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EFFECT OF TEMPERATURE AND PACKAGING MATERIALS ON STORAGE OF COCOA, *THEOBROMA CACAO* (L.)

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Abstract

The potential of storing dried cocoa powder in polythene-in-polythene, polythene-in-hessian and polythene-in-paper packages at 15, 28 and 40° C over a period of three months was investigated. Of all the packages tested, polythene-in-polythene package was best with regard to moisture content, loss in weight, total ash, free fatty acid and iodine value. Cocoa powder stored best at 15° C and the quality of stored samples deteriorated with increased temperature. The percentage weight loss was significantly higher ($P < 0.025$) in treatment stored at 40° C than in those stored at 28 and 15° C. At any particular temperature, powdered cocoa stored in polythene-in-polythene package had slightly lower percentage free fatty acid value in relation to those stored in other packages. The best combination of package and temperature was polythene -in-polythene at 15° C.

Keywords: Cocoa; Storage; Temperature; Packaging material.

Introduction

The storage of cocoa beans, *Theobroma cacao* (L.) in the tropics and its attendant problems have been reported by various researchers (Wood, 1973). Temperature, moisture, relative humidity and packaging environment are agents of deterioration of cocoa during storage. According to Guenott *et al.* (1976), temperature affects the relative humidity directly and this has made the long term storage of cocoa in a hot and humid zone difficult. Any increase in moisture level will lead to increase in respiratory activities of the microorganisms which will in turn lead to an increase in temperature.

Although various authors have worked on the storage of dried raw cocoa beans using packaging materials (Gerhadt and Lindgren, 1954; Yerington, 1961; Wood, 1973), no serious attempt has been made to store cocoa beans in powdered form. In the cocoa processing industries in Nigeria, the intermediate products, butter and cake, are packaged in different containers and stored at low temperatures (18-20° C). While cocoa butter is packaged in paper cartons lined with cellophane, the cake is packaged in hessian bags lined with cellophane. According to Fadamiro (1992), the deterioration in quality and the attendant economic situation in the country are problems facing these industries. The storage of cocoa in an alternative intermediate form to prevent deterioration at low cost is therefore necessary. The present study investigates the effect of temperature and packaging microclimate on powdered cocoa beans in storage.

Materials and Methods

Cocoa beans used in this study were bought from 5 stores located in Akure Local Government Area of Ondo State. Samples were collected in polythene bags and bulked. The bulk was sun-dried for seven days. The beans were further dried in the oven at 104° C for 4 hours. The dehauling of the beans was done manually. This was followed by winnowing through which the testa were separated from the kernels (nibs). The nibs were then bulked and ground first with a large kenwood grinder and later with a smaller national grinder. The resulting powder was then stored in dessicators containing dessicants to prevent moisture absorption or loss.

The packaging materials used were purchased from commercial shops in Akure. The materials were polythene, hessian made from polypropylene and paper. All the materials were made into sacks (15 x 30 cm). Double packaging was used and the different packaging combinations used were polythne-in-polythene, polythene-in-hessian and polythene-in-paper.

A total of 9 sacks (15 x 30cm) were prepared per packaging material. Each was filled with 500g of the cocoa powder already prepared and then sealed. The packages were stored for 3 months in incubators at temperatures of 15, 28 and 40° C. At each temperature, each packaging material was introduced in three replicates.

At the end of the storage period, the treatments, were examined visually for presence of moulds. The moisture contents of the stored samples were estimated in accordance with the method of Anon (1975). The weight of each package with its content at the beginning of storage was compared to that at the end of the storage period. The method outlined by Anon (1975) was used to determined the total ash content of samples after storage. Also, the free fatty acid and iodine values of the samples were determined using this method.

All data were statistically analysed using the analysis of variance test. Further grouping was done using Duncan's (1955) multiple range test.

Results

As shown in Table 1, cocoa powder at 40° C in all the packages had lighter surfaces while those stored at 28 and 15° C had the normal dark-brown colour associated with properly processed and preserved cocoa powder.

There were variations in percentage moisture contents of the treatments (Table 2). There were significant differences ($P < 0.025$) in the percentage moisure contents of samples stored at 40° C and those stored at 28 and 15°C . The moisture content was higher in samples stored at 15° C than 28 and 40°C. Also at the same temperature, moisture content was highest in samples stored in polythene-in-polythene packages followed by samples stored in polythene-in-hessian while those stored in polythene-in-paper boxes had the lowest.

Table 1. Effect of temperature and packaging on mould development in cocoa powder stored for 3 months

Temperature (° C)	Type of package	Score for mouldiness
15	Polythene - in - Polythene	-
	Polythene - in - Hessian	-
	Polythene - in - Paper	-
28	Polythene - in - Polythene	-
	Polythene - in - Hessian	-
	Polythene - in - Paper	-
40	Polythene - in - Polythene	+
	Polythene - in - Hessian	+
	Polythene - in - Paper	+

Key: - = absent; + = present

The mean percentage weight loss varied with temperature and type of package material (Table 3). There were significant differences ($P < 0.025$) in the various treatments with respect to percentage weight loss. The mean percentage weight loss was higher in samples stored at 40° C than in those stored at 28 and 15° C. At the same temperature, samples stored in polythene-in-paper box had higher percentage weight loss than those stored in polythene-in-hessian and in polythene-in-polythene containers.

