Original Research Article

Effect of Some Packaging Materials on the Storage, Carotenoid Content and Storage Properties of Ground Pepper

ABSTRACT

The effects of selected packaging materials on the storage, carotenoid content and sensory properties of ground pepper was investigated. Ground pepper was packed with polypropylene of different thickness such as (PP) 3 micron, 4 micron, 5 micron, 12.5 micron, 20 micron and 30 micron. Samples were analyzed for changes in proximate, carotenoid, mould count and sensory qualities at days 0, 30 and 60 for three months during storage at room temperature. The moisture content (7.94 - 8.28%) and carbohydrate content (33.21 - 35.77%) increased while protein (10.20 - 9.43%), fat (6.97 - 16.17%), ash (5.58 - 5.01%) and crude fibre content (26.11 - 25.29%) decreased with the prolongation of storage period but no significant ($p>0.05$) variation was recorded for different packaging materials. There was a significant ($p<0.05$) decrease in the carotenoid content of different packaging materials with a better level retained in PP 30 micron (19.27mg/g) and PP 20 micron (16.12mg/g) after 60 days of storage. There was also an increase in the mould count of the ground pepper packed with different packaging materials with PP 20 micron (2.8×10^{-4}cfu/g) and PP 30 micron (4.1×10^{-4}cfu/g) having the least counts. Sensory evaluation result showed that samples packed in PP 30 micron had better retention of pungency, PP 20 micron for aroma and PP 12.5 micron for colour. However, there was no significant ($p>0.05$) difference in the overall acceptability of the ground pepper as influenced by packaging materials. The PP 30 micron and 20 micron may prove very useful for the storage of ground pepper for longer shelf life and good retention of carotenoid content, colour and pungency.

Keywords: *Pepper Fruit, Packaging Materials, Shelf Life, Phytochemicals, Quality Attributes' Retention, Microbial Count,*

1. INTRODUCTION

Pepper fruits (*Capsicum annum*) are important vegetable widely used as spice condiments and there are varieties of these condiments. They second most popular vegetable after tomatoes used in cooking [1]. Nigeria has an abundance of pepper varieties being the highest producer in Africa [2]. They are grown for their sensorial characteristics of colour, aroma and pungency. They are good source of nutritional phytochemicals such as carotenoids, tocopherols, ascorbic acid and phenolic compounds [3]. They are also rich in capsaicinoids which is responsible for the taste, pungency and its hotness [4].

Ground *Capsicum* also known as paprika has a high demand in the domestic and international markets. They can be used as natural food colourants or seasoning agents due to their colour, flavour and pungency depending on the specie. They can also be used to modify the flavour of foods such as soups, stews and sausages as well as standard ingredient and as a flavour additive in processed

foods [5]. The main parameters of ground pepper are colour and pungency [6]. Handlers and consumers of ground pepper therefore attach a lot of importance to the retention in the colour and pungency. This is why packaging of this pepper product is important as temperature, air, sunlight and relative humidity can cause losses in the quality attributes.

Packaging materials play a significant role for better shelf life of the packed product. Packaging supplies an adequate environmental condition for shelf life extension of foods. Ground and powdered pepper requires protection against moisture, oxygen and loss of flavour and colour compounds. Carotenoids present in ground pepper are susceptible to degradation, oxidation and isomerization due to the effect of light and heat thereby resulting to colour loss [7]. Packaging them with suitable packaging materials will provide a good market value and also ensure quality for consumer's requirement. In recent days, different packages have been used to package food products so as to increase its shelf life. However, the storage life of the product depends on the appropriate selection of the packaging films. The effectiveness of different packaging materials used will not be the same as each material will have different permeability rates. Permeability of the packaging films to water vapour and gases is considered for shelf life [8].

Considering the demand of ground pepper, efforts has been made to study the most appropriate packaging material to increase its shelf life. Polypropylene, plastics, polyethylene among others are widely used in the market to package ground pepper. On this premise, the present study was designed to further evaluate the effect of packaging materials on the proximate, carotenoid and sensory properties, as well as the rate of microbial growth during 60 days of the storage period.

