Impact of Shelf life on the Quality of Cocoa Butter Extracted by Screw Press

ABSTRACT

Aims: To evaluatethe changes in the quality of cocoa butter during storage extracted using the developed screw press-type cocoa butter extractor.
Study design:
Place and Duration of Study: The study was conducted at Processing and Food Engineering lab, Kelappaji College of Agricultural Engineering and Food Technology, Tavanur under ICAR-AICRP on Post-Harvest Engineering and Technology Scheme for 3 months.
Methodology: Shelf life study of the cocoa butter extracted at optimized condition (100ºC barrel temperature, 50 rpm screw speed, 2 kg/hr feed rate) was done in polyethylene pouch of 80 micron thickness and stored under ambient temperature (25±5°C)for a period of 3 months.Various quality parameters viz., free fatty acid, iodine number, peroxide number, moisture content and water activity of stored butter were determined at regular intervals of 30 days for 3 months.
Results: Statistical analysis (t-test) showed that, there was no significant changes in the quality of cocoa butter during storage. The quality parameters of cocoa butter viz.,free fatty acid (1.28%), iodine number (34.74), peroxide value (1.685),moisture content (0.15%) and water activity (0.645) were within the allowable limits recommended by CODEX standards even after 3 months of storage.
Conclusion: During the course of storage, all quality parameters viz., free fatty acid, peroxide value, iodine number, moisture content and water activity were found to be increased. However, all the quality parameters of cocoa butterstored under ambient temperature werewithin the acceptable limit prescribed by CODEX standards till 90 days with constant quality attributes.

Keywords: Cocoa butter, shelf life, free fatty acid, iodine number, peroxide value, moisture content, water activity

1. INTRODUCTION

Cocoa (Theobroma cacao L.) is a crucial plantation crop and serves as a source of profitability and employment for millions of people worldwide. Over 70% of cocoa beans are exported in one way or another, which is a significant source of exchange revenues (Foreign Agricultural service, 2022). The global cocoa production for the year 2022-2023 estimated to be around 4.9 million metric tons (ICCO, 2023). The World's largest cocoa producing country, including Ivory Coast and Ghana in West Africa, contribute about 70 per cent to the global production rate.Cocoa bean, seed of the cocoa tree, are processed to produce chocolate liquor, cocoa powder, and cocoa butter, which are the main ingredients of chocolate and are used to make a wide variety of products such as cocoa beverages, ice cream, and baked products. The cocoa beans has a cellular structure that contains approximately 55 per cent fat (cocoa butter) in solid form that is locked within the cells. Theobroma oil, another name for cocoa butter, is an edible pale yellow fat that is extracted from cocoa nibs. It is made from cocoa beans, which yield about 55 percent of the dry weight in the final product. Cocoa butter is a necessary component of chocolate because it forms the continuous phase of the chocolate and gives characteristic gloss, texture and melting behaviour (Wang *et al*., 2006). The composition of cocoa butter includes several components essential for its texture and stability. A significant amount of cocoa butter consists of monosaturated and saturated fats, which give it a stable form at room temperature and allow it to melt at body temperature. Antioxidants present in raw cocoa butter can neutralize free radicals and reduce oxidative stress. It contains omega-6 and omega-9 fatty acids, as well as natural antioxidants like alphatocopherol and phytosterols and nutrients that help with mood and immunity . About 98% of the total fatty acid content of cocoa butter is composed of the major fatty acids palmitic acid (C16), 25–33.7 per cent, stearic acid (C18:0), 33.7–40.2 per cent, oleic acid (C18:1), 26.3–35 per cent and linoleic acid (C18:2), 1.7–3 per cent (Asep *et al*., 2008). Cocoa butter is distinct in that it is brittle at room temperature and quickly liquefies at body temperature. Cocoa butter was primarily used in the food, cosmetic and pharmaceutical industries due to its remarkable functional properties. Cocoa butter was used in the food industry to create chocolate products with a mild texture, mouth feel, flavour release and gloss (Liendo *et al*., 1997; Schilchter-Aronhimeand Garti, 1998). The shelf life of cocoa butter significantly influenced by how it is stored. During storage, oxidation and loss of desirable texture may occur when it is not properly stored. Proper storage conditions can preserve its rich aroma and essential antioxidants. Cocoa butter maintains its quality best when stored in a cool, dry place away from light. Excessive exposure to heat can cause the cocoa butter to melt and potentially spoil, while light can degrade its quality.

