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Full Length Research Paper

Effect of drying method on the quality and storability of 'egusi' melon seeds (*Colocynthis citrullus* L.)

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The effect of sun-, oven-, smoke- and solar drying on the physicochemical properties and storability of melon seeds (*Colocynthis citrullus* L.) was investigated. Oven drying most significantly reduced the moisture content, followed by smoke drying and solar drying in decreasing order. The proximate composition of seeds was not significantly affected by the drying methods, but panelists most preferred the oven-dried seeds in the sensory analysis. Oven- and smoke dried seeds had the lowest incidence of diseased seeds, moisture content and level of *Aspergillus* spp. infestation and also recorded the highest seed germination and oil content in stores. The peroxide values and percentage free fatty acids were lowest in oven dried seeds, followed by the smoke dried seeds and the lowest in sun dried seeds. Thus, oven- and smoke drying could be used to dry melon seeds, particularly during the first season harvest when sun drying often proves difficult.

Key words: Drying method, melon seeds, quality, storability.

INTRODUCTION

Melon (*Colocynthis citrullus* L.) is a widely cultivated and consumed oil seed crop in West Africa. The seeds popularly called 'egusi' contain about 53% oil, 28% protein and some other important mineral nutrients (Oyolu, 1977; Abaelu, 1979). They are consumed in 'egusi soup', melon ball snacks and ogiri, (a fermented condiment) (Oyenuga, 1968; Odunfa, 1981). Melon seeds contain a fairly high amount of unsaturated fatty acid, linoleic acid (Girgis and Said, 1968) suggesting a possible hypocholesteronic effect. The oil expressed from the seeds is used for edible purposes (Ajibola et al., 1990), while the residual cake is fried and consumed as a snack. In some rural parts of southeastern Nigeria, the inhabitants mix milled seed with ground *Pleurotus tuber regium* and shape them into balls to substitute meat in their diet (Nwokolo and Sim, 1987).

One major problem that besets melon seeds is that it deteriorates quickly in storage due to fungal infection (Aboaba and Amasike, 1991; Bankole, 1993). The effect of fungal attack on melon seeds include decreased nutritive value, change in colour, increase in the peroxide value, reduced seed germination and mycotoxin production (Bankole et al., 1999; 2004a,b). The moisture content plays a vital role in the maintenance of seed quality in stores. Harrington (1972) observed that a 1% decrease in moisture doubles the life of seeds. To reduce quality loss in stored products, rapid drying to low moisture is often emphasized, because all scenarios leading to mould contamination and subsequent damage relate to non-maintenance of stored products at safe moisture content (Awuah and Ellis, 2002; Bankole and Adebanjo, 2003).

Most African farmers spread their harvests to dry under the sun, which require longer durations for the product to attain 'safe' moisture level. Conditions of high ambient relative humidity particularly during the period of the first season harvest (July to September) often result in extended drying times, which may affect the quality of the product. This often results in dust and foreign matter contaminating the produce with significant losses to rodents and birds. It has been demonstrated that considerable benefit in storage life could be gained by paying attention to seed drying and to store design and

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Table 1. Proximate composition (g per 100g dry wt) of melon seeds dried by different methods.

Parameters	Sun-dried	Oven-dried	Smoke-dried	Solar dried
Moisture	9.26±0.26a	6.24±0.41d	7.42±0.09c	8.68±0.17b
Protein	28.63±0.33a	28.55±0.53a	28.55±0.53a	28.28±0.49a
Fat	53.85±0.78a	53.33±0.52a	53.62±1.29a	52.92±0.88a
Ash	6.84±0.52a	6.92±0.28a	6.87±0.64a	6.99±0.80a
Crude fibre	5.27±0.14a	5.19±0.08a	5.25±0.36a	5.16±0.62a

Means of three determinations ± standard deviations.
Figures along horizontal lines followed by the same letter are not significantly different according to Duncan's' Multiple Range Test at the 95% confidence level.

management (O'Dowd and Dobie, 1983). The objectives of our study were to compare the traditional sun drying with other drying methods with regard to the quality and storability of melon seeds.

MATERIALS AND METHODS

Mature melon seeds variety 'Serewe' were harvested from the Teaching and Research farm of the Olabisi Onabanjo University in the last week of July 2001. The fruits were cracked with a pole and heaped to ferment for 7 days. Seeds were manually extracted from the fruits and washed.

