Original Research Article

PHYSICO-CHEMICAL QUALITY RESPONSES OF MANGO CHIPS DRIED TO DIFFERENT MOISTURE CONTENTS, PACKAGED AND STORED FOR SIX MONTHS

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ABSTRACT

Fresh mango is a delicate fruit with high perishability and postharvest losses. Dried fruits are highly susceptible to mold infection and moisture reabsorption, must be packed well and stored immediately after drying to extend its shelf life. This study was thus to determine the effect of packaging methods on the quality of mango chips dried to three moisture content and stored for six months at tropical ambient condition. Mango chips (10%, 15% and 20% moisture contents) obtained from FriutProtech Consortium, Kintampo, were packed in different packages and stored for 6 months in a 3×5 factorial in completely randomized design and replicated 3 times. Physico-chemical attributes were studied. Results revealed that mango chips at 10% moisture content, vacuum-packed in polypropylene and polyethylene were significantly different (p≤0.01), the driest, firmest and most crispy. They also were richest in vitamin c, high in pH, highest in TSS and but high TTA. Chips at 20% moisture content in plastic pack (clamshells) were lowest in most of the measured parameters. It can be concluded that, mango chips should be dried to, at most, 15% moisture content and vacuum-packaged in polypropylene or polyethylene if they are to maintain their quality and be stored for longer periods.

Keywords: [perishability, crispy, anitoxidants, hydrolysis, ripening. enzyme}

1. INTRODUCTION

Mango (*Mangifera indica* L.*)* fruit belongs to the family of Anacardiaceae and is grown in many parts of the world, particularly in tropical countries. According to [1], mango fruit has been reported the 2nd position as a tropical crop, behind only bananas in terms of production and acreage used. It has been well indicated that mango fruits are highly nutritious. [2], indicated that mangoes are essential to human growth, development and health. Mangoes form a 50 per cent share of all the tropical fruits produced worldwide. Within the horticultural sector, mango cultivation can easily become a major foreign exchange earner if well developed and provided with the necessary logistics and support.

Due to high postharvest losses of fruits and vegetables, there is the need to process and preserve perishable fruits during bumper harvest to make them available throughout the year in a value-added form. Dehydrated mango fruits slices could be processed from the glut by individuals or farmer-groups to address the vitamin A and C problems experienced in certain part of the country. According to [3] vitamin A deficiency is a major public health problem in Ghana especially in the northern part of the country in children under 5 years of age. [4], reported that mango fruit is climacteric with a high rate of perishability and after harvesting at ambient conditions reaches the peak of its ripening process on the third (3rd) to fourth (4th) day. According to [5], the longevity is between four to eight days at room storage (130^{0}C). [6] also reported that the fruit is highly sensitive to decay, low temperature and its perishability caused by rapid ripening and softening reduce the storage, handling and transport potential. Mango fruits have been processed into chips and other forms to extend the shelf-life and improve its commercial potentials through value-addition. Dried fruits are highly susceptible to mold infection and moisture reabsorption and must be well- packaged and stored immediately after drying to maintain its quality [7]. The type of packaging material used has been reported to have effect on nutrient content during storage [8]. Packaging is an inevitable component of food processing, for assuring the safe handling and delivery of fresh and processed agricultural products from producer to the consumer [9]. It is therefore important to assess the packaging method to ascertain their performance in ensuring product quality during storage. Postharvest management is essential for extending the consumption period of fruits, for regulating their supply to the market and for transporting them over long distances. The objective of the study was to determine the effect of packaging methods (sealed polyethylene, vacuumed polyethylene, sealed polypropylene, vacuumed polypropylene and plastic pack-clamshell) on the physico-chemical properties of mango chips dried to three different moisture contents (10%, 15% and 20%) and stored for six (6) months at tropical ambient temperature.

2.0 MATERIALS AND METHODS

2.1 STUDY SITE

The study was conducted at the laboratories of the Department of Horticulture, Faculty of Agriculture, and the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

2.2 EXPERIMENTAL MATERIAL

The following materials were used in the experiment: dried mango chips at three different moisture contents (10%, 15% and 20%), five different packaging methods [sealed polyethylene (0.085mm thick) (PolyEthyseal), vacuumed polyethylene (0.085mm thick) (PolyEthyvac), sealed polypropylene (0.055mm thick) (PolyPropseal), vacuumed polypropylene (0.055mm thick) (PolyPropvac) and plastic pack (clamshell) (PP)], vacuum machine, sealer, a pair of scissors, top-loading electronic balance.

2.3 SOURCE OF MANGO CHIPS AND PRODUCTION

The mango chips were obtained from the FriutProtech Consortium at Kintampo.

2.3.1 Mango Chips Production

Keitt variety of mango fruits at a stage of fully ripe were weighed and washed thoroughly under running water after which they were reweighed. The mango fruits were then peeled using a sharp knife and cut into two equal halves and the seeds removed. The pulp was then cut into slices (approximately 0.5cm thick) and dried in a solar-LPG hybrid oven at between 65^0C- 70^0C for at most 8 hours. Moisture contents of mango chips were tested periodically to ensure that the three moistures (10%, 15% and 20%) were achieved.

Plate 1: Bulk mango chips at different moisture contents packaged at FruitProtech consortium, Kintampo before being sent to the laboratory for further studies.

2.4. SAMPLE PREPARATION

Forty (40) grams each of dried mango chips (10%, 15% and 20%) were weighed into each of the five different packaging methods [sealed polyethylene (0.085mm thick) (PolyEthyseal), vacuumed polyethylene (0.085mm thick) (PolyEthyvac), sealed polypropylene (0.055mm thick) (PolyPropseal), vacuumed polypropylene (0.055mm thick) (PolyPropvac) and plastic pack (clamshell) (Plasticpack)], stored and observed for six (6) months under tropical ambient conditions (27^0C temperature at 70% relative humidity).