2. MATERIALS AND METHODS

2.1 Materials

Dried chili pepper was procured from Mile 3 market Port Harcourt, Rivers State, Nigeria and was sorted for damaged samples. Packaging materials used were polypropylene packages of different thickness such as 3 micron, 4 micron, 5 micron, 12.5 micron, 20 micron and 30 micron. These packaging materials were purchased from Trans-Amadi in Port Harcourt. All chemicals used were of the analytical grades, products of BDH chemical Ltd pool, England and were obtained from Food Technology Laboratory, Department of Food Science and Technology, Rivers State University, Port Harcourt.

2.2 Methods

2.2.1 Sample Preparation, Packaging and Storage Condition

Two kilograms (2kg) of chilli pepper berries were cleaned, sorted and oven dried at 50^0C for 24h in a hot air fan oven (Model QUB, 305015, Gallenkamp, UK) and ground using a laboratory mill (Numex and Pep Grinding Mill, India). Fifty grams (50g) of the milled pepper samples were packed in polypropylene of thickness 3µ, 4µ, 5µ, 12.5µ, 20µ and 30µ. All samples were stored at room temperature for a period of three (3) months. Pepper samples were analyzed at the intervals of 0, 30 and 60 days of storage for proximate, carotenoid, sensory properties and for the identification of moulds.

2.2.2 Proximate Analysis of the Ground Pepper Samples

Moisture, ash, crude protein, crude fat and crude fibre contents were determined according to AOAC [9] standard method while carbohydrate content was determined by difference.

2.2.3 Total Carotenoid Determination

Total carotenoid of the pepper samples were estimated using the methods of Harbone [10]. The sample (0.5g) was weighed into a centrifuge tube and 10ml of 80% acetone added. It was mixed properly and centrifuged at 4000rpm for 10mins and filtered. The supernatant was made up to a volume of 15ml using 80% ethanol. The optical density (absorbance) was read at a wavelength of 480nm using ultraviolent (UV) visible spectrophotometer.

$$Total\ Carotenoid\ Content\ \left(\frac{mg}{kg}\right) = \frac{4\ x\ OD\ x\ Total\ Vol.of\ Sample\ x\ 1000}{Sample\ Weight}$$

2.2.4 Identification of Moulds

Twenty five grams (25g) of the sample was weighed and dissolved into 225ml of prepared diluents and mixed to dissolve completely (10^{-1}). One milliliter (1ml) was measured from the first dilution (10^{-1}) into the second and the third diluents (10^{-2}). From the last dilution, 0.1ml was measured and inoculated in a prepared plate of Sabouraud Dextrose agar (SDA) and incubated at 28±2^{0}C for 2 days before colonies were counted [11].

2.2.5 Sensory Evaluation

The sensory attributes of the ground pepper samples were obtained by using simple hedonic tests as described by Larmond [12]. This was done using a 20 member panel comprising of students of the Department of Food Science and Technology, Rivers State University who are familiar with the sensory attributes of pepper. The Judges were asked to score each attribute on a 9-point hedonic scale where 1 and 9 represent dislike extremely and like extremely, respectively. The attributes that were evaluated include colour, pungency, aroma, flavour and overall acceptability.

2.2.6 Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0, software 2011. All analysis were done in duplicate and means separated using the Least Significant Difference test (LSD).

3. RESULTS AND DICUSSION

3.1 Proximate Composition of Ground Pepper

Effect of packaging materials on the proximate compositions of ground pepper are presented in Figure 1A to 1F. The result showed that the moisture content of the pepper increased from 7.94% (at day 0) to 8.28% (at day 60). It was observed that the packaging materials significantly ($p>0.05$) did not affect the moisture content of the pepper samples rather, they were affected by the storage period. The change in moisture content during storage may be attributed to the permeability of these packaging materials to water and gas. It may also be due to the condensation of respiratory water on the inside of the packaging materials. Kumar and Mishra [13] also reported a gradual increase in the moisture content of mango yoghurt powder during storage when packed with polypropylene packages. Panda *et al.* [14] equally reported an increase in strawberry packed with materials. Moisture content is an indicator of shelf stability and an increase in moisture content can enhance microbial growth leading to food deterioration [15]. The recommended safe level of moisture content during storage of food powders is within the range 12 - 14% [16]. Moisture content of all the non stored and stored pepper samples falls within this range. Moisture content of the ground pepper samples were within the range reported by Esayas *et al*. [17] for some capsicum varieties.