Nowadays, hydraulic press is commonly used for the extraction of cocoa butter, which is suitable for large scale cocoa processing. But in the case of small and marginal cocoa entrepreneurs, cocoa butter extraction by hydraulic press is not economical due to high cost, lower extraction efficiency, availability of skilled labour and longer processing time. For small-scale cocoa processors, screw press extraction presents a more affordable and practical alternative, offering simplicity, lower cost, and ease of operation. However, there is a lack of suitable screw press designs with integrated heating mechanisms tailored to the needs of small-scale or home-based chocolate production units. So we developed a screw press-type cocoa butter extractor equipped with a heating mechanism. As compared with hydraulic press, extraction of cocoa butter is occurred at higher temperature in screw press. Hence this work was carried out to evaluatethe quality of cocoa butter extracted using the developed screw press during storage.

2. MATERIAL AND METHODS

Cocoa butter was extracted using the screw press-type cocoa butter extractor developed at Processing and Food Engineering lab, Kelappaji College of Agricultural Engineering and Food Technology, Tavanur. Prior to storage, cocoa butter was packed in polyethylene pouches of 80 micron thickness and stored under ambient temperature (25±5°C). The quality parameters such as FFA (free fatty acid), peroxide value, iodine number, moisture content and water activity were analysed at an interval of 30 days.

2.1 Free fatty acid

FFA is a number that is usually calculated as oleic acid, also expressed in mg KOH/g and it indicates the purity of oil. Five grams of cocoa butter extracted from cocoa nibs was weighed into 250 ml conical flask to which added 50 ml of a mixture of equal volumes of alcohol and diethyl ether previously neutralized were added. One millilitre of phenolphthalein was used as indicator. The solution was titrated with N/10 KOH with constant shaking until pink colour persists for 15 seconds (AOAC 2009).

$$\text{Acid value} = \frac{\text{Titre value} \times \text{Normality of KOH} \times 56.1}{\text{Weight of sample}} \quad (1)$$

$$\text{Free Fatty Acid} = \frac{\text{Acid value}}{1.99} \quad (2)$$

2.2 Iodine number

Iodine number is a measure of the degree of unsaturation in oil or fat. It is the weight of iodine absorbed by 100 parts by weight of the sample and is expressed in (mg/g). Exactly 0.3 g of oil/fat was transferred to a clean dry iodine glass containing 10 ml of chloroform/carbon tetrachloride, mixed well and 25 ml of iodine monobromide (IBr) was added to it. One conical flask was kept as a blank without oil. Both the flasks were shaken well and were placed in dark. After this, stirring was done for each flask for every 5 min for about 30 min. 50 ml of water and 10 ml of 10% potassium iodide solution was added to each flask. Then the solutions were titrated against standard 0.1 N $Na_2S_2O_3$ solution using 2 ml of starch as indicator with end point blue to colourless. Iodine number was calculated using the following formula.

$$\text{Iodine value} = \frac{(V1 - V2) \times N \times 126.9}{W \times 1000} \times 100 \quad (3)$$

Where V1 is the volume of $Na_2S_2O_3$ used for blank,
V2 is the volume of $Na_2S_2O_3$ used for oil,
N is the normality of $Na_2S_2O_3$,
W is the oil/fat in gram.