The extracted seeds were sun-, oven-(50°C), smoke- and solar dried (50-60°C), at spreading loading of 4.5 kg/m^2. Sun drying was done by spreading the seeds on concrete floors. The hot air oven employed was Stuart Scientific oven, England. A flat plate solar drier having a black painted base and a glass on top of the cabinet was used. Sun- and solar- drying took place between 10.30 am and 5.30 pm daily till the seeds attained constant weight, but whenever there was rainfall, the seeds were covered with thick polyethylene bags. Oven-drying was done continuously, but smoke drying was carried out between 10.30 and 5.30 pm. For smoke drying, a wire mesh on which melon seeds were spread was placed 1.6 m above a burning wood fire, where the temperature was 52 to 62°C. The temperature and relative humidity were monitored with a thermohygrograph. Seeds were collected at intervals for the determination of moisture content, and the drying was terminated when the seeds had attained constant moisture. The moisture content was determined by oven drying 10 g of ground seeds in the oven at 105°C to constant weight.

The protein, fat, ash and crude fibre of the dried shelled seeds were analysed following the AOAC (1990) methods. The dried shelled seeds were assessed for colour, flavour and texture by ten semi-trained panelists (undergraduates) using a nine point hedonic scale, where 1 represents extremely disliked to 9 extremely liked (Larmond et al., 1991). The dried seeds were used to cook 'egusi' soup and the panelists also rated the taste and overall acceptability.

For each drying method, 10 kg of unshelled seeds were separately put in moisture-proof polypropylene sacks and securely tied at the mouth with a string. Seeds were loaded into three bags for each drying method, and the experiments were arranged in a completely randomized design. The seeds were stored under ambient conditions in a room and samples were taken immediately after bagging and on a monthly basis for 6 months. Sampling was essentially based on the method of Fan et al. (1976), whereby each bag was well shaken before drawing 300 g of seeds at a time. The indices used to determine storability were proportion of visibly diseased seeds (determined by scoring for presence of visibly mouldy and dicoloured seeds in 200 seeds per bag per sampling period) , moisture content , percentage of seeds infected with *Aspergillus* spp, seed germinability, oil content, peroxide values and the free fatty acid content.

To determine *Aspergillus* infection, 100 seeds were surface sterilized by immersion in 1% NaOCl for one minute and rinsed thrice with sterile distilled water, then ten seeds were placed on each of 10 plates of potato dextrose agar plus chloramphenicol, and incubated at room temperature (28±2°C) for 5-10 days. The percentage of seeds infected with *Aspergillus* spp. was counted (this genus is the most frequently associated with egusi melon in Nigeria (Bankole, 1993; Bankole et al., 2004b)

For the germination tests, moist sand was sterilized by drying at 150°C for 12 h, and filled into perforated pots. Three replicates of 100 seeds were put in the sand and incubated at 28±2°C. Germination was checked from 7-10 days. A seed was considered as germinated if normal seedlings emerged as described by AOSA (1981).

The peroxide value and the free fatty acid content of oil extracted from dried seeds was determined at the beginning and end of storage as follows. The oil in the ground seed samples was extracted with n-hexane for 6 h with a Soxhlet apparatus. The peroxide values of the extracted oil were determined according to the thiocyanate method (Pearson, 1970) while the free fatty acid content was determined titrimetrically by the method of Ogundero (1981).

For the statistical analysis, percentage values were transformed to the arcsine of the square root to normalize distributions, and data were analysed by the analysis of variance using the SUPERANOVA (Abacus Concepts Inc CA, USA) computer. The separation of treatment means was done using Duncan's multiple range tests (Peterson, 1985).

RESULTS AND DISCUSSION

The ambient temperature at the period of drying ranged from 25-32°C (mean 27.9°C), while the relative humidity fluctuated between 65-100% (mean 83%). The number of sunshine hours per day varied from 3 to 6 hours, mean of 4.3 h. The time taking for the seeds to attain constant weight was 26, 9, 11 and 18 h for sun, oven, smoke and solar-drying, respectively. For sun and solar drying, the drying was done over a period of 6 and 5 days, respectively, due to interruption by rainfall. The final moisture content is as shown in Table 1, and it was significantly lowest for oven-dried seeds, followed by that of smoke, and then solar-dried seeds, while it was highest in sundried seeds.