Protein, fat and crude fibre contents of the ground pepper samples decreased with storage period. Protein decreased from 10.20 - 9.43%, fat 16.97 - 16.17% and crude fibre 26.11 - 25.29%. There was an increase in the carbohydrate content from 33.21 - 35.77%. These reductions in protein, fat and

fibre have also been reported by Adebowale *et al*. [18] for water yam flour under different packaging materials. This may be attributed to the growth of microorganisms as a result of the increase in moisture content. Achi and Akubor [19] stated that increased moisture can lead to the disintegration of nutrients of food. Samples stored in polypropylene of thickness 30 micron and 20 micron recorded the least protein, fat, fibre and carbohydrate depletion. There was no significant ($p<0.05$) difference in the protein, fat, crude fibre and content of ground pepper samples packed in the different packaging materials implying that packaging had no significant effect during the storage period of 60 days. This trend was also reported by Pavani and Aduri [20] who observed no significant difference between packaging materials at 5% level of significance after 45 days of storage in both dried spinach and amaranths leaf powder.

The ash content is an indication of the mineral element of food and was observed to decreased during storage period from 5.58 - 5.01%. There was also no significant ($p>0.05$) difference in the ash content of the pepper samples as affected by packaging. These values are within the range reported by Emmanuel-Ikeme *et al*. [21]. This decrease could be as a result of biochemical activities of microorganisms. Pepper samples stored in polypropylene of thickness 30 micron and 20 micron were also seen to record the least depletion.

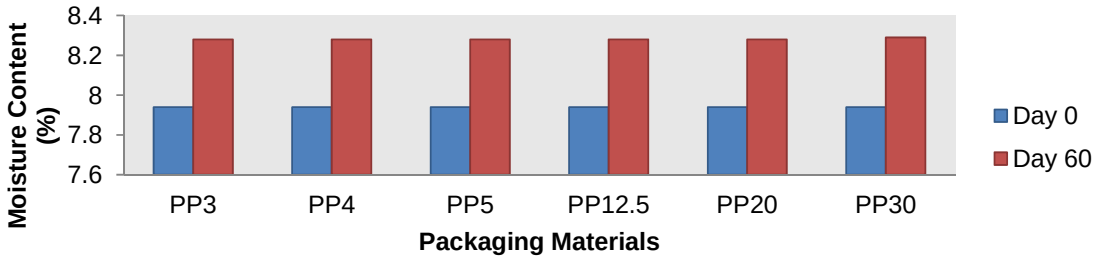


Figure 1A: Effect of Packaging Materials on Moisture Content of Ground Pepper

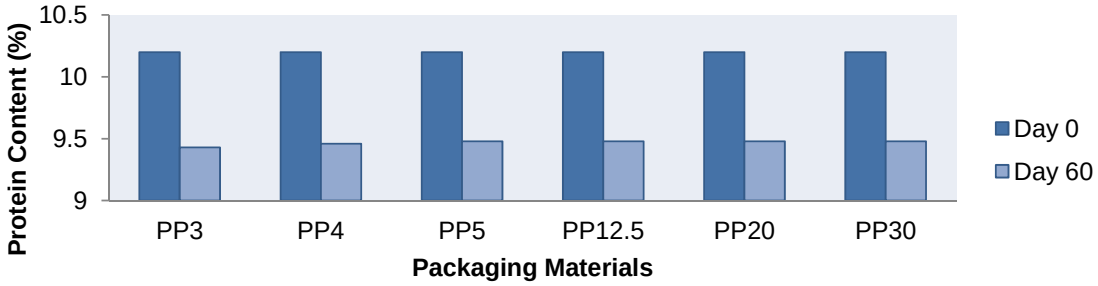
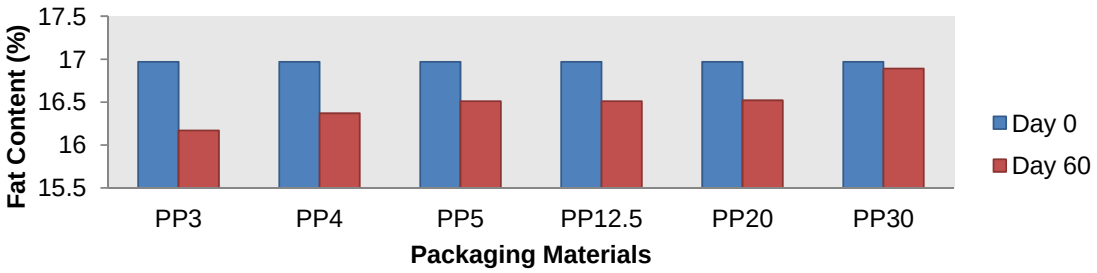