2.3 Peroxide value

Peroxide value of cocoa butter was estimated to find the rate of rancidity. It was evaluated according to AOCS official method (2003). Weigh 5g of oil/fat into a 500 ml flask, add 30 ml acetic acid chloroform mixture and dissolve the oil. Add0.5 ml of saturated KI solution mix well and allow standing for 1 min. Add 30 ml of water, 3-4 drops of starch indicator and mixing well. Titrate against standard 0.01N sodium thiosulphate with vigorous shaking liberate all from chloroform layer until the blue colour just disappears. A blank solution was also prepared and peroxide value was calculated and expressed in milliequivalent per kg of the sample.

$$\text{Peroxide value} = \frac{(\text{Blank} - \text{sample}) \times \text{Normality of sodium thiosulphate}}{\text{Weight of sample}} \times 100 \quad (4)$$

2.4 Moisture content

The amount of moisture present in cocoa butter sample were estimated using AOAC (2005) methodology. For the moisture determination 5 g of cocoa butter was taken in petri plates and was further kept in hot air oven (105± 2°C). Further the samples were dried to a constant weight and moisture content was expressed in terms of % wet basis. Moisture content was found by using the following equation:

$$\text{Moisture content (\% w.b)} = \frac{wi - wf}{wi} \times 100 \quad (5)$$

Where,
Wi – initial weight of cocoa butter, g
Wf– dry weight of cocoa butter, g

2.5 Water activity

Cocoa butter sample (2g) was spread over the bottom of a sample cup and placed in a water activity meter.T (Model: Aqua Lab, Decagon Devices Inc., Pullman, USA) to measure water activity.

3. RESULTS AND DISCUSSION

Statistical analysis was done using t-test. Table 1 shows the changes in the various quality parameters during storage.

Table 1 Changes in the various quality parameters during storage

Sl. No	Storage days	Free fatty acid, %	Iodine number	Peroxide value	Moisture content, %	Water activity
1	0	1.23	33.18	1.68	0.1	0.428
2	30	1.24	33.5	1.68	0.11	0.511
3	60	1.25	33.9	1.683	0.12	0.592
4	90	1.28	34.74	1.685	0.15	0.645
	P value	0.1088*	0.5986*	0.1112*	0.1088*	0.1048*

* indicates there is no significant changes ($P > 0.05$) in the quality of cocoa butter after 90 days of storage

3.1 Effect of storage on FFA

FFA is the measure of extend at which triglycerides in the oil or fat have been decomposed by lipase action. The FFA of cocoa butter during the initial day of packaging was 1.23. After 90 days of storage, the FFA of cocoa butter was increased to 1.28. Statistical analysis showed that, there was no significant changes (*P*= *.10*) in FFA of cocoa butter during storage. The change in the FFA for cocoa butter sample during storage, expressed in terms of per cent oleic acid is shown in fig 1.

According to CODEXstandards for cocoa butter, the FFA expressed in terms of per cent oleic acid for cocoa butter is not more than 1.75 per cent. From the fig 1, FFA of cocoa butter sample increased during the storage time. This increase in FFA during storage is due to the thermal hydrolysis of triglyceride and lipolytic breakdown as a result of the growth of yeasts and moulds (Ibrahim *et al*., 1994). During storage, cocoa butter had no rancid flavour indicating that the level of FFA production was not to extend that would cause the off flavour. Saba *et al*. (2018) reported that FFA of shea butter increase gradually with increase in storage time. Similar trends of rise in FFA content of stored cow ghee were also observed by Bhari *et al*. (2020).