Plate 2: Vacuuming of packaged mango chips in vacuum machine.

Plate 3: Differently processed, packaged and labeled mango chips stored at ambient conditions (L-R: sealed polyethylene (0.085mm thick) (PolyEthyseal), vacuumed polyethylene (0.085mm thick) (PolyEthyvac), sealed polypropylene (0.055mm thick) (PolyPropseal), vacuumed polypropylene (0.055mm thick) (PolyPropvac) and plastic (clamshell) pack (PLASTICPACK)).

2.5 EXPERIMENTAL DESIGN

A 3×5 Factorial Completely Randomized Design (CRD) was used in the experiment. The three-different moisture content (10%, 15% and 20%) against five packaging methods [sealed polyethylene (0.085mm thick) (PolyEthyseal), vacuumed polyethylene (0.085mm thick) (PolyEthyvac), sealed polypropylene (0.055mm thick) (PolyPropseal), vacuumed polypropylene (0.055mm thick) (PolyPropvac) and plastic pack (clamshell) (PLASTICPACK)]. Each treatment was replicated three times

2.6. PHYSICO-CHEMICAL PROPERTIES OF MANGO CHIPS DETERMINED.

2.6.1 Determination of moisture content (%)

Moisture content was determined by following the procedures of AOAC, 2005 [10].

2.6.2 Firmness determination (N)

Pieces of mango chips of each treatment were tested using a type-C digital durometer (LX-C durometer, China) and readings recorded initially and subsequently, monthly.

2.6.3 Vitamin C determination

Vitamin C was determined by following the procedures of AOAC, 2005 [10].

2.6.4 pH determination

Five grams of blended oven dried sample was weighed into a 50ml beaker. Twenty-five (25) ml of distilled water was added and stirred vigorously for 20 minutes. Sample water suspension was allowed to stand for 30 minutes by which time most of the suspended ions would have settled out from the suspension. A pH meter-ELICO (L1617) was calibrated blank at pH of 7 and 4 respectively. The electrode of the pH meter was inserted into the partly settled suspension. The pH value was read from the pH meter and recorded.

2.6.5 Total titratable acid determination

TTA was determined by following the procedures of AOAC, 2005 [10].

2.6.6 Total soluble solids (^{o}Brix) determination

The total soluble solid was determined by using HANNA refractometer (HI9680). Before determining the sugar content, the refractometer was first calibrated using 25% sucrose solution and distilled water. A 10ul of the prepared sample solution was placed on the prism surface of the refractometer. The reading on the prism scale was noted and recorded to one decimal in degree Brix [11].

3.0 RESULTS

3.1 Changes in moisture content during storage

There was significant difference (P≤ 0.01) between the moisture content over the storage period. Moisture reduced consistently over the storage period except for month five (5) where 15% moisture content increased and decrease the following month (Figure 1).

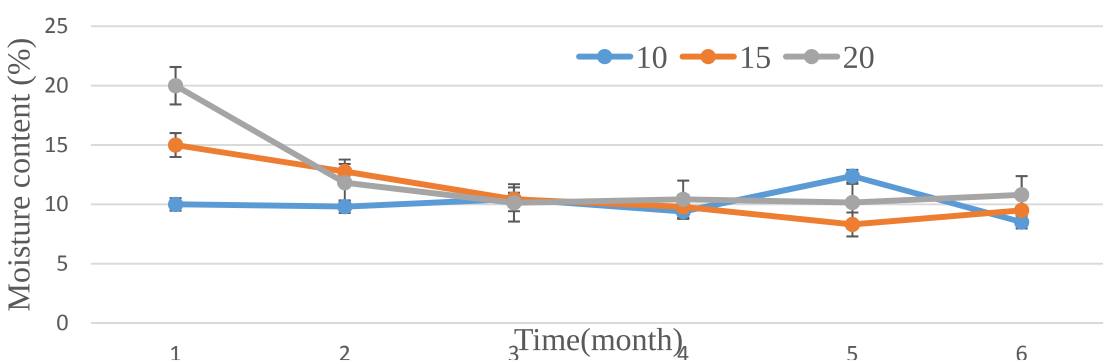

Figure 1: Changes in moisture content of mango chips (10%, 15% and 20% moisture contents) during a six (6) months storage period

There was significant difference (P≤ 0.01) between different packaging methods on mango chips during storage period. Moisture content was reduced by PolyEthyvac throughout the storage period (Figure 2)

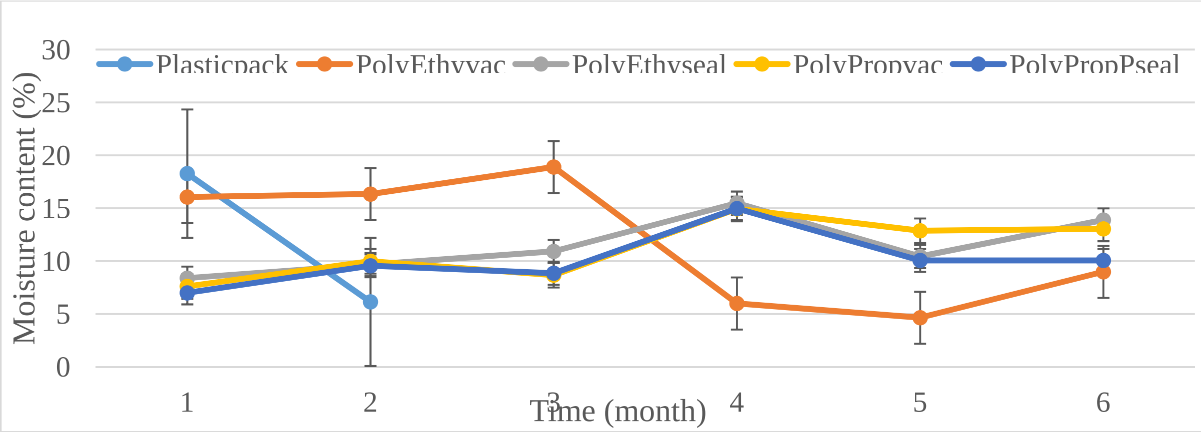

Figure 2: Moisture content of mango chips in different packages during a six (6) months storage period.