Variations occured in the percentage total ash of the treatments (Table 4). It was significantly higher ($P < 0.025$) in treatments stored at 40° C than in those stored at 28 and 15° C. Powders stored in polythene-in-polythene container had the lowest percentage total ash when compared to other packages.

Table 2. Influence of temperature and packaging material on moisture content of stored cocoa powder.

Temperature (° C)	Type of Package	Mean % Moisture Content ± SD
15	Polythene - in - Polythene	4.45 ± 0.03f
	Polythene - in - Hessian	4.31 ± 0.02e
	Polythene - in - Paper box	4.20 ± 0.02e
28	Polythene - in - Polythene	4.11 ± 0.01d
	Polythene - in - Hessian	4.01 ± 0.02c
	Polythene - in - Paper box	3.80 ± 0.03b
40	Polythene - in - Polythene	3.83 ± 0.02b
	Polythene - in - Hessian	3.77 ± 0.02b
	Polythene - in - Paper box	3.67 ± 0.02a

Means followed by the same letter do not differ significantly ($P < 0.025$).

Table 3. Effect of temperature and packaging material on weight loss of stored cocoa powder.

Temperature (° C)	Type of Package	Mean % weight loss (± SD)
15	Polythene - in - Polythene	0.85 ± 0.04a
	Polythene - in - Hessian	0.90 ± 0.04a
	Polythene - in - Paper box	1.17 ± 0.02b
28	Polythene - in - Polythene	2.82 ± 0.04c
	Polythene - in - Hessian	2.94 ± 0.05cd
	Polythene - in - Paper box	3.105 ± 0.09
40	Polythene - in - Polythene	3.69 ± 0.04e
	Polythene - in - Hessian	3.79 ± 0.02ef
	Polythene - in - Paper box	3.89 ± 0.05f

Means followed by the same letter do not differ significantly ($P < 0.025$).

Table 4. Effect of temperature and packaging material on ash content of stored cocoa powder.

Temperature (° C)	Types of Package	Mean % Total Ash (± SD)
15	Polythene - in - Polythene	4.13 ± 0.03b
	Polythene - in - Hessian	4.15 ± 0.01c
	Polythene - in - Paper box	4.26 ± 0.02d
28	Polythene - in - Polythene	4.37 ± 0.02d
	Polythene - in - Hessian	4.40 ± 0.01d
	Polythene - in - Paper box	4.40 ± 0.04d
40	Polythene - in - Polythene	4.53 ± 0.02e
	Polythene - in - Hessian	4.62 ± 0.01e
	Polythene - in - Paper box	4.77 ± 0.03f

Means followed by the same letter do not differ significantly ($P < 0.025$).

Tables 5 and 6 show the variations in the percentage free fatty acid (F.F.A.) and iodine value of the treatments and control respectively. The percentage FFA was significantly higher ($P < 0.025$) in samples stored at 40° C than in those stored at 28 and 15° C. Cocoa samples stored at 15° C had the lowest percentage FFA when compared to those held at 28 and 40° C.

Moreover at any particular temperature, samples stored. In polythene-in-polythene package had slightly lower percentage FFA value in relation to those stored in other packages.

Table 5. Influence of temperature and packaging material on free fatty acid value (F.F.A.) of stored cocoa powder.

Temperature (° C)	Types of Package	Mean % FFA (± SD)
15	Polythene - in - Polythene	3.51 ± 0.06a
	Polythene - in - Hessian	3.54 ± 0.01a
	Polythene - in - Paper box	3.57 ± 0.5a
28	Polythene - in - Polythene	4.23 ± 0.01b
	Polythene - in - Hessian	4.60 ± 0.02d
	Polythene - in - Paper box	4.44 ± 0.04c
40	Polythene - in - Polythene	5.84 ± 0.06e
	Polythene - in - Hessian	6.02 ± 0.02f
	Polythene - in - Paper box	6.10 ± 0.06f

Means followed by the same letter do not differ significantly ($P < 0.025$).

Table 6. Effect of temperature and packaging material on the iodine value of stored cocoa powder.

Temperature (° C)	Types of Package	Mean % Iodine Value (± SD)
15	Polythene - in - Polythene	34.3 ± 1.53a
	Polythene - in - Hessian	35.67 ± 0.58ab
	Polythene - in - Paper box	34.33 ± 0.58a
28	Polythene - in - Polythene	36.33 ± 0.58b
	Polythene - in - Hessian	37.67 ± 0.58c
	Polythene - in - Paper box	36.67 ± 0.58b
40	Polythene - in - Polythene	38.33 ± 0.58d
	Polythene - in - Hessian	40.00 ± 1.00f
	Polythene - in - Paper box	39.33 ± 1.15f

Means followed by the same letter do not differ significantly ($P < 0.025$).

