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p. 123-136

Quality Changes in Dried Tomatoes Stored in Sealed Polythene and Open Storage Systems

Peter Aba IDAH, Bosede Adelola ADERIBIGBE

Dept of Agricultural Engineering, Federal University of Technology, P.M.B. 65 Minna Niger State, Nigeria
pabaidah@yahoo.co.uk, bibiorhevba@yahoo.co.uk

Abstract

Studies were conducted to quantify the changes in quality attributes of dried tomatoes during storage using High Density Polythene Film (HDPF) and normal (traditional) open storage systems. 300g of the dried tomato fruits were packaged in each of the six (6) high-density polythene film (HDPF) bags while similar quantities were in open bowls as practiced by the rural processors. Periodic assessment of some quality parameters, microbial loads, moisture content, color, vitamins A and C, and phosphorus were conducted for a period of three months to ascertain how these two storage systems influence the changes in these quality attributes. The results showed that the fungal load counts of the dried samples prior to storage were 3.6·103 cfu/g. After three months of storage, the counts were 5.4·103 cfu/g and 7.2·103 cfu/g for the samples stored in HDPF and open systems respectively. These were significantly different at 5% level of confidence. Vitamin A of the samples changed from the initial value 134μg prior to storage to 98 μg and 103.4 μg after three months of storage in open and HDPF systems respectively. Vitamin C content changed from 5.21 mg/ 100g prior to storage to 3.69 mg/100g and 4.24 mg/100g in the samples stored in open and HDPF systems respectively after three months. The moisture content of the dried sample prior to storage was 4.2%. After three months of storage, the values were 7.13% and 3.93% respectively for samples stored in open and HDPF systems and these were highly significant at 5% level of confidence. The HDPF method gave better results compared to the traditional method of storage in Nigeria as far as these quality parameters assessed are concerned.

Keywords
Dried tomatoes, Quality, Sealed- Polythene film, Open-storage

Introduction

Vegetables, particularly tomatoes are of great importance in human nutrition as they supply essential vitamins and minerals (which are necessary to maintain good health) to the diet, provide variety to the food and make food appetizing. Unfortunately, they are not only seasonal but highly perishable and deteriorate very fast few days after harvest, losing almost all their required quality attributes and some could likely result to total waste. It has been shown that as high as 50% of these produce are lost between rural production and town consumption in the tropical areas (Oyeniran, 1988). Studies have also recorded that 20 to 40 % of harvested vegetables are not eaten because they are made unavailable through some forms of spoilage (Anne,et al 1968).

It is estimated that 45 million tones of tomatoes are produced each year from 2.2 million hectares excluding the large amount grown in home gardens (Villareal, 1980). In Nigeria, figures like 6 million tones of tomatoes have been given as annual production level (Oyeniran, 1988). Little considerations and attention are however, given to preservation aspect of this important agricultural produce in Nigeria. The increase in the production of these vegetables usually results in gluts at harvest time and very low price, while few months after, scarcity sets in resulting in high prices.

One major means of preserving tomato fruit is by drying. Drying is one of the oldest techniques of preserving agricultural products. Drying as a process for food conservation and preservation seems to be an adequate method under most conditions in the developing economies (Ali and Sakr, 1981). New drying techniques had increased demand for dried foods than in the past due to improved quality and researchers are of the opinion that if more attention is given to food quality during drying, there would even be more significant boost to its demand (McCarthy, 1986).

Kordylas (1990) revealed that food processing, (in particular; drying) is essential to human civilization because it provides advantages in respect of food hygiene, distribution and storage. A study also revealed that dehydrated products have advantages over other forms of preserved foods in that they are easily packaged and stored at ambient temperature conditions. (Holdsworth, 1971).

It is also noted that a good drying method must be followed by a good storage method if the quality attributes are to be maintained (Anon, 1997). At present, majority of the rural populace (especially women) are engaged in vegetable drying particularly tomatoes. However, the dried products are hardly packaged before storage. The products are thus exposed to the open air thereby predisposing them to further contamination and subsequent deterioration.

