Biotechnology Journal International

20(3): 1-7, 2017; Article no.BJI.37393
ISSN: 2456-7051
(Past name: British Biotechnology Journal, Past ISSN: 2231–2927, NLM ID: 101616695)

Effects of Length of Fermentation and Storage Media on Chemical Properties of Palm Oil

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Authors' contributions

This research work was carried out in collaboration between the both authors. Author TAA designed the study, supervised the experimental procedures and wrote the first draft of the manuscript. Author POA did the literature searches, carried out the experimental procedures, managed the analyses of the study and performed the statistical analysis. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJI/2017/37393
Editor(s):
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Complete Peer review History: http://www.sciencedomain.org/review-history/22766

Original Research Article

Received 13th October 2017
Accepted 29th December 2017
Published 17th January 2018

ABSTRACT

This study examined the effects of different length of fermentation and storage media on quality characteristics of palm oil produced at the processing centre of Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado-Ekiti, Nigeria. Fresh palm fruits were collected immediately after harvesting and divided into three samples. Each sample was processed into palm oil at intervals of three days and the respective palm oil obtained from each sample was subjected to laboratory test under the same conditions to determine their respective saponification values, moisture content, free fatty acid values and thiobabituric acid number (TBA). Samples were also stored in media such as tin, rubber and glass and their chemical properties were determined after 18 days of storage. The result shows that free fatty acid (FFA) increases with increase in day of fermentation of the palm fruits for both freshly processed oil and those stored for 18 days. Only the oil processed in the first day have the moisture content which are within the 0.01-0.04% standard moisture content values of palm oil while the oil stored in glass had the lowest saponification value of 202.97mgKOH/g and TBA values which are within the standard values of 0.1 to 0.2.

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Keywords: Fermentation; storage; palm oil; chemical properties; FFA; TBA.

1. INTRODUCTION

Palm oil is mostly adopted edible oil orange-red to brownish or yellowish-red in colour. It is extracted from the mesocarp of fruits of oil palm tree (*Elaeis guineensis* Jacq). The fruit, a drupe, varies between 20 to 50 mm in length and usually could be found as large as 25 mm in diameter. These fruits grow in bunches that are attached to the crown of the tree through a stalk1, 2 or more. The oil is obtained from the fruit pulp which surrounds a nut. On the other hand, palm kernel oil is another oil obtained from the innnermost kernel [1].

This plant could be considered the highest oil producing plant for its capability of producing an average of 3.5 tons of oil/ha/year. The crude palm oil (usually referred to as CPO) is extracted from the mesocarp of the fruit. It represents 95% of the total oil production of the oil palm which also provides the palm kernel oil.

The oil palm fruit is comparatively more profitable crop because it can produce more oil per land area than any other oil producing plant [2]. Now-a-days, almost 80% of palm oil has been applied for the purpose of human consumption and oil palm fruit has become a regular source of edible oil.

In edible oil refining industry, low content of free fatty acid (FFA) and oxidative products is one of the most important quality [3]. Therefore, the importance of palm oil in human nutrition for healthy life cannot be over emphasized. The acceptability of palm oil in the international market is largely based on physiochemical properties of the oil at the time of purchase. Some of the properties or parameters usually considered include free fatty acids (ffa), iodine value (iv) peroxide value (pv), moisture, impurities content, colour, taste, aroma, melting point, tocopherol and tocotrienol contents [1, 4-7].

The quality of palm oil depends on deterioration due to microbial infestation that might have occurred before processing in the palm fruit via bruises. These often manifest in the taste and odor of the CPO over a period of time, increasing its rancidity. The rancidity of CPO could be associated with FFA increase due to atmospheric oxidation [8]. The microbial quality of CPO essentially play adverse role in food and feed products. Though, CPO used for cooking is subjected to heat which may reduce and or kill all the microorganisms that could invade the CPO. The storage time of is a major problem that could activate the lipase enzymes and reduce the oil quality [9]. Thus, the effect of length of fermentation and storage media on quality of palm oil has been studied in this research.