There were significant difference in (P≤ 0.01) moisture content and different packaging methods interaction for changes in moisture during six (6) months storage period (Table 1). Mango chips processed at 10% moisture content and packaged using Polyethylene vacuum recorded the highest (13.76) moisture content and the least (3.27) was recorded by mango chips processed at 20% moisture content and packaged using plastic pack (clamshell). Across the different packaging methods, Polyethylene vacuum recorded the highest (12.79) and plastic pack (clamshell) recorded the least (4.89) moisture. Across the moisture content, highest (10.53) moisture content was recorded at 20% moisture content and the least (9.47) was recorded by moisture content at 10%.

Table 1: Means of moisture content (%) of mango chips dried to different moisture content and packaged differently using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	Plastic$_{pack}$	PolyProp$_{seal}$	PolyProp$_{vac}$	PolyEthy$_{seal}$	PolyEthy$_{vac}$	Means
10	3.27^{j*}	8.52^{h}	11.05^{def}	10.77^{efg}	7.46^{i}	8.21^{b}
15	3.93^{j}	10.52^{fg}	11.38^{cde}	10.17^{g}	12.79^{b}	9.76^{b}
20	13.76^{a}	11.24^{cdef}	10.02^{g}	12.09^{c}	11.82^{cd}	11.81^{a}
Mean	6.99^{d}	10.09^{c}	10.82^{b}	10.98^{a}	10.69^{b}	

CV=2.21 HSD(0.01) mc=0.25 pm=0.37 mc*pm=0.77

*Means followed by the same letter are not significantly different at p=0.01

3.2 Changes in firmness during storage

There was significant difference (P≤ 0.01) between firmness and moisture content from month one to month four (Figure 3). Mango chips processes at 10% moisture content recorded the highest firmness and moisture content at 20% recorded the least. In month five and month six, moisture content at 10% recorded the highest firmness and the least, moisture content at 15%.

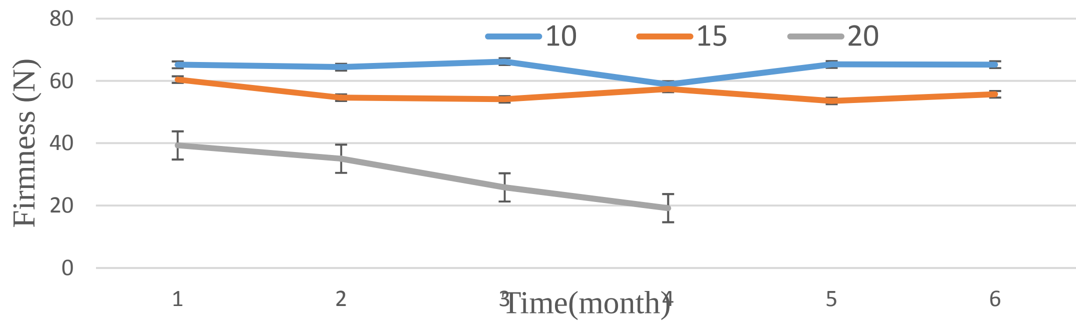

Figure 3: Firmness of mango chips processed at three moisture content over six (6) months storage period.

There was significant difference ($P \leq 0.01$) between Firmness and the different packaging methods (Figure 4). Vacuum packaging increases hardness hence scored highest firmness while Polyethylene seal packaging recorded least for firmness throughout storage periods except for month five (5) where plastic pack (clamshell) recorded the highest (43.61) firmness and Polyethylene seal (33.78) recorded the least firmness.

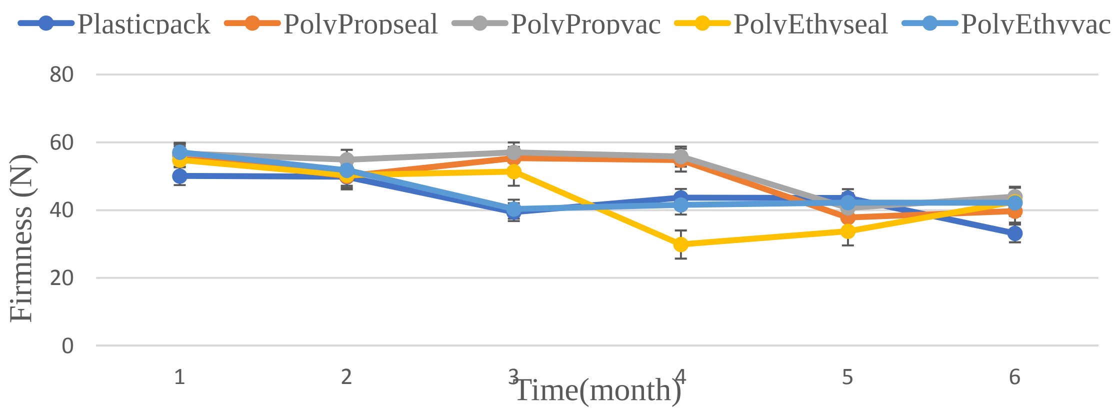

Figure 4: Firmness of mango chips in different packages stored over storage period.