It is revealed that the shelf life of a packaged food is controlled by the physical characteristics of the products such as water activity, pH value, susceptibility to enzymatic or microbial deterioration, mechanism of spoilage, requirement for sensitivity to oxygen, light, carbon dioxide and moisture (Fennema and Tannencbaum, 1985). Moisture loss or uptake is one of the most important factors that control shelf life of foods. There is a microclimate within a package, which is determined by the food at the temperature of storage. Ability of packaging material to retain food sensory characteristics and properties throughout the storage period cannot be under stressed in the choice of any material to package a type of food (Williams, 1981). Williams (1982) stated that a number of factors determine a good and effective packaging of dried food products. Food safety is related to packaging in two ways: (Robertson, 1993),

The packaging material must provide a suitable barrier around the food to prevent microorganisms from contaminating the food

Such material must not contain toxic substances that make the food unsafe.

Rozis (1997) noted that the choice of packaging material depends on several factors such as the kind of foodstuff, the storage conditions, the material's protective qualities and the materials availability and cost. Polythene films are good materials widely used in packaging due to their relatively low cost, good moisture and gas barrier properties. They are either described as low density (LDPF) or high density (HDPF) (Williams, 1981) depending on their thickness.

As already stated earlier, the quality of dried food products especially tomatoes is of utmost importance and should be able to reach a certain level of acceptance in terms of appearance, taste, moisture content, extractible constituents, microbial quality, flavor, nutritive value, texture and degree of contamination (Williams, 1981). The current practice by the processors in some states in Nigeria whereby the dried products are stored without packaging of any sort leaves much to be desired. It is therefore necessary to investigate the level of changes taking place in the quality of the stored products. In this study a comparative assessment of two methods of storage of dried tomatoes was carried out with a view to quantify the level of the changes in some of these quality attributes of the dried produce during the period of storage. The two systems were the sealed high-density polythene film and the traditional open storage system.

Materials and Methods

Fresh samples of tomatoes (Roma variety) were purchased from Minna Central Market. The samples were first sorted to remove infested ones and then washed. Three kg of the sorted samples was randomly selected from the baskets. The moisture content of the fresh sample was determined using the oven dry method. The samples were dried at 65oC and weighed at interval until there was no change in the weight of the dried samples. The samples were sliced using stainless steel knife. The sliced tomatoes were then dried using a tray drier to a moisture content (4.2%) which was within the range considered to be safe enough for storage (Hall, 1986).

Prior to packaging and storage the following quality attributes of the dried tomatoes were assessed: Vitamins C and A, moisture content, color, texture, Calcium and phosphorus contents and microbial load counts (fungi and bacteria). The standard methods as adopted by AOAC (1970) were used to determine the following, vitamin C, phosphorus and calcium contents. Vitamin A was determined using the method spectrophotometer. The fungal and bacteria loads were enumerated using the nutrient agar method (Atlas et al, 1984). 300g of the dried samples were then packaged in the 6 packs of 0.950g/cm3 (high density) polythene films(15cm x 10 cm) and then sealed. Similar quantities of the dried samples were put in 3 bowls and the two groups were stored in the laboratory under ambient temperature and

Issue 10, January-June 2007
p. 123-136

relative humidity (with the average values being 23oC and 65% respectively during the period of storage). The same sets of quality parameters were assessed every month for a period of 3 months to ascertain the level of changes in theses parameters under the two methods used.

The sensory evaluation method was used to assess the color and texture of the samples. A ten-man panel chosen from students, laboratory technicians, lecturers, and other workers were constituted to evaluate the color and texture of the dried tomatoes using an eight- point hedonic scoring scale method (Derosier, 1977). The panelists who recorded their assessment/evaluation on a descriptive graduated scale assessed coded samples for colour and texture that best described the assessment scoring given an indication of the size and direction of differences of variation from the standard sample, which is the fresh tomato. The categories on the scale were assigned numerical values (1 -8). The data collected were transferred and analyzed using Chi-square statistical method with the formula stated by Kwanchai et al, (1984):

$$\chi^2 = \sum\left(\frac{O-E}{E}\right) \text{ (Kwanchai et al., 1984)}$$

where O = observed value for each sample, E = corresponding expected value

Results and Discussion

The results of the microbial load counts (cfu/g) for the dried tomatoes using the two storage systems are presented in Table 1.