2. MATERIALS AND METHODS

2.1 Preparation and Processing of Palm Fruits

Bunches of palm fruits weighing between 10 to 12 kg were obtained at Aisegba community of Ekiti State. They were brought to the palm fruits reception bay at the processing centre of Department of Agricultural and Bio-Environmental Engineering of The Federal Polytechnic, Ado-Ekiti and were kept in open air under a roofed shed. They were then divided into 3 equal parts A, B and C. Part A was processed immediately after harvesting, while Part B and C were processed on the 4th and 7th day of the harvesting respectively. The palm oil was extracted at the processing centre. The fruits were manually removed from the bunches and boiled for 4 hours. They were then fed into a vertical shaft digester until a hot crushed pulp of good consistency was obtained. The pounded mass was then loaded into a screw pressed for removing the oil from both nuts and chaffs. The extracted liquid was then fed into a clarifier from where the final oil was obtained. The part B and C parts of the fruits were processed in the same way on the 4th and 7th days respectively.

2.2 Storage of Palm Oil

5kg of samples of the processed palm oil were taken from each of parts A, B and C and stored separately in different containers namely; tin, rubber and glass at room conditions in post-harvest laboratory. This was done immediately after processing each of the parts and the palm oil was stored in each of the media for 18 days after which their chemical properties were determined.

2.3 Determination of Chemical Properties of Palm Oil

Four chemical properties of the stored palm oil were determined after 18 days of storage using

AOAC method [10]. The chemical properties determined are: (i) Free Fatty Acid (FFA) Value (ii) Saponification Value (iii) Moisture Content and (iv) Thiobabituric Acid Number

2.3.1 Determination of free fatty acid value

Neutral alcohol (95 percent ethanol and diethyl ether mixed in ratio of 1:1 (v/v) was heated with 1g of palm oil until the mixture began to boil. This was done to completely free the oil of free fatty acid. 4 drops of indicator was added to the mixture and was titrated with 0.01M of NaOH and constantly shaken. The volume (V) of NaOH required to produce the first permanent pink colour was recorded and the free fatty acid content of the oil was determined from the formula:

$$\text{Free Fatty Acid Value (FFA)} = \frac{lume\ of\ NaOH\ used \times 2.82 \times 0.1}{Weight\ of\ sample} \quad (1)$$

2.3.2 Determination of saponification value

The saponification value of palm oil or fat is expressed as the number of milligrams of Potassium Hydroxide required to saponify 1g of oil or fat [10]. 2g of palm oil were accurately weighed into round bottom flask and exactly 25 mL of alcoholic potassium hydroxide solution was added. A reflux condenser was attached to the flask and heated for 1h and frequently shaken. 1mL of phenolphthalein (1%) solution was also added and titrated with 0.5mL hydrochloric acid. A blank was carried out at the same time. The saponification value was calculated from the following expression:

$$\text{Saponification value} = \frac{(b-a) \times 28.05}{Weight\,(g)\,of\ sample} \quad (2)$$

2.3.3 Determination of moisture content

Gravimetric method was used to determine the moisture content of palm oil. A petri dish was weighted empty and then 5g of palm oil were weighed into the petri dish. The dish was placed inside an oven which was maintained at 105^0C and heated for 3 h. The content was cooled inside a desiccator for 30minutes and was reweighed. The moisture content was determined as follows:

$$\text{Moisture content (\%)} = \frac{(a+b)-x}{b} \times 100 \quad (3)$$

Where a = weight of petri dish, b = weight of sample and x = weight of sample after oven drying.

2.3.4 Determination of moisture content

The TBA is a measure of deterioration in both extractable and non-extractable lipids. 5g of palm oil was macerated with 25 mL reagent for 2 minutes and washed into a distillation flask with 47.5mL water. 2.5mL of 4M hydrochloric acid was added to bring the PH to 1.5, followed by an antifoaming preparation and a few glass beads. The flask was then heated and 10mL distillate was collected in 10 minutes from the time boiling commenced. 5mL distillate was pipetted into a glass stoppered tube and 5mL of TBA reagent (0.2883g/100mL of 90% glacial acetic acid) was added and heated in boiling water for 35minutes. A blank was prepared similarly using 5mL water with 5mL reagent. The tubes were cooled in water for 10minutes and the absorbance (D) was measured against blank at 538mm using 1cm cells TBA number (as mg malonaldehyde per kg sample). The TBA value was given as:

TBA value = 7.8D

3. RESULTS AND DISCUSSION

3.1 Results

Tables 1-4 give the result of FFA value, saponification value, moisture content and thiobabituric acid number of the palm oil in tin, rubber and glass containers before and after 18 days of storage. The values were obtained for parts A, B and C of palm fruits processed in 1st, 4th and 7th days respectively.