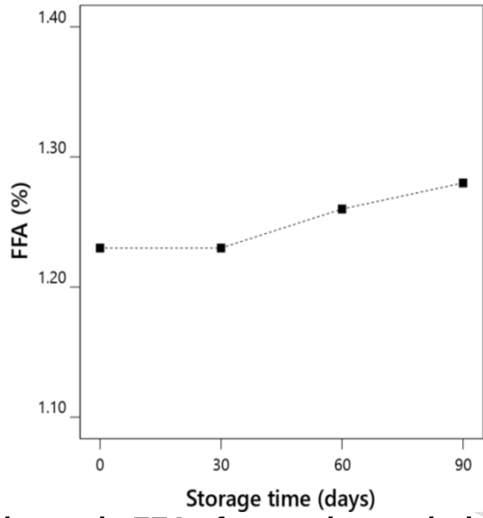

Fig 1. Change in FFA of cocoa butter during storage

3.2 Effect of storage on iodine number

Iodine number is an indicator of lipid oxidation and the degree of unsaturation, a greater iodine number indicates that the oils are prone to oxidation. The change in iodine number of cocoa butter during storage is presented in the fig 2. The standard value of iodine number for cocoa butter is in between 30 and 42. From fig 2, it was observed that iodine number of cocoa butter increased during storage. The iodine number for cocoa butter during the initial day of packaging was 33.18. After 3 months of storage the iodine value of stored cocoa butter is increased to 34.74. Statistical analysis showed that, there was no significant changes (*P=.59*) in iodine number of cocoa butter during storage. This increase is due to the storage temperature in which the lipases found favourable and affect the property of cocoa butter. Bhari *et al*. (2020) reported that iodine number increased during storage of herbal cow ghee. Similar trend was also reported in the storage of shea butter (Saba *et al*., 2018).

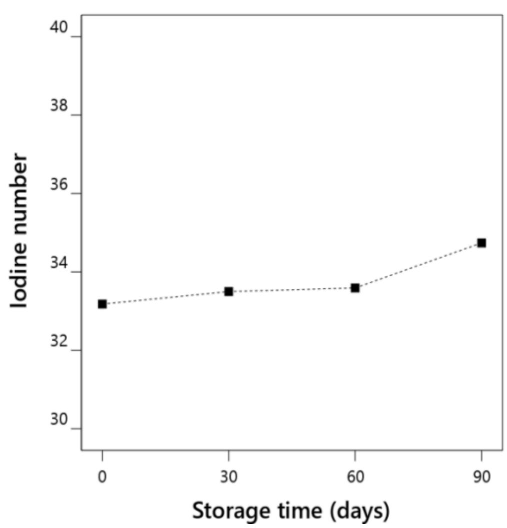

Fig 2. Change in iodine number of cocoa butter during storage

3.3 Effect of storage on peroxide value

Peroxide value is an essential indicator of the rancidity of a sample and is the primary products of lipid oxidation. The higher the peroxide value, the easier it for fat to oxidize or turn rancid. Fig 3. shows the change in peroxide value during cocoa butter storage. The standard value of peroxide value of cocoa butter is 1.78±0.83. From fig 3, it was observed that peroxide value of cocoa butter increased during storage. The peroxide value for cocoa butter during the initial day of packaging was 1.68. After 3 months of storage the iodine value of stored cocoa butter is increased to 1.685. Statistical analysis showed that, there was no significant changes (*P=0.11*) in peroxide value of cocoa butter during storage. The increase in peroxide value during storage is due to the thermal hydrolysis of triglycerides of oil which releases peroxide and free fatty acid. Ramaswamy *et al*. (2001) stated increase in peroxide values of cow cream butter stored for 3 months. Similar trend was also observed by Lee (2020) for goat cream butter over 6 months of storage and Saba *et al*. (2018) for shea butter.