Table 1. Average bacterial and fungi load counts (cfu/g) in the stored dried tomatoes in open and sealed HDPF storage systems

Period of Storage (days)	Sealed HDPF system		Open Storage system	
	Bacterial loads	Fungi loads	Bacterial loads	Fungi loads
1	$5.6\cdot10^4$	$3.6\cdot10^3$	$5.6\cdot10^4$	$3.6\cdot10^3$
30	$0.12\cdot10^4$	$2.6\cdot10^3$	$1.9\cdot10^5$	$4.4\cdot10^3$
60	$0.5\cdot10^4$	$0.64\cdot10^3$	$2.1\cdot10^5$	$7.2\cdot10^3$
90	$0.76\cdot10^4$	$0.54\cdot10^3$	$9.5\cdot10^5$	$7.2\cdot10^3$

Cfu = colony forming units/gram

The microbial load counts obtained from the fresh sample prior to drying were $6.3 \cdot 10^5$ cfu/g and $4.2 \cdot 10^3$ cfu/g for bacteria and fungi respectively. This load generally reduced to $5.6 \cdot 10^4$ cfu/g and $3.6 \cdot 10^3$ cfu/g for bacteria and fungi after drying. After three months of storage in the two systems, the fungi loads decreased from the initial value of $3.6 \cdot 10^3$ cfu/g to $0.54 \cdot 10^3$ cfu/g in the samples stored in the sealed HDPF.

The bacterial counts on the other hands decreased from the initial value of $5.6 \cdot 10^4$ cfu/g to $0.76 \cdot 10^4$ cfu/g after 90 days of storage in the sealed HDPF. The decline noted in those stored in HDPF could be due to the exhaustion of the nutrients on which these microbes thrive (Adebanjo and Shopeju, 1993).

The results however, showed that the microbial load counts increased tremendously from the initial values of $5.6 \cdot 10^4$ cfu/g and $3.6 \cdot 10^3$ cfu/g to $9.5 \cdot 10^5$ cfu/g and $7.2 \cdot 10_3$ cfu/g for bacteria and fungi in the samples stored in the open storage system. In particular, the fungi load count of the samples stored in the open system increased tremendously within the 90 days. There is therefore a significant difference between the two systems as far as the fungi load count is concerned (Table 1a).

Table 1a. ANOVA for fungi load counts of the samples stored in the two systems

Source of var.	df	Sumof squares	Mean square	F value
Storage Systems	1	$2.82 \cdot 10^7$	$2.82 \cdot 10^7$	11.38*
Error	7	$1.734 \cdot 10^7$	$2.48 \cdot 10^6$	

* Highly significant at $\alpha = 0.05$

This increase could be attributed to secondary infection resulting from exposing the produce to atmosphere. Though the differences were not statistically significant at 5% level (Table 1b), in the case of the bacteria load count it can however be noted from the figures that the sealed packaging system provides better quality products than the open storage system.

Table 1b. ANOVA for bacteria load count

Source of var.	df	Sumof Square	Mean square	F-value
Storage Systems	1	$2.477 \cdot 10^{11}$	$2.477 \cdot 10^{11}$	2.33
Error	7	$7.418 \cdot 10^{11}$	$1.060 \cdot 10^{11}$	

The value of F from the Table is 5.59 at $\alpha = 0.05$ which is greater than the F-calculated. In other words there is no significant difference between the bacteria load count in the samples stored in the two systems.

The results however showed that the bacteria load counts of the samples were generally lower than the level of contamination observed in Nigerian dried food condiments revealed by Obuekwe and Ogbimi (1989). The assessment also showed that the microbe's species identified agreed with earlier studies (Ijah, 1999).

Moisture Content

The fresh samples were dried from the initial moisture content of 92.2% (wet basis) to 4.2% which falls within the values recommended for safe storage of dried product to prevent microbial growth during storage (Hall, 1986). The results of the monitored moisture content during the storage period using the two systems are shown in Table 2.