3.2 Discussion

3.2.1 Effects of length of fermentation and storage media on free fatty acid (FFA) values of palm oil

Fig. 1 shows that the free fatty acid content of the oil increases with number of days before processing. This is due to increase in moisture absorption of the fruits as the number of days increases and it results into rapid acceleration of the lipolytic enzyme which simultaneously builds up the FFA content. This is in agreement with report of [11]. The oil freshly produced before storage had the lowest FFA content compared to the values obtained after storage in different media. Analysis of variance at 95% significance

(Table 5) shows that there is no significant difference in the FFA content of oil in the different media though there was gradual increase in FFA content in all the storage media after processing of the fruits with oil stored in glass having the lowest FFA content. T-test also shows that there is no significant difference in values obtained before storage and after storage (Table 6).

3.2.2 Effects of length of fermentation and storage media on saponification value

It was observed generally that the saponification values increased with number of days before processing the palm fruits as shown in Table 5. Oil stored in tin had the highest saponification value of 234.95mgKOH/g while those stored in glass had the lowest saponification value of 202.97mgKOH/g though the ANOVA result in Table 5 shows that the difference across different media is not significant. Saponification value indicates deterioration of oil and was found to be increased with time of storage (Fig. 2). This trend explains that with long storage of this oil, fatty acids are likely to be formed which increases the saponification value and its indicates that long stored degraded oils can play a favourable role in producing soaps and toiletry products profitably [12].

3.2.3 Effect of length of fermentation and storage media on moisture content of palm oil

The moisture content values of the oil before and after storage gradually increased with number of days before processing of the fruits with the exception of oil obtained before storage which showed gradual decrease. Both ANOVA and t-test (Table 5 and Table 6) show that there is no significant difference in moisture content across different media before and after storage and also as number of days before processing increases. Moisture is an undesirable quality in oil, since, it increases the rate of hydrolysis, which may be explained by the fact that moisture together with

Table 1. Free fatty acid values (%) of samples of palm oil before and after storage in different media

Days of processing of fruits	Freshly processed before storage	After 18 days of storage in different media		
		Tin	Rubber	Glass
1	1.86	2.11	1.95	1.99
4	1.92	1.97	2.03	1.96
7	3.29	2.84	2.89	2.61

Table 2. Saponification Values (mgKOH/g) of samples of palm oil before and after storage in different media

Days of processing of fruits	Freshly processed before storage	After 18 days of storage in different media		
		Tin	Rubber	Glass
1	206.17	206.17	206.17	208.97
4	210.16	234.95	222.14	210.04
7	224.77	243.18	232.99	220.74

Table 3. Moisture content (%) of samples of palm oil before and after storage in different media

Days of processing of fruits	Freshly processed before storage	After 18 days of storage in different media		
		Tin	Rubber	Glass
1	0.08	0.04	0.02	0.04
4	0.15	0.19	0.08	0.13
7	0.13	0.06	0.22	0.50

Table 4. Thiobabituric acid (TBA) values of samples of palm oil before and after storage in different media

Days of processing of fruits	Freshly processed before storage	After 18 days of storage in different media		
		Tin	Rubber	Glass
1	0.24	0.31	0.26	0.16
4	0.35	0.46	0.38	0.18
7	0.56	0.58	0.47	0.2

Table 5. ANOVA of results of chemical properties of the palm oil

	P-value			
	FFA	**Saponification value**	**Moisture content**	**TBA**
Number of days before processing	0.000829832	0.038795884	0.244661819	0.057836484
Storage media	0.344092759	0.174288421	0.515589921	0.012206503