There were significant ($P \leq 0.01$) moisture content and different packaging methods interaction for Firmness during six (6) months storage period (Table 2). Mango chips processed at 10% moisture content and packaged using Polypropylene vacuum recorded the highest (12.67) firmness and the least (1.73) was recorded by mango chips processed at 20% moisture content and packaged using Polyethylene vacuum. Across the different packaging methods, Polypropylene vacuum recorded the highest (9.38) and plastic pack (clamshell) recorded the least (7.89) firmness. Across the moisture content, highest (11.67) firmness was recorded at 10% moisture content and the least (3.63) was recorded by moisture content at 20%.

Table 2: Means of Firmness (N) of mango chips dried to different moisture content and packaged differently using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	$Plastic_{pack}$	$PolyProp_{seal}$	$PolyProp_{vac}$	$PolyEthy_{seal}$	$PolyEthy_{vac}$	Means
10	11.77^{b*}	11.23^{d}	12.67^{a}	11.20^{d}	11.50^{c}	11.67^{a}
15	9.70^{f}	9.77^{f}	10.17^{e}	9.50^{g}	11.77^{b}	10.18^{b}
20	2.20^{k}	5.70^{h}	5.30^{i}	3.20^{j}	1.73^{l}	3.63^{c}
Mean	7.89^{d}	8.90^{b}	9.38a	7.97^{d}	8.33^{c}	
CV =0.63	HSD (0.01)	mc=0.06	pm=0.90	mc*pm=0.19		

*Means followed by the same letter are not significantly different at p=0.01

3.3 Vitamin C (mg/100ml) content during the storage period.

There were no significant differences in the Vitamin C content for mango chips processed at moisture content level in the early months of storage (Figure 5.). Meanwhile, in month four, mango chips processed at 10% moisture content had the highest vitamin c (3.48) and moisture content at 20% recorded the least (2.62). Mango chips processed at (10%) moisture content, maintained a higher vitamin C content while moisture content at 20% lost vitamin C content considerably throughout the storage period.

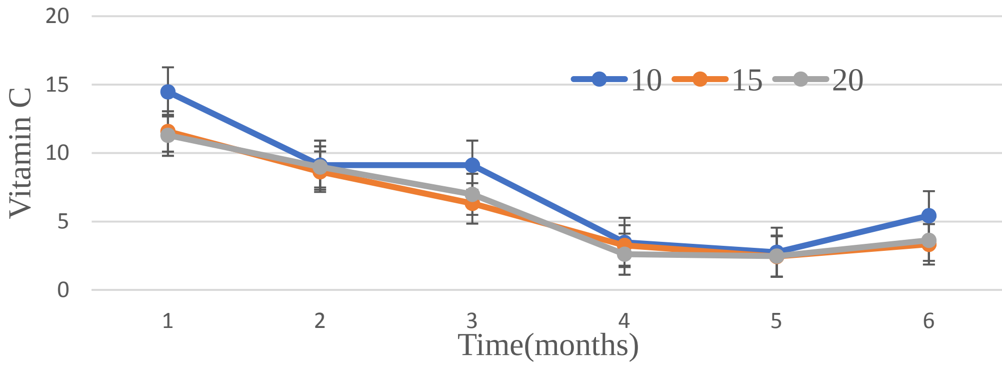

Figure 5: Vitamin C content of mango chips processed at three moisture content over storage period.

There were significant differences ($P \leq 0.01$) Vitamin C content between the different packaging methods during storage (Figure 6). Polyethylene vacuum recorded the highest vitamin c (9.70) and Polypropylene vacuum recorded the least (5.20) in month one. In subsequent months, vitamin c reduced with time yet mango chips packaged in Polyethylene seal packaging methods recorded the highest vitamin c (7.30) compared to Polyethylene vacuum which recorded the least (2.86) in the final month.

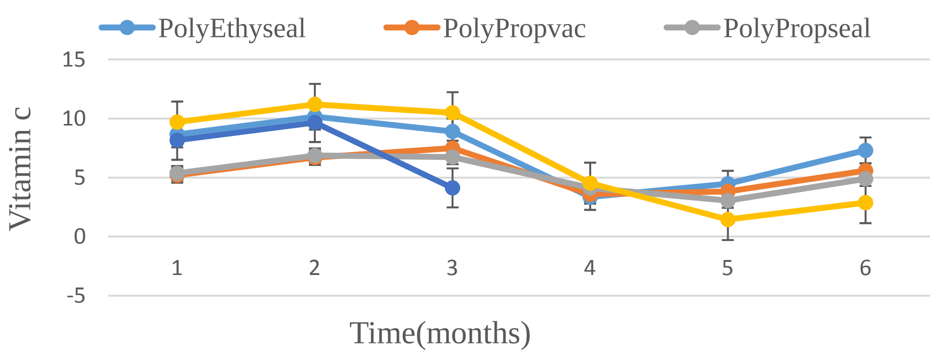

Figure 6: Vitamin C content of mango chips in different packages stored over storage period.

There were significant ($P \leq 0.01$) packaging methods and moisture content interaction for Vitamin C during six (6) months of storage (Table 3). Highest Vitamin C (8.61) was indicated by mango chips processed at 10% moisture content and packaged using Polyethylene vacuum. The least (1.67) was recorded by mango chips proceeded at 20% moisture content and packaged using plastic pack (clamshell). Across the moisture content, moisture content at 10% recorded the highest (6.00) and moisture content at 15% recorded the least (4.81). Across the different packaging method, Polyethylene seal recorded the highest (6.80) and plastic pack (clamshell) recorded the least (2.76).

