative humidity of 57% had the higher titratable acidity values.

There was an increase in titratable acidity during storage irrespective of packaging materials. The increase in titratable acidity with storage period was also observed by [23] where titrabale acidity increased during storage of flours from soaked, malted and their blend of millet grains (*Pennesitum glacum*) for 90 days.

4. CONCLUSION

The result of the study showed that the increase in moisture content was directly proportional to the increase in storage time, conversely a decrease in protein, carbohydrate, ash, fibre and fat content was observed with increased storage time.

The pH of the samples decreased with an increase in the storage time. An inverse relationship was observed for titratable acidity.

Storage of soy-maize flour in relative humidity of 57% should not exceed a period of 4 months because adverse changes in the quality of the product are evident.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/49078