Table 6. t-test: paired two sample for mean values before storage and after storage

	FFA		**Saponification value**		**%Moisture content**		**TBA**	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Mean	2.3566	2.2611	213.7000	220.5944	0.1200	0.1323	0.3833	0.3333
Variance	0.6542	0.2022	95.8887	161.1424	0.0013	0.0134	0.0264	0.0075
Observations	3	3	3	3	3	3	3	3
Pearson Correlation	0.9975		0.9046		0.5286		0.9701	
Hypothesized Mean difference	0		0		0		0	
df	2		2		2		2	
P-value	0.6922		0.1697		0.8477		0.3974	

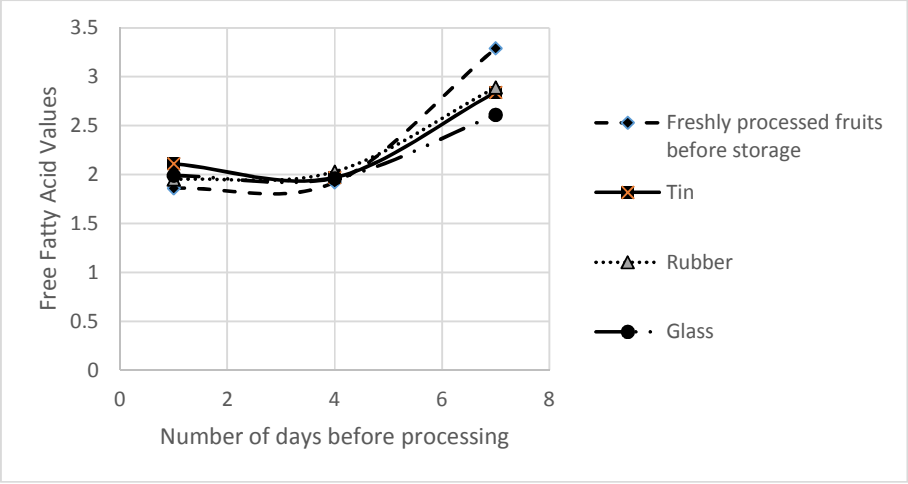

Fig 1. Graph of free fatty acid values against number of days before processing for different storage media

impurities contain or provide nutrients for micro-organisms. Only the oil processed in the first day have the moisture content which are within the 0.01-0.04% standard moisture content values of palm oil (Fig. 3) [9]. However the oil stored in tin appeared to have the lowest values of moisture content.

3.2.3 Effect of length of fermentation and storage media on thiobabituric acid value of oil

TBA value test is one of the most widely used tests for evaluating the extent of lipid oxidation [13]. The thiobabituric acid (TBA) is undesirable in palm oil before it leads to production of Malonaldehyde which can be carcinogenic in humans. As shown in Fig. 4, The TBA values obtained ranged from 0.24 to 0.36, 0.11 to 0.28, 0.16 to 0.27 and 0.09 to 0.19 for oil freshly produced and those stored in tin, rubber and glass respectively over the periods of fermentation of fruits. There is much significant difference in TBA values of oil in different media after 18 days of storage at 95% level of significance as shown in Table 5. The results are in agreement with that of [14], and [15] who reported thiobarbituric acid values on storage for a few oil blends and confirmed the increase as storage period increased. It was however