Figure 1B: Effect of Packaging Materials on Protein Content of Ground Pepper



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152 **Figure 1C:** Effect of Packaging Materials on Fat Content of Ground Pepper

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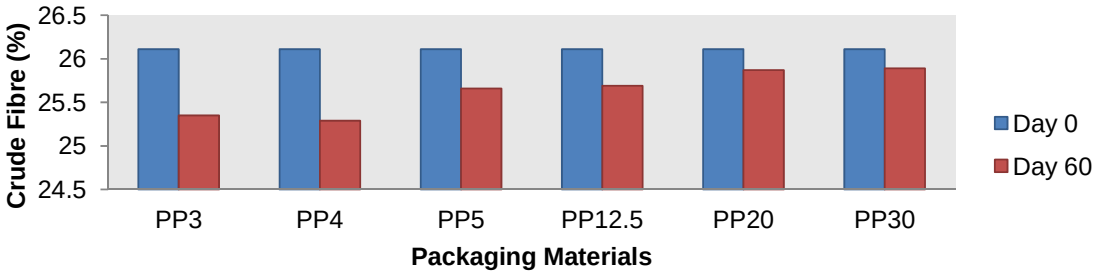

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155 **Figure 1D:** Effect of Packaging Materials on Crude Fibre Content of Ground Pepper

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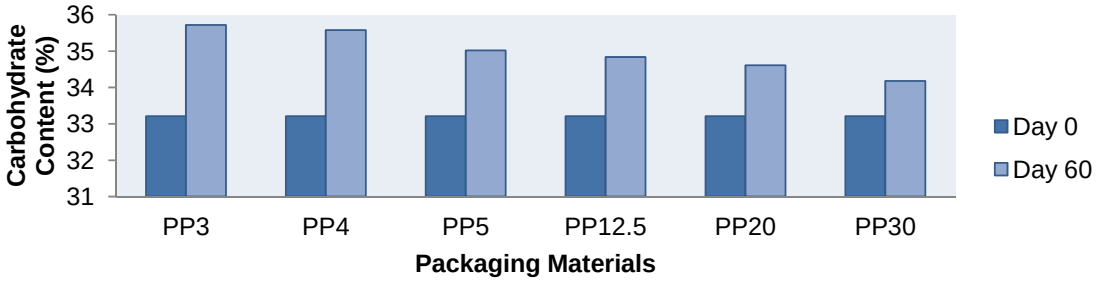

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158 **Figure 1E:** Effect of Packaging Materials on Carbohydrate Content of Ground Pepper

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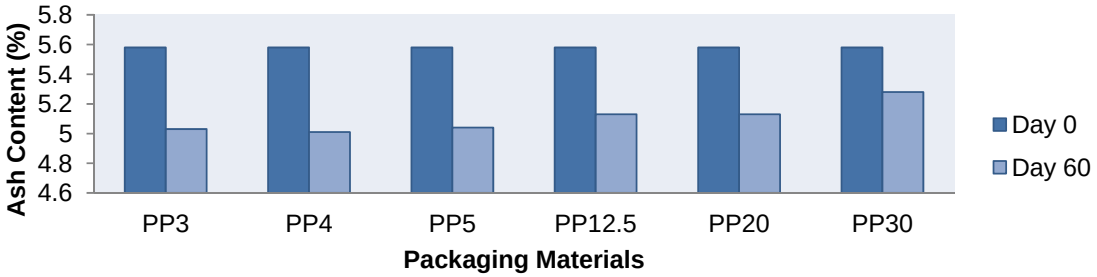

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Figure 1F: Effect of Packaging Materials on Ash Content of Ground Pepper

Keys:
PP3µ = Polypropylene 3 micron
PP4µ = Polypropylene 4 micron
PP5µ = Polypropylene 5 micron
PP12.5µ = Polypropylene 12.5 micron
PP20µ = Polypropylene 20 micron
PP30µ = Polypropylene 30 micron