The results of proximate analysis showed that there were no significant differences in the chemical

Table 2. Sensory assessment of melon seeds dried by different methods.

Parameter	Sun-dried	Oven-dried	Smoke-dried	Solar dried
Colour	6.5±0.52a	6.7±0.35a	6.4±0.21a	6.2±0.37a
Flavour	6.9±0.50ab	7.5±0.45a	6.5±0.33b	7.1±0.45a
Texture	7.3±0.60a	7.4±0.30a	6.8±0.30a	7.3±0.67a
Taste	6.9±0.54a	7.0±0.73a	6.7±0.25a	6.7±0.44a
Overall qua	6.8±0.83a	7.1±0.25a	6.7±0.64a	6.7±0.28a

Data represent a nine point scale ranging from 1 (extremely disliked) to 9 (extremely liked).
Means of three determinations ± standard deviations.
Figures along horizontal lines followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 95% confidence level.

Table 3. Effect of drying methods on the incidence (%) of diseased seeds in melon seeds during storage.

Drying methods	Sampling period per month						
	0	1	2	3	4	5	6
Sun	0	0	6.7a	15.1a	27.3a	32.7a	44.5a
Oven	0	0	3.6b	7.4b	9.4c	12.3b	16.6b
Smoke	0	0	2.3b	5.2b	7.6c	13.5b	16.5b
Solar	0	0	5.3a	12.5a	21.8b	36.5a	47.7a

Figures along vertical lines followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 95% confidence level.

Table 4. Effect of drying methods on the moisture content (%) of melon seeds during storage.

Drying methods	Sampling period (months)						
	0	1	2	3	4	5	6
Sun	9.26a	10.3a	11.9a	11.2a	10.6a	9.4a	8.7a
Oven	6.24d	7.5b	9.3c	9.1b	8.7c	7.4c	6.5c
Smoke	7.42c	7.8b	10.1b	9.8b	9.4b	8.3b	7.7b
Solar	8.68b	10.9a	12.1a	11.6a	10.1ab	9.6a	8.6a

Figures along vertical lines followed by the same letter are not significantly different according to Duncan's' Multiple Range Test at the 95% confidence level.

compositions of the melon seeds subjected to different drying techniques (Table 1). Similar results were reported by Sanni et al. (1998), who observed that lafun (fermented cassava flour) subjected to various drying methods showed no appreciable differences in their chemical composition.

The panelists' assessments indicated that no significant differences were observed in the colour, texture and taste, but smoke drying imparted a slightly smoky flavour on the seeds (Table 2). For the overall acceptability, panelists most preferred the oven dried seeds, followed by sun dried seeds while the smoke- and solar dried seeds had the same rating of 6.7.

The percentage incidence of visibly diseased seeds was highest in solar dried seeds (47.7%), followed by sun drying (44.5%), while significantly lower values were recorded in oven- and smoke dried seeds after 6 months storage (Table 3). The incidence of diseased seeds has been found to be positively correlated to levels of mould and aflatoxin contamination contamination in stored melon seeds (Bankole et al., 2004). Table 4 shows that irrespective of the drying methods, the moisture content increased in the first two months, and thereafter declined. Oven dried seeds had significantly lowest moisture content followed by smoke dried seeds, while the highest moisture content was found in sun dried seeds (Table 4). The storage deterioration of melon seeds is significantly influenced by the moisture content, because the biodeteriogens require moisture for their activity (Bankole and Ikotun, 2002). The first two months of storage, September and October, fall within the rainy season with high relative humidity, thus the increased moisture content. However, the dry season started in November, thus the subsequent decline in moisture content. That the moisture content fluctuated with the prevailing weather in stored seeds indicates the inadequacy of woven polypropylene bags, which is the most widely used materials for storage of agricultural materials in Nigeria. This means that investigations must be conducted to find storage structures that will minimize moisture exchange of stored materials with the surroundings.

Table 5. Effect of drying methods on the percentage of melon seeds infected with *Aspergillus* spp. during storage.

Drying methods	Sampling period (months)						
	0	1	2	3	4	5	6
Sun	3a	3a	15a	30a	51a	47a	58a
Oven	3a	3a	6b	8b	13c	21b	28b
Smoke	4a	5a	9b	12b	22b	26b	34b
Solar	3a	4a	18a	33a	47a	49a	55a

Figures along vertical lines followed by the same letter are not significantly different according to Duncans' Multiple Range Test at the 95% confidence level.