Table 3: Means of Vitamin c (mg/100ml) of mango chips dried to different moisture content and packaged using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	$Plastic_{pack}$	$PolyProp_{seal}$	$PolyProp_{vac}$	$PolyEthy_{seal}$	$PolyEthy_{vac}$	Means
	4.31^{de*}	5.16^{cd}	5.36^{c}	6.56^{b}	8.61^{a}	6.00^{a}

10						
15	2.30^{f}	5.41^{c}	5.43^{c}	6.74^{b}	4.15^{e}	4.81^{b}
20	1.67^{f}	4.83^{cde}	5.53^{c}	7.11^{b}	5.57^{c}	4.94^{b}
Mean	2.76^{d}	5.13^{c}	5.44^{c}	6.80^{a}	6.11b	
CV =5.30 HSD (0.01).		mc=0.32	pm=0.47	mc*pm=1.0		

*Means followed by the same letter are not significantly different at p=0.01

3.4 Acidity (pH) of mango chips during storage.

There were no significant differences in pH for mango chips processed at different moisture content) during storage (Figure 7). Mango chips processed at 10% moisture content recorded highest pH (3.70) while mango chips processed at 20% moisture content increased with time and recorded least pH (2.77) at the later stage of storage.

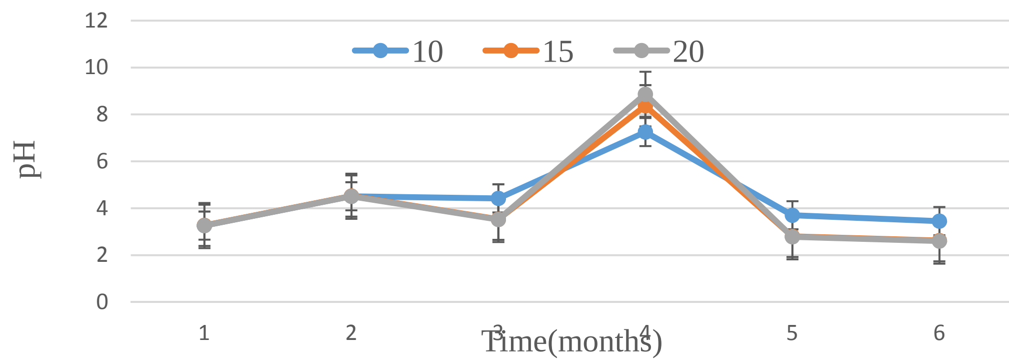

Figure 7: pH of mango chips processed at three moisture content over storage period.

There were significant differences (P≤ 0.01) between the packaging methods over the storage period (Figure 8). Mango chips packaged using Polypropylene seal recorded the highest (3.33) pH and the least (3.22) was recorded by mango chips packaged using Polypropylene vacuum at the initial stage of storage. Meanwhile in the final month of storage, Polyethylene seal packaging method recorded the highest pH (4.38) and Polyethylene vacuum recorded the least (1.45)

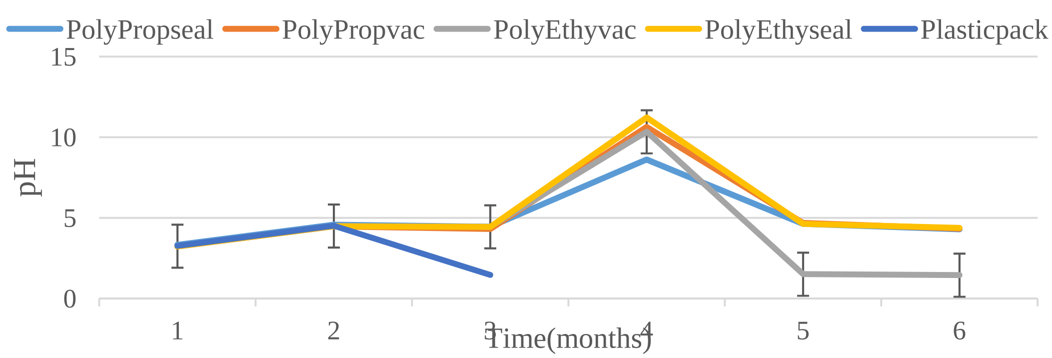

Figure 8: pH of mango chips in different packages stored over storage period.

There were significant (P≤ 0.01) moisture content and different packaging methods interaction for acidity (pH) during six (6) months of storage (Table 4). Mango chips processed at 20% moisture content and packaged using Polyethylene seal recorded the highest (5.93) pH and the least (0.89) was recorded by mango chips processed at 20% moisture content and package using plastic pack (clamshell). Across the packaging methods, highest (5.83) pH was recorded by mango chips packaged using Polyethylene seal and the least (1.19) was recorded by the plastic pack (clamshell) packaging method. Across the moisture, highest (4.67) pH between the moisture content was recorded at 10% and the least (4.36) at 15%.

Table 4: pH of mango chips dried to different moisture content and packaged using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	$Plastic_{pack}$	$PolyProp_{seal}$	$PolyProp_{vac}$	$PolyEthy_{seal}$	$PolyEthy_{vac}$	Means
10	1.78^{g*}	4.47^{e}	5.51^{d}	5.72^{bc}	5.85^{ab}	4.67^{a}
15	0.91^{h}	5.77^{abc}	5.63^{cd}	5.83^{ab}	3.69^{f}	4.36^{c}
20	0.89^{h}	5.70^{bc}	5.92^{a}	5.93^{a}	3.81^{f}	4.45^{b}
Mean	1.19^{e}	5.31^{c}	5.69^{b}	5.83^{a}	4.45^{d}	

CV =1.18 HSD (0.01). mc=0.06 pm=0.09 mc*pm=0.19

*Means followed by the same letter are not significantly different at p=0.01

3.5 Total Titratable Acid (TTA) Content During Six (6) Storage Periods.

There were no significant differences (P≤ 0.01) in total titratable acid for mango chips at different moisture content during six (6) months of storage (Figure 9). Mango chips processed at 20% moisture content recorded highest (0.29) total titratable acid and lowest total titratable acid (0.11) of chips were recorded by moisture content at 15%. At the sixth (6) month of storage, mango chips processed at 10% and 15% moisture content recorded the highest total titratable acid (0.11) while mango chips processed at 20% moisture content recorded the least total titratable acid (0.08).