Similarly, cocoa samples stored at 15° C had significantly ($P < 0.025$) lower iodine value when compared to those stored at 28° C and 40° C. At the same temperature, samples stored in polythene-in-hessian and polythene-in-paper box packages had higher iodine value than those stored in polythene-in-polythene package.

Discussion

The higher the temperature of an environment, the lower the humidity and the higher its moisture absorbing capacity (Riley *et al.*, 1977). Also the nature of the package have effect on the quality of products. According to Guenott *et al.*, 1976), temperature, moisture, relative humidity and packaging are agents of deterioration in cocoa during storage. In the present study, the differences in the percentage moisture content values with respect to the different packages is noteworthy. Highest moisture content was recorded in treatments stored in polythene-in-polythene package. This is probably due to the hermetic nature of polythene material which prevented materials stored there in from giving off moisture.

The increase in percentage weight loss in treatments with incresed temperature may be due to loss of moisture. Experiment on long term storage of cocoa beans showed that loss of moisture was one of the many factors that caused weight loss (Cornes and Walker, 1961). Also there may be losses due to biochemical activities (Mejule and Lemeke, 1982). The temperature and relative humidity of the storage environment may also play a role in weight loss (Riley and Rolling, 1963). The higher the temperature of the store, the lower the humidity and the lower the moisture content of materials held

there in. This will manifest as loss in weight. In this study of all the samples, weight loss was highest in samples stored in polythene-in-paper boxes. This is probably because this type of package is less hermetic and thus there was possibility of moisture exchange.

The sharp increase in free fatty acid and iodine values with increased temperature could be traced to infection of some samples by mould. Although no mould identification nor quantification was carried out in this study, mould contamination was visible in treatments stored at 40oC. This could have caused the increase in free fatty acid. According to Sowunmi et al (1982), mould infection of crops during storage is responsible for the formation of free fatty acid which ususlly results in the production of rancid off flavours which leads to loss of quality and acceptability. Kuku (1979), reported that at low temperatures, activities of most moulds are reduced. This explains the lower free fatty acid value and hence lower iodine value associated with samples stored at 15 and 28° C. An increase in free fatty acid level of an oil would lead to increase in its iodine value (Gaillard, 1975). Since increase in temperature leads to increase in free fatty acid, storage of oil seeds at high temprature would therefore have a positive effect on its iodine value.

The present study reveals that powedered cocoa can be properly stored in hermetic materials such as polythene-in-polythene package at lower temperature of 15° C without significant quality deterioration. For effective use of these findings, cocoa powder for storage in hermetic packages should be properly processed and dried to the safe moisture level (4-5%) to prevent mouldiness.

References

Anon, 1975. Official Methods of Analyses 13th Ed. Association of Official Agricultural Chemsits, Washington D.C.

Cornes, M.A. and Walker, H.M. 1961. Long term storage of cocoa under polythene sheets. Rep. Nigerian Stored Prod. Res. Inst. 1960, 33-42.

Duncan, D.B. 1955. Multiple range and multiple F tests. In Biometric II. McGraw-Hill, New York, pp 1-42.

Fadamiro, H.Y. 1992. Quality assessment of cocoa, *Theobroma cacao* (L) stored in different packaging materials at different temperatures. M.Sc. Thesis, Federal University of Technology, Akure, 47pp.

Gaillard, T. 1975. Recent advances in Chemistry and Biochemistry of plant llpids. Academic press London, U.K.

Gerhadt, P.D. and Lindgren, D.L. 1954. Penetration of various packaging filsm by common stored products insects. Journal Econ. Entomol. 48, 282-287.

Guenott, M.C., Perritt, J.J. and Vincent, J.C. 1976. Development of the microflora and fatty acids by cocoa beans during storage. Preliminary study. Cafe cacao XX, 38-53.

Kuku, F.O. 1979. Some biodeteriorative effects of lipolutic mouls on vegetable oil Rep. Nigerian Stored prod. Res. Inst. 1977/78, 23-29.

Mejule, F.F. and Lemeke, R. 1982. Changes weight of cocoa during storeage Rep. Nigerian Stored Prod. Res. Inst. 1982, 137-142.

Riley, J. And Rollings, M.J. 1963. Temperature measurements in a large stack of bagged cocoa beans during two months storage. Rep. Nigerian Stored Prod. Res. Inst. 1963, 25-33

Riley, J. Cornes, M.A. and Wood, P.A.R. 1977. A study of the transporation of cocoa in container with special reference to moisture content. Rep. Nigerian Stored Product Res. Inst. 1973, 27-32.

Sowunmi , O., Fetuga, B.L. and Agboola, S.D. 1982. Changes in some chemical quality factors of oil of stored cowpea treated with insecticides. Rep. Nig. Stored Product Res. Inst. 1982, 53-61.

Wood, G.A.R. 1973. Cacao. Longmans Green & Co. London, U.K. 3rd Ed.