Table 6. Effect of drying methods on germination (%) of melon seeds during storage.

Drying methods	Sampling period (months)						
	0	1	2	3	4	5	6
Sun	96.3a	95.7a	92.3a	79.2c	63.0c	58.3c	46.7c
Oven	96.7a	95.7a	94.0a	93.3a	88.3a	82.3a	75.7a
Smoke	94.3a	94.7a	92.7a	89.3ab	78.0b	72.7b	66.3b
Solar	95.7a	94.3a	93.3a	83.0bc	68.7c	57.3c	48.3c

Figures along vertical lines followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 95% confidence level.

Table 7. Effect of drying methods on the oil content (%) of melon seeds during storage Drying

Drying Methods	Sampling period (months)						
	0	1	2	3	4	5	6
Sun	53.4a	53.2a	51.3a	50.6a	48.4b	46.2b	42.3b
Oven	53.3a	53.4a	52.3a	52.4a	51.7a	50.4a	49.2a
Smoke	53.6a	53.4a	52.1a	51.9a	51.1ab	48.8ab	47.5a
Solar	52.9a	52.7a	51.5a	51.1a	50.3ab	47.7ab	44.3b

Figures along vertical lines followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 95% confidence level.

The percentage of seeds infested with *Aspergillus* spp progressively increased with time (Table 5). Oven dried seeds had significantly the lowest fungal infestation followed by smoke dried seeds. The isolation of *Aspergillus* spp. from melon seeds at the beginning of storage is in agreement with earlier reports (Bankole, 1998) indicating the presence of this genus in freshly harvested sun dried melon seeds.

Table 6 shows that the drying methods had no negative effect on the initial seed germination. The seed germination did not differ significantly in the first two months, but from the third month, it was significantly different for the various drying methods. For oven- and smoke dried seeds, germination decreased by 21% and 28% respectively after 6 months, whereas it declined by 49.6% in sun dried seeds. The decreased seed germination observed with time may have been due to the increased number of storage fungi, which can kill the seed germ due to increased metabolic activities by fungi (Sauer et al., 1992).

The oil content did not show any significant difference in the first three months of storage (Table 7). Thereafter, the oil content declined progressively at different rates, but the lowest decrease of 4.1% was recorded in oven-dried seeds, followed by smoke drying (6.1 %) after 6 months. The reduction in quantity and quality of oil in oil rich crop is due to consumption of oil by invading fungi (Chakrabarti, 1987). Storage fungi particularly *Aspergillus* spp have been reported to decrease the oil content in infected seeds (Eggins, 1963; Lalith, Vdyasekaran, Govindaswamy and Draiswamy, 1987).

The peroxide values which ranged from 3.13 to 3.67 meq/kg in seeds dried by various methods before storage increased to 16.17, 18.86, 31.28, 31.28 and 37.53 meq/kg with oven-, smoke-, solar- and sun drying, respectively, after 6 months. These findings agree with the report of Adebiyi Adebiyi et al. (2002) who also observed increased peroxide value in dry roasted groundnuts stored at different relative humidities for 3 months. It should however be pointed out that the peroxide values obtained for all the drying methods were lower than the 42-47 meq/kg at which oilseeds become unfit for human consumption (Evranuz, 1993).

The free fatty acid content of extracted oil from seeds

was 0.34 to 0.55% before storage but increased to 0.7, 0.9, 1.3 and 2.1% with oven-, smoke-, solar- and sun drying respectively. The free fatty acid results from the hydrolysis of the constituent glycerides in oil by lipolytic enzymes from moulds (Kuku and Adeniji, 1976), and is the most important criterion used in determining the market value of oil seeds.

The results of the present study show that oven- and smoke drying significantly decreased the moisture content of freshly harvested melon seeds compared to the traditional sun drying. These two methods (oven and smoke drying) did not alter the physicochemical attributes of melon seeds, and also resulted in improved storability of the seeds. Thus, these methods may be preferable for the first season harvest (July-August) in the rain forest belt of West Africa) when sun drying often proves very difficult due to the humid weather conditions (high relative humidity).

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