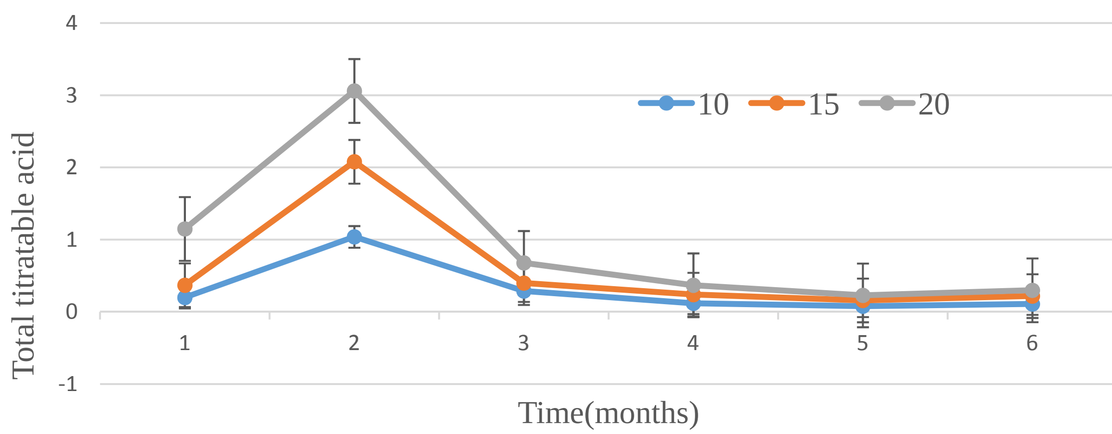

Figure 9: Total titratable acid of mango chips processed at three moisture content over storage period.

There was significant difference (P≤ 0.01) in total titratable acid for mango chips packaged at different packaging methods during storage (Figure 10). Plastic pack (clamshell) recorded the highest total titratable acid (1.10) and Polyethylene seal recorded the least (0.67) at the beginning of storage. Polyethylene seal recorded the highest (0.14) total titratable acid and Polyethylene vacuum recorded the least (0.05) in the last month.

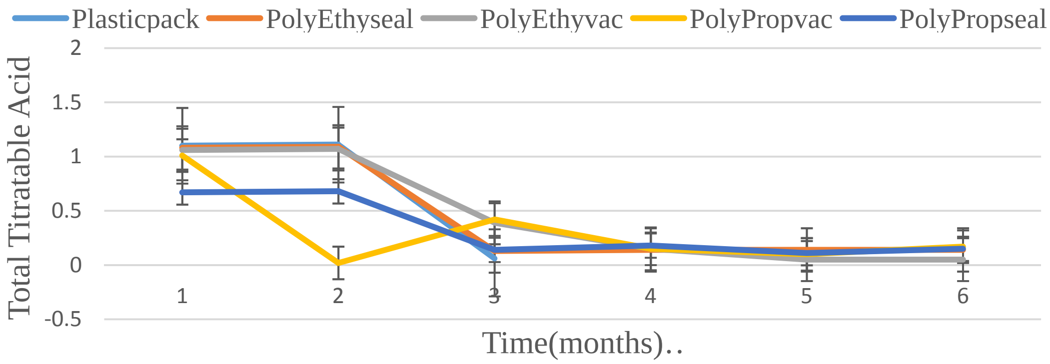

Figure 10: Total titratable acid content of mango chips in different packages stored over storage period.

There were significant (P≤ 0.01) moisture content and different packaging method interaction for Total titratable acidity over the six (6) storage period (Table 5). Highest total titratable acid (0.53) was recorded by mango chips processed at 10% moisture content and packaged using Polyethylene vacuum. The least (0.14) was recorded by mango chips processed at 10% moisture content and packaged using Polypropylene seal. Across the moisture content, moisture content at 10% recorded the highest (0.32) total titratable acid and the least (0.29) by 15% moisture content. Across packaging method, highest (0.37) total titratable acid was recorded by Polypropylene vacuum. The least (0.23) was recorded by plastic pack (clamshell).

Table 5: Means of Total titratable acid (%) of mango chips dried to different moisture content and packaged using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	$Plastic_{pack}$	$PolyProp_{seal}$	$PolyProp_{vac}$	$PolyEthy_{seal}$	$PolyEthy_{vac}$	Means
10	0.27^{de*}	0.14^{f}	0.32^{cd}	0.32^{cd}	0.53^{a}	0.32^{a}
15	0.19^{f}	0.34^{c}	0.34^{c}	0.34^{c}	0.25^{e}	0.29^{b}
20	0.24^{e}	0.28^{de}	0.46^{b}	0.32^{cd}	0.25^{e}	0.31^{a}
Mean	0.23^{c}	0.25^{c}	0.37^{a}	0.33^{b}	0.34^{b}	

CV =5.19 HSD (0.01). mc=0.2 pm=0.3 mc*pm=0.06

*Means followed by the same letter are not significantly different at p=0.01

3.6 Total soluble solids (^{o}Brix) during storage period.

There were significant differences in Total soluble solids for mango chips processed at different moisture content over the storage period (Figure 11). Mango chips processed at 15% moisture content recorded highest total soluble solids (11.77) and mango chips processed at 10% moisture content recorded lowest total soluble solids (9.47) in the initial stage of storage. Total soluble solids reduced at the later stage of storage. Processed chips at 10% moisture content recorded highest total soluble solids (9.53) and mango chips processed at 20% moisture content recorded least (6.93)