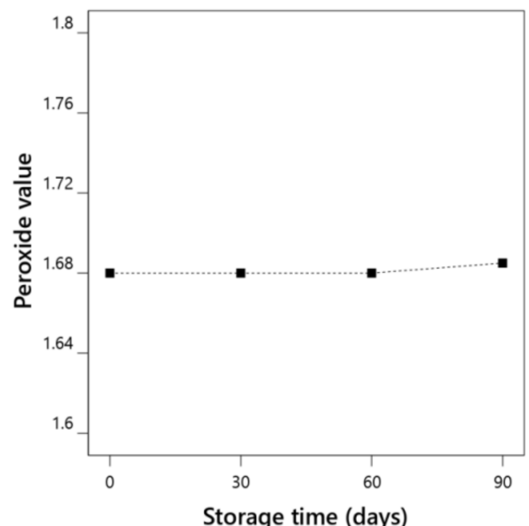

Fig 3. Change in peroxide value of cocoa butter during storage

4.4 Effect of storage on moisture content of cocoa butter

The amount of water in oils affects negatively the performance and shelf-life of fat. Water may accelerate the lipolysis and oxidation of oils/fats. The changes in the moisture content for cocoa butter sample during storage time, expressed in terms of per cent are shown in fig 4. The initial moisture content of cocoa butter at the time of packaging was 0.1 per cent. After 90 days of storage, the moisture content of the stored cocoa butter was 0.15. Statistical analysis showed that, there was no significant changes (*P=0.10*) in moisture content of cocoa butter during storage. From fig 4, the moisture content of cocoa butter increased from 0.1 to 0.15 per cent, which is in the permitted limit. The increase in moisture content was also found in shea butter during storage of 2 months (Honfo *et al*., 2011) and in peanut butter during the storage of 16 weeks (Rozalli *et al*., 2015).

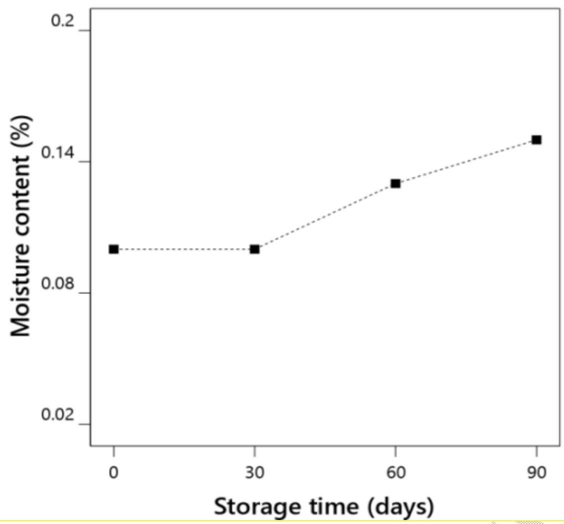

Fig 4. Change in moisture content of cocoa butter during storage

4.5 Effect of storage on water activity of cocoa butter

The change in water activity of cocoa butter during storage is presented in the fig 5. From fig 5, it was observed that water activity of cocoa butter increased during storage. The water activity for cocoa butter during the initial day of packaging was 0.428. After 3 months of storage the water activity of stored cocoa butter is increased to 0.645. Statistical analysis showed that, there was no significant changes (*P=0.10*) in water activity of cocoa butter during storage. This increase is due to the increase in moisture content which promote the lipasic activities.Rozalli *et al*. (2015) reported that water activity increased during storage of peanut butter. Similar trend was also reported in the storage of shea butter (Saba *et al*., 2018).

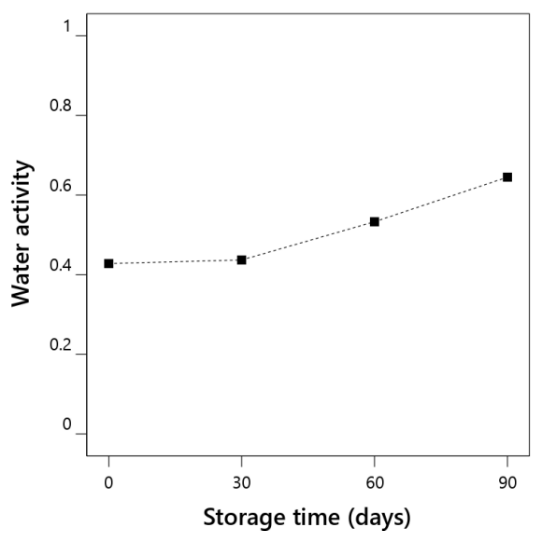

Fig 5. Change in water activity of cocoa butter during storage

4. CONCLUSION

Cocoa butter extracted using cocoa butter extractor was packed in polyethylene pouches of 80 micron thickness and stored under ambient temperature (25±5°C). Various quality parameters of stored cocoa butter sample was analysed on every 30th day of storage for a period of 90 days. During the course of storage, all quality parameters viz., FFA, peroxide value, iodine number, moisture content and water activity were found to be increased. However, all the quality parameters of cocoa butterstored under ambient temperature werewithin the acceptable limit prescribed by CODEX standards till 90 days with constant quality attributes.

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