3.2 Carotenoid Content of Ground Pepper

Effect of packaging materials on the carotenoid content of ground pepper is shown in Table 1. It was observed that carotenoid content of the ground pepper packed in different packaging materials varied significantly ($p<0.05$) over the storage period. There was a decrease in the carotenoid content on day 30 with maximum carotenoid recorded in ground pepper packed with PP 30 microns (24.36mg/g) followed by PP 20 micron (22.02mg/g) and pp12.5 micron (21.42mg/g) while PP 3 micron, PP 4 micron and PP 5 micron recorded 2.31mg/g, 17.43mg/g and 19.35mg/g, respectively. At day 60, there was a decrease in the carotenoid content of the samples with maximum value recorded in the sample packed with PP 30 micron (19.27mg/g). Over the prolongation of the storage period, the total carotenoid content was on a decreasing trend. This decrease might be attributed to the modification of the atmosphere inside the packaging materials with respect to oxygen concentration [22]. Different packaging materials have varying water vapour, oxygen transmission rate and sunlight resistance as reported by Allahvaisi [23] which might have affected the carotenoid contents. This might also be due to the oxidation and degradation of carotenoid pigment as light catalyzes the oxidation reaction [24]. This decreasing trend in carotenoid content was equally observed by Awoyale *et al.* [25].

Table 1. Effect of Packaging Materials on the Carotenoid Content of ground pepper powder

	Storage Period (Days)		
Storage Materials	**0**	**30**	**60**
A	27.79±0.00^{a}	21.31±0.00^{c}	14.34±0.00^{c}
B	27.79±0.00^{a}	17.43±0.33^{e}	11.84±0.34^{e}
C	27.79±0.00^{a}	19.35±0.33^{d}	13.75±0.17^{d}
D	27.79±0.00^{a}	21.42±0.00^{c}	14.71±0.33^{c}
E	27.79±0.00^{a}	22.02±0.16^{b}	16.12±0.16^{b}
F	27.79±0.00^{a}	24.36±0.17^{a}	19.27±0.00^{a}
LSD	**0.00**	**0.51**	**0.59**

Values bearing different superscript within the same column differ significantly ($p<0.05$) at 5% level of probability, ± standard deviation of duplicate determination.

Keys:
A = (PP3µ) Polypropylene 3 micron
B = (PP4µ) Polypropylene 4 micron
C = (PP5µ) Polypropylene 5 micron
D = (PP12.5µ) Polypropylene 12.5 micron
E = (PP20µ) Polypropylene 20 micron
F = (PP30µ) Polypropylene 30 micron

3.3 Mould Count of Ground Pepper

Table 2 shows the effect of packaging materials on the mould count of stored ground pepper powder. An increase in the mould count was observed in the samples during storage period. At day zero, mould count for all the pepper samples were 3.0×10^{-3}Cfu/g. They increased to the range of 3.9×10^{-4}Cfu/g to 4.3×10^{-5}Cfu/g at day 30 with PP 12.5 micron, PP 20 micron and PP 30 micron recording lower mould counts. At day 60, mould count ranged from 2.8×10^{-4}Cfu/g to 8.0×10^{-5}Cfu/g with PP 20

micron, PP 30 micron and PP 12.5 micron recording lower counts. An increase in the mould count could be due to increasing moisture content during storage. The difference in the level of mould load in all the ground pepper packed with different packaging materials could probably be due to the relative permeability of these materials to atmospheric gases such as oxygen, carbon dioxide and water vapour [26]. This increase was also reported by Adebowale *et al.* [18] in water yam flour stored with different packaging materials. Polypropylenes of thickness 12.5µ, 30µ and 20µ exhibited a better protection against mould attack thereby acting as an effective barrier and better packaging material for food shelf life.

Table 2. Effect of Packaging Materials on the mould count (Cfu/g) of ground pepper

	Storage Period (Days)		
Storage Materials	**0**	**30**	**60**
A	$3.0x10^{-3}$	$4.1x10^{-5}$	$5.0x10^{-5}$
B	$3.0x10^{-3}$	$4.3x10^{-5}$	$8.0x10^{-5}$
C	$3.0×10^{-3}$	$4.1x10^{-5}$	$7.0x10^{-5}$
D	$3.0x10^{-3}$	$3.8x10^{-5}$	$4.9x10^{-4}$
E	$3.0x10^{-3}$	$3.8x10^{-5}$	$2.8x10^{-4}$
F	$3.0x10^{-3}$	$3.9x10^{-4}$	$4.1x10^{-4}$

Mean values are outcome of duplicate determination.