Table 2. Average values of moisture content of dried tomatoes stored in Sealed HDPF and Open storage systems

Period of Storage (days)	Moisture content variation (wet basis)	
	Open storage system	Sealed HDPF
1	4.2	4.2
0	6.21	4.33
60	6.87	4.26
90	7.13	3.93

The results showed that there was a significant difference between the moisture content of the samples stored in the two systems at 5%confidence level .as the calculated F is greater than the Table value (Table 2b).

Table 2b. ANOVA for the moisture content variation in the storage systems

Source of var	df	Sum of squares	Mean square	F-value
Storage systems	1	7.277	7.277	9.65*
Error	7	5.279	0.754	

* Highly significant at $\alpha = 0.05$

The attained moisture content remained nearly constant for the samples of the products stored in the sealed HDPF storage system throughout the 90 days period of storage. Those stored in the open system however increased from the initial 4.2% prior to storage to 7.13% after 3 months of storage. This increase showed that the samples absorbed moisture from the surrounding atmosphere. Since moisture is one of the critical factors influencing the shelf life of any stored product, it can be inferred from these results that the sealed HDPF is better in terms of long term storage of dried tomatoes. The increase could have influenced the results of the microbial loads in the open storage system as discussed earlier.

Sensory Analysis

The results of the sensory analysis carried out to ascertain the changes in color of the stored dried tomato samples are presented in Table 3.

Table 3. Summary of the Chi-square Statistical analysis of the color variation during the storage period under the two systems of storage

Period of storage (days)	Storage Systems		Table values	
	Sealed HDPF (calculated X^2 values from color assessment)	Open Storage (Calculated X^2 values from color assessment)	5%	1 %
1	2.38	2.38	16.92	21.60
30	3.88	9.63		
60	8.13	15.63		
90	10.00	31.75*		

*Highly significant at both 5 % and 1 % levels.

The results (Table 3) showed that the values of the computed X2 for the color of the dried tomato samples stored in both the sealed and open storage systems were less than the Table values at both 5 % and 1 % levels of errors. It means that the samples do not show any significant changes in color from initial color of the fresh samples after 60 days of storage. However, the computed value for the sample stored in the open storage system after 90 days of storage indicated that there was a significant change in the color of the dried tomatoes. Color is one of the important quality attributes normally used by consumers in accepting or rejecting food product especially vegetable products.

It can be seen from these results that the sealed HDPF storage system gave a better keeping color quality as far as these two systems are concerned. The current practice whereby the dried produce is left open without any form of protection in terms package calls for serious enlightenment of the processors about this decrease in quality. It is this color change that makes the locally dried tomatoes unattractive and this normally discourages consumers.

Nutritional Analysis

The results of the assessments of some nutritional contents of the samples are presented in Tables 4, 5,6 and 7.

Table 4. Mean values of Vitamin C content (mg/100g) changes in the stored dried tomatoes under the two storage systems

Period of storage (days)	Sealed HDPF	Per. changes (%)	Open Storage system	Per changes (%)
1	5.21		5.21	
30	4.99	4.2	4.11	21.1
60	4.72	9.4	3.72	28.6
90	4.24	18.6	3.69	29.2

Fresh sample =16.25mg/100g

Table 5. Mean values of Vitamin A content (μg/100g) variations in the stored dried tomato samples under the two storage systems

Period of storage (days)	Sealed HDPF	Per. change (%)	Open storage system	Per. change (%)
1	134		134	
30	124	7.5	118	11.9
60	121.4	9.4	108	19.4
90	103.4	22.8	98	26.7

Fresh sample 156 μg/100g

The fresh samples of the tomato used for the studies contained 16.23 mg/100g of vitamin C content. These values compared favorably with the values given by other studies (Gopalan et al, 1985). After drying, the value decreased to 5.21mg/100g. The results in Table 4 show that the values of this quality attribute decreased to 3.69mg/100g after 3 months of storage in the open storage system. This showed 29.2 % of the vitamin C content were lost from the stored dried tomato samples after three months of storage using the traditional open system as practiced by the rural processors. On the other hand, the values of those stored in the high-density polythene film (HDPF) reduced from the initial value of 5.21mg/100g prior to storage to 4.24mg/100g (8.6 % loss) during the period of storage. These changes were however, not significantly different at 5% level of confidence (Table 4b)

Table 4b. ANOVA for Vitamin C content in the samples stored in the two systems

Source of variation	df	Sum of Squares	Mean Square	F-value
Storage Systems	1	0.738	0.738	2.53
Error	7	2.041	0.292	

The F value from Table is 5.59 which is greater than the F-calculated, hence there is no significant difference between the Vitamin C contents of the samples stored in the two systems after 3 months of storage.