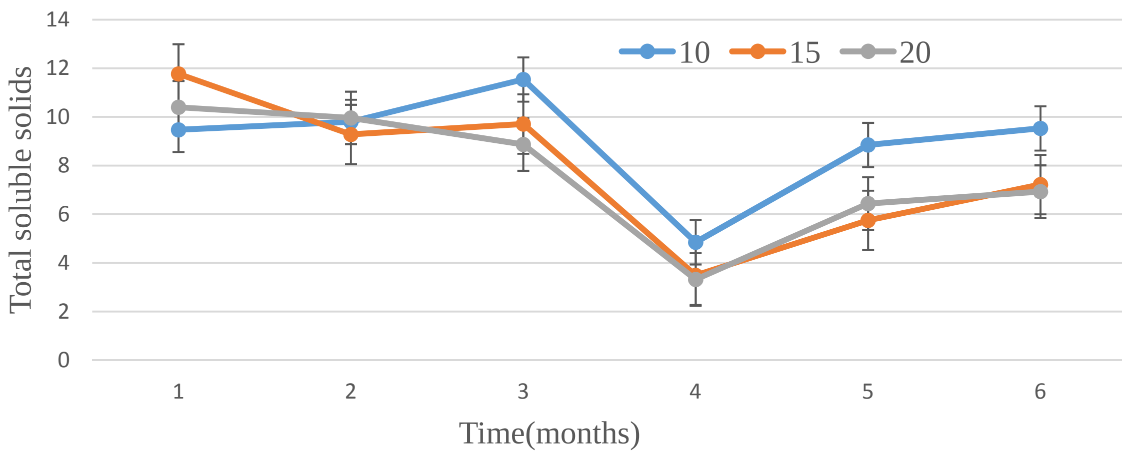

Figure 11: Total soluble solids of mango chips processed at three moisture content over storage period.

Total soluble solids of Mango chips packaged using different packaging methods declined and increased during storage (Figure 12). Polyethylene seal packaging method lost the highest (12.29) total soluble solids to Polypropylene seal in month six (6) yet Polyethylene vacuum maintained the least (4.19) total soluble solid.

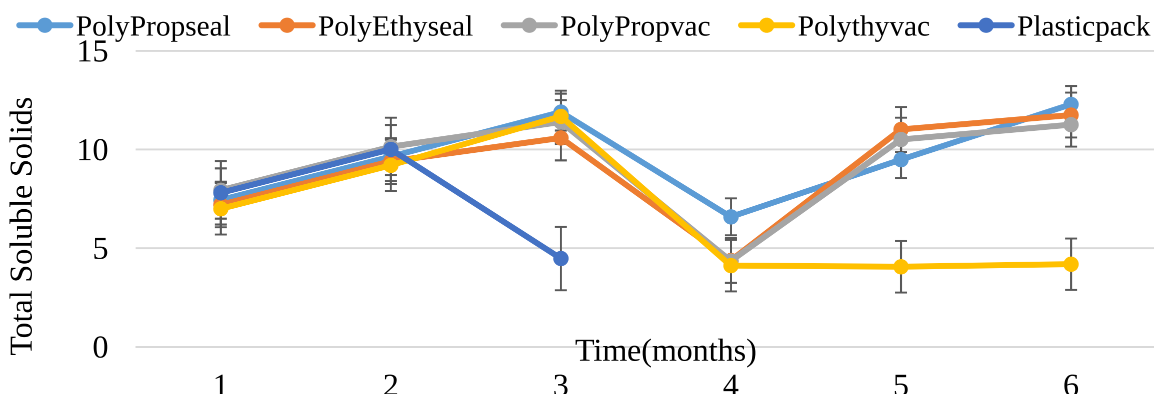

Figure 12: Total soluble solids content of mango chips in different packages stored over storage period.

There were significant (P≤ 0.01) packaging methods and moisture content interaction for Total soluble solids during six (6) months storage (Table 6). Highest total soluble solids (10.86) were recorded by mango chips processed at 10% moisture content and packaged using Polypropylene seal. The least (1.87) was recorded by mango chips processed at 20% moisture content and packaged using plastic pack (clamshell). Across the different packaging methods, highest (9.98) total soluble solids was recorded by Polypropylene seal and the least (2.96) by plastic pack (clamshell). Across the moisture content, processed mango chips at 10% moisture content recorded the highest (8.91) total soluble solids and least (7.09) by moisture content at 20%.

Table 6: Means of Total soluble solids (^{o} Brix) of mango chips dried to different moisture content and packaged using different methods and stored for six (6) months.

Moisture content of chips (%)	Packaging Methods					
	$Plastic_{pack}$	$PolyProp_{seal}$	$PolyProp_{vac}$	$PolyEthy_{seal}$	$PolyEthy_{vac}$	Means
10	4.97^{h*}	10.86^{a}	9.98^{bc}	9.03^{g}	9.73^{cd}	8.91^{a}
15	2.05^{i}	9.73^{cd}	9.52^{de}	$9.18f^{g}$	4.98^{h}	7.13^{b}
	1.87^{i}	9.35^{ef}	9.09^{fg}	10.07^{b}	5.24^{h}	7.09^{b}

20					
Means	2.96^{d}	9.98^{a}	9.53^{b}	9.43^{b}	6.65^{c}
CV =0.19 HSD (0.01).		mc=0.09	pm=0.14	mc*pm=0.29	

*Means followed by the same letter are not significantly different at p=0.01

4.0 DISCUSSIONS

4.1 Moisture content

There were significant (P≤ 0.01) moisture content and different packaging methods interaction on changes in moisture during six (6) months storage period. This result illustrated a general decrease in moisture over the storage period. Also, different packaging method, had a significant effect on the moisture content of mango chip due to the fact that, packaging method had a moisture reabsorption barrier properties (PolyEthyvac). According to [12], dried products absorb moisture from its surrounding which increases moisture content, decreasing shelf-life. Deterioration and chemical reactions could be higher in plastic pack (clamshell) with higher moisture content (20%) due to the proliferation characteristics of the packaging method during storage time [12].