Keys:
A = (PP3µ) Polypropylene 3 micron
B = (PP4µ) Polypropylene 4 micron
C = (PP5µ) Polypropylene 5 micron
D = (PP12.5µ) Polypropylene 12.5 micron
E = (PP20µ) Polypropylene 20 micron
F = (PP30µ) Polypropylene 30 micron

3.4 Effect of Packaging Materials on the Sensory Scores of Ground Pepper

The sensory attributes of colour, flavour and aroma on day 0 were 6.7, 7.30 and 7.35, respectively while pungency and overall acceptability of the ground pepper were 7.95 and 8.35, respectively as presented in Table 3. At 60 days of storage period, the colour of the pepper samples ranged from 6.55 - 7.40, flavour 6.0 - 7.65, aroma 6.80 - 7.60, pungency 7.2 - 8.05 and overall acceptability 7.25 - 7.80. There was no significant ($p>0.05$) difference in the overall acceptability of the stored pepper samples. PP 12.5µ was most preferred for colour, PP 20µ for aroma and overall acceptability while PP 30µ was most preferred for flavour and pungency. The changes observed in the sensory scores of the ground pepper in the different packaging material may be associated with the level of protection offered by the packaging materials such as permeability, absorption or migration properties of the polypropylenes and microbial action [27]. The findings are in close aggregation with that of Panda *et al.* [14]. The color of the pepper packaged with polypropylene of high thickness were most preferred than those of low thickness. This might be attributed to the characteristic feature of these films having a proper balance for the permeability of CO_2 O_2 and relative humidity.

Table 3. Effect of Packaging Materials on the sensory scores of ground pepper

	Colour		**Aroma**		**Flavour**		**Pungency**		**Overall Acceptability**	
	Storage Period (Days)									
Storage Materials	**0**	**60**	**0**	**60**	**0**	**60**	**0**	**60**	**0**	**60**
A	6.75^{a}	6.55^{b}	7.35^{a}	6.80^{d}	7.30^{a}	6.90^{b}	7.95^{a}	7.25^{b}	8.35^{a}	7.25^{a}
B	6.75^{a}	7.25^{ab}	7.35^{a}	7.00^{cd}	7.30^{a}	7.30^{a}	7.95^{a}	7.60^{ab}	8.35^{a}	7.30^{a}
C	6.75^{a}	6.90^{a}	7.35^{a}	7.20^{bcd}	7.30^{a}	7.45^{ab}	7.95^{a}	7.65^{ab}	8.35^{a}	7.45^{a}
D	6.75^{a}	7.40^{a}	7.35^{a}	7.30^{abc}	7.30^{a}	7.40^{ab}	7.95^{a}	7.65^{ab}	8.35^{a}	7.40^{a}
E	6.75^{a}	7.15^{ab}	7.35^{a}	7.60^{a}	7.30^{a}	7.15^{ab}	7.95^{a}	7.85^{ab}	8.35^{a}	7.15^{a}
F	6.75^{a}	7.30^{a}	7.35^{a}	7.50^{ab}	7.30^{a}	7.65^{a}	7.95^{a}	8.05^{a}	8.35^{a}	7.65^{a}

LSD	**0.00**	**0.60**	**0.00**	**0.46**	**0.00**	**0.65**	**0.00**	**0.77**	**0.00**	**0.77**

Values bearing different superscript within the same column differ significantly ($p<0.05$) at 5% level of probability, ± standard deviation of duplicate determination.

Keys:

A = (PP3µ) Polypropylene 3 micron
B = (PP4µ) Polypropylene 4 micron
C = (PP5µ) Polypropylene 5 micron
D = (PP12.5µ) Polypropylene 12.5 micron
E = (PP20µ) Polypropylene 20 micron
F = (PP30µ) Polypropylene 30 micron

4. CONCLUSION

The present study establish that pepper can be stored for a longer period and different packaging materials can help facilitate its storage and shelf life at room temperature. Polypropylene of thickness 30 micron and 20 micron attest to be the most effective measure in controlling the decrease observed in the proximate and carotenoid contents of the stored pepper samples, as well as efficient in reducing the microbial load of the stored ground pepper samples.

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