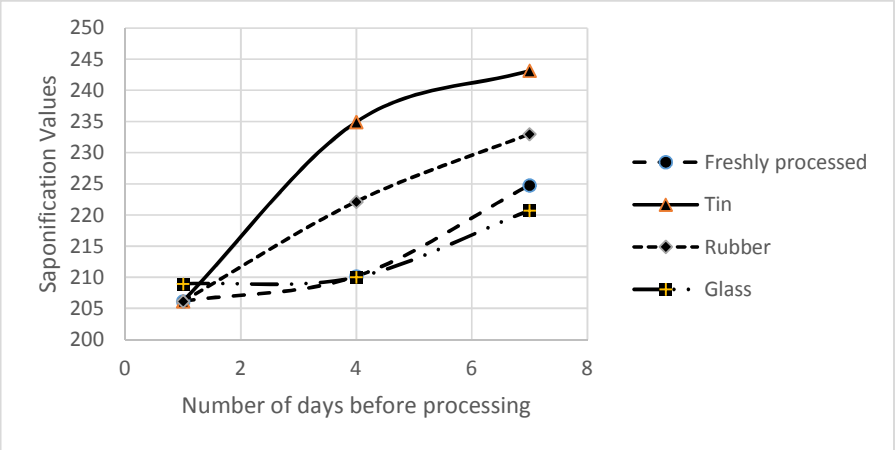

Fig 2. Graph of saponification values against number of days before processing for different storage media

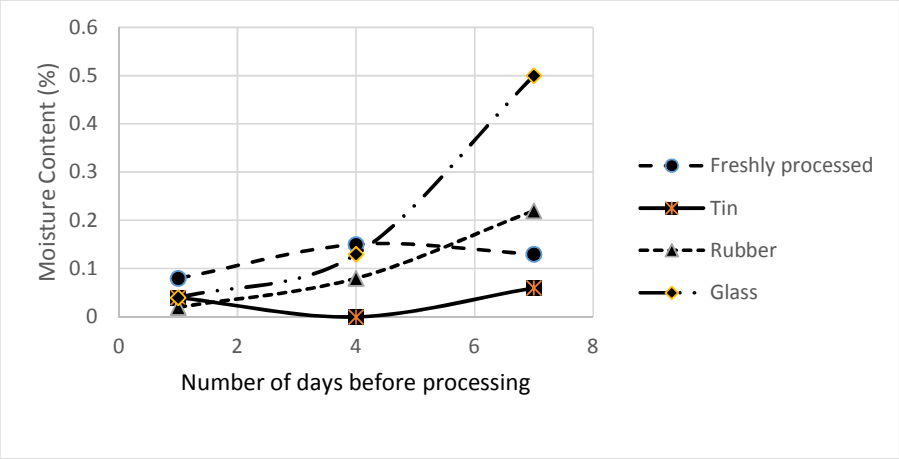

Fig. 3. Graph of moisture content (%) against number of days before processing for different storage media

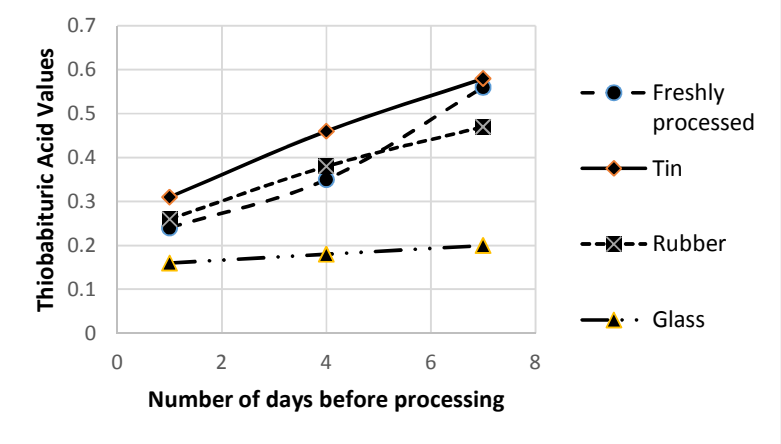

Fig. 4. Graph of thiobabituric acid (TBA) values against number of days before processing for different storage media

observed that only the oil stored in glass had TBA values which are within the acceptable range of TBA value required for crude oil: 0.1-0.2 [16].

4. CONCLUSION

Length of fermentation of oil palm fruits before processing into palm oil has effects on the quality of oil produced after processing especially the chemical properties of the oil. The media in which the oil is stored after processing also has effects on the chemical properties such as free fatty acid, moisture content, saponification values and thiobabituric acid values. The results of this study showed that the oil freshly produced before storage had the lowest FFA and moisture content estorage in different media. Among the three media of storage viz: tin, rubber and glass, only the glass storage medium gave the lowest values of chemical properties which had negative effects on quality of palm oil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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