Similar trends are observed in the variation of the other nutritional quality attributes assessed. In Vitamin A for instance (Table 5), the values decreased from 134µg/100g prior to storage to 103.4 µg/100g in the samples stored in sealed HDPF. This showed a decrease of 22.8 % in this quality after three months of storage. In the samples stored in the open storage system, there was a 26.7 % loss in the vitamin A content during the same period but these losses were not significantly different at $\alpha = 0.05$ (Table 5b).

Table 5b. ANOVA for Vitamin A content of the samples stored in the two systems

Source of var	df	Sum of squares	Mean Square	F-value
Storage systems	1	103.68	103.68	0.60
Error	7	1212.16	173.166	

The results in Table 6 show that the values of calcium content decreased by 6.6 % from the initial value of 9.12 mg/100g to 8.52 mg/100g after three months of storage in sealed HDPF. Those of the samples stored in open system indicates 19.7 % loss as the value reduced from 9.12 to 7.32 mg/100g within the same period of storage.

Table 6. Average values of Calcium content (mg/100g) changes in the stored dried tomato samples under the two storage systems

Period of storage (days)	Sealed HDPF	Per. change (%)	Open storage system	Per. Change (%)
1	9.12		9.12	
30	8.97	1.6	8.23	9.5
60	8.85	3.0	8.05	11.7
90	8.52	6.6	7.32	19.7

Fresh sample = 7.21mg/100g

Though, this changes were not significantly different at α = 0.05 (Table 6b), it is however, of great concern the rate at which this useful nutrient is being depleted in the stored product.

Table 6b. ANOVA for Calcium content of the samples stored in the two systems

Source of var	df	Sum of squares	Mean square	F-value
Storage systems	1	0.93845	0.93845	3.57
Error	7	1.8379	0.26256	

A similar trend could be seen in the results of the values of the phosphorus content (Table 7).

Table 7. Average values of Phosphorus content (mg/100g) changes in the stored dried tomato samples under the two storage systems

Period of storage (days)	Sealed HDPF	Per. changes (%)	Open storage system	Per. Changes (%)
1	16.12		16.12	
30	15.56	3.5	13.24	17.9
60	15.46	4.1	12.24	21.1
90	14.46	10.3	11.43	29.1

Fresh sample 19.62mg/100g

There was a 29.1 % decrease in the phosphorus content of the samples stored in the open system as against the 10 % loss from those stored in the sealed HDPF system during the same period of three months. The changes were, however, not significantly different at 5% level of confidence (Table 7b).

Table 7b. ANOVA for Phosphorus contents of the samples stored in the two systems

Source of var	df	Sum of squares	Mean squares	F-value
Storage system	1	9.180612	9.180612	4.59
Error	7	14.000475	2.000475	

The fast depletion in the values of these useful quality attributes of the dried samples in the open system of storage may be due to the exposure of these samples to the atmosphere which predisposes the products to interplay of various agents of deterioration. This is more so as the moisture content shows a very significant increase in this system. The increase in microbial growth could as well influence other reaction and changes in these parameters

Conclusions

The aim of this study was to quantify the changes in some quality attributes in dried tomatoes stored under two different storage techniques namely, the sealed high density polythene film (HDPF) and the traditional Open storage system used by the rural processors in Nigeria.

The results of the assessment showed that the loss in the values of the assessed quality of the product is greater and faster in the open system of storage than the sealed HDPF. In other words, the sealed HDPF provides better keeping quality of the product compared to the traditional open system. Since quality of this product cannot be compromised, it is advised based on the findings from this study that the HDPF should be encouraged in the storage of dried tomatoes in order to retain some of these quality attributes during the storage period and also reduce the level of infestation by microbes. The sealed HDPF is also a means of package, which can also assist in the marketing of this product.

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