4.2 Firmness

Low moisture content (10%) makes the chips quite brittle and crispy whiles the higher moisture (20%) renders it flabby. Mango chips processed at 10% moisture content and packaged using polypropylene vacuum recorded the highest firmness and the least was recorded by mango chips processed at 20% moisture content and packaged using polyethylene vacuum. This suggests that moisture content at which the chips were processed had significant impact on firmness. According to [13], firmness is the result of complex interactions among food components at micro- and macro-structural levels. Again, [14] indicated that during drying of fruits and vegetables, several changes in texture and firmness are common (e.g.; hardness, cohesiveness, springiness and chewiness). The results of the present study corroborate their findings.

4.3 Vitamin C content during the storage period.

Results indicated that vitamin C content reduced when chips were processed at 20% moisture content and packaged using plastic pack (clamshell) whiles those processed at 10% moisture content and packaged a using polyethylene vacuum increased. Furthermore, higher reduction in Vitamin C content occurred when storage duration increased. This could be due to the fact that the vacuum polyethylene methods prevented exchange of gases between the dried chips at 10% moisture content and the storage environment. However, for the plastic pack (clamshell), there was a possibility of gas exchange between the chips and the environment which enhanced rapid oxidation of abundant Vitamin C leading to its breakdown. Oxidation becomes faster when dried products absorb moisture at higher temperature. According to [15] oxidation causes the disruption of the cell membrane leading to the release of membrane bound phytochemicals. The presence of oxygen could also initiate the conversion of vitamin C to dehydroascorbic acid and other oxidized products. [16] indicated that light has a significant influence on the stability of vitamin C during storage. This could also be a contributory factor for the loss in vitamin C in the plastic pack (clamshell). The results of the present study agree with findings of) [17] who reported that the degradation rate of ascorbic acid (Vitamin C) of dried tomato pulp increased with high temperature, longer storage period and higher moisture content. Reduction in the vitamin C could be attributed to the fact that, increasing moisture content increases water activity a condition suitable for oxidative degradation of vitamins C as noted by (1995) [18] and [8]. Vitamin C is sensitive to air, light and heat.

4.4 pH during the storage period.

Results showed that pH of dried mango chips processed at 20% moisture content and stored in Polyethylene seal was the highest and the least was least was recorded by mango chips processed at 20% moisture content and packaged using plastic pack (clamshell) probably due to the effect of organisms responsible for the spoilage, some of which can release basic substances into the samples. This corroborates with the work of [19] who reported that certain organism were responsible for spoilage by releasing basic substances into food products. The plastic pack (clamshell) undoubtedly enhanced rapid absorption of moisture by the chips creating a conducive environment for microorganisms to proliferate. Furthermore, [20] also explained that the pH values of vegetables and fruits being weakly acidic allow growth of certain microorganisms. The food acidity (pH) is an important parameter in food. Food acidity not only affects flavor but also the growth and survival of bacteria and other microorganism in foods. Water ionizes as temperature rises, so hydrogen ion concentration rises which means that pH decreases.

4.5 Total titratable acidity during the storage period.

Titratable acidity gives a measure of the amount of acid present in a fruit [21]. Major acid in mango is known to be caused by Citric acid [22]. The decline in acidity by mango chips processed at 10% moisture content and packaged using polypropylene seal was probably due to [23]. Again, the reduction in acidity in ripening process was as a result of starch hydrolysis which led to a rise in total sugars and a decline in acidity as opined by [24]. Chips produced in this study had reduced sourness with potential taste improvement as a result of decreased acidity.

4.6 Total soluble solids during the storage period.

Highest total soluble solids were recorded by mango chips processed at 10% moisture content and packaged using Polypropylene seal. The least was recorded by mango chips processed at 20% moisture content and packaged using plastic pack (clamshell). This could be due to the oxidation of dried mango chips kept in plastic pack (clamshell) and processed at 20% which possibly absorbed moisture from its environment thereby increasing the breakdown or hydrolysis of sugars. As the storage time increased this rate of sugar hydrolysis was also increased thereby reducing the available sugars in the product. A study done by [25], showed that mango pulps are mainly made up of fructose, with about 30% sucrose and 20% glucose. In addition, sucrose is known to be the major sugar in mango [26]. The high increase in total soluble solids during ripening is reported to be the major cause of significant increase in the amount of sucrose. This could probably due to the conversion of starch to soluble sugars as the carbohydrates in the fruit are broken down into simple sugars with the action of phosphorylase enzyme during ripening [27]. Conversely, the amylase enzyme is closely associated with hydrolysis of starch in the ripening of mango fruit. The extent of sweetening was due to the increase in total soluble solids during ripening [28].

COMPETING INTERESTS

"Authors have declared that no competing interests exist.".

5.0 CONCLUSION

The study revealed that mango chips processed at 10% moisture content and vacuum packaged using polypropylene were and recommended drier, firm and crispy during the storage period. For vitamin C, mango chips processed at 10% moisture content and vacuum packaged using polyethylene had the highest vitamin C content while mango chips processed at 20% moisture content and packaged using plastic pack (clamshell) had the least. Mango chips processed at 20% moisture content and packaged in plastic pack (clamshell) had the least pH and mango chips processed at 20% moisture content and seal packaged using polyethylene recorded the least. Mango chips processed at 10% moisture content and packaged in polypropylene sealed had the highest total soluble solids while mango chips processed at 20% moisture content and packaged using plastic pack (clamshell) had the least. Total titratable acid of mango chips processed at 10% moisture content and packaged in polypropylene seal had the lowest and highest recorded by 10% vacuumed in polyethylene.

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