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Effect of Different Treatments on Keeping Quality of Pearl Millet Flour

Rashmi Kapoor & Amin C. Kapoor*

Department of Foods and Nutrition, Haryana Agricultural University, Hisar (Haryana) 125004, India

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ABSTRACT

*The flour of pearl millet (*Pennisetum americanum*) after different treatments, namely, addition of antioxidants (butylated hydroxyanisole, butylated hydroxytoluene and ascorbic acid), thermal treatment, defatting and salting was stored in earthen pots at prevailing room temperature (28 to 34°C) and relative humidity (60 to 80%) for 30 days. The flour was analysed periodically (10, 20 and 30 days) for keeping quality by chemical methods. The levels of peroxide and fat acidity increased and that of unsaturated fatty acids decreased during storage. The development of peroxides in antioxidant-treated flour samples was lower than other treated (thermal and salt) and untreated flour. Butylated hydroxyanisole and thermal treatments significantly retarded the increase in fat acidity values. The defatted flour had the lowest fat acidity and peroxide values, which did not vary during storage. The loss of unsaturated fatty acids was slightly less in flour treated with butylated hydroxyanisole and butylated hydroxytoluene. The proportion of unsaturated fatty acids remained almost constant in defatted flour. Microbiological examination of the flour samples revealed a considerable increase in fungal count while the bacterial count remained constant during storage. Butylated hydroxyanisole and ascorbic acid showed inhibitory effects against fungal growth.*

INTRODUCTION

Storage of pearl millet (*Pennisetum americanum*) flour is associated with the development of rancid taste and off-flavour. This has been attributed to its

* To whom correspondence should be addressed.

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high lipid content (7%) and a large proportion of unsaturated fatty acids (70%) (Rooney, 1978; Lai & Variano-Marston, 1980), which undergo oxidative and hydrolytic changes under the conditions of moderately high moisture and oxygen exposure during storage (Carnovale & Quaglia, 1973; Lai & Variano-Marston, 1980; Chaudhary & Kapoor, 1984). Until recently pearl millet was ground daily by housewives for their daily needs. But now, with the modernization and advancement of technology, large amounts of pearl millet are ground in power mills, which necessitates storage. Earlier studies in this laboratory indicated that pearl millet flour could be stored at 20°C and 70% relative humidity for 6, 7, 8 and 10 days in gunny sacks, earthen pots, tin cans and polythene bags, respectively, without affecting its acceptability (Chaudhary & Kapoor, 1984). Since the pearl millet flour has a short shelf-life, it is imperative to increase its storage life. Therefore the present study was undertaken to investigate the effect of different treatments on the keeping quality of pearl millet flour.

MATERIALS AND METHODS

Materials

Grains of cultivar HC-4 of pearl millet (*Pennisetum americanum*) obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar, were cleaned and ground to fine powder (60 mesh) in round milling stones (Chakki).

Treatments

The flour samples were given the following treatments immediately after grinding:

Addition of antioxidants
Three antioxidants, namely butylated hydroxyanisole (BHA—0·02%), butylated hydroxytoluene (BHT—0·02%) and ascorbic acid (0·5%), were mixed separately with three batches of flour as permitted by 'The Prevention of Food Adulteration Act and Rules of India, 1955'. The required quantity of antioxidants was first mixed by hand in a small portion of flour. The mixture was then added to the bulk flour and passed through a sieve several times to ensure uniform distribution.

Thermal
Flour was laid in a thin layer and kept in an oven maintained at 100°C for

1 h. This treatment was given to kill the micro-organisms already present in flour and also to inactivate the lipase.

Defatting
Defatting was done by keeping the flour in *n*-hexane for 12 h with occasional shaking and then decanting the excess *n*-hexane. The hexane to flour ratio was 10:1. The residual solvent was removed by drying the flour on filter paper at room temperature.

Salting
A lump of rock salt was kept inside the earthen pot containing flour. It is a common practice in villages of this area to keep a lump of salt in ground flour.

The treated and untreated flour samples were stored for 30 days at prevailing room temperature (28 to 34°C) and relative humidity (70 to 80%) in earthen pots of 2 kg capacity. In villages the earthen pot is mostly used for storing pearl millet flour. The samples were periodically (10, 20 and 30 days) analysed for different parameters.

Analytical methods
Peroxide value and fat acidity
For peroxide value determination, 5-g samples were mixed with 50 ml of chloroform in a homogenizer for 30 min. The peroxide value of filtrate was determined by the method of Tagaki *et al.* (1978). Fat acidity was determined by the AOAC rapid method (1980).

Fatty acid composition
Fatty acids in free lipids were determined by gas–liquid chromatographic analysis of their methyl esters. The free lipids were extracted by the method of Huber and Newman (1975) and methyl esters were prepared according to Luddy *et al.* (1968). The methyl esters so prepared were analysed by gas–liquid chromatography (Hewlett–Packard 5730A column, stainless steel 3 m × 0·32 cm packed with 20% diethylene glycol succinate and 60 to 80 mesh Chromosorb W). The column temperature was 190°C and nitrogen carrier gas flow rate was 35 ml min^{-1}. The tentative identification of the peaks was obtained by comparison with known fatty acids. Peak areas were calculated by multiplying the peak height by the width at half height and these were then converted into relative percentages.

Microbiological examination
The flour was mixed with sterile water in a vortex mixer in a ratio of 1:10 and allowed to stand for 5 min. From the supernatant, different dilutions were

made. One millilitre of proper dilution was transferred to Petri plates in duplicate. The plates were poured with plate count agar and potato dextrose agar, incubated at 32°C for 3 days and then colonies were counted.

Statistical analysis

The data were subjected to analysis of variance to know the significant differences among various treatments (Snedecor & Cocharan, 1967).

RESULTS AND DISCUSSION

Peroxide value

Peroxide value increased significantly ($P < 0{\cdot}05$) during storage (Fig. 1). The development of peroxides in antioxidant-treated flour samples was significantly ($P < 0{\cdot}05$) less than in the untreated flour samples. Thermal and salt treatments did not retard the peroxide formation during storage. The defatted flour had the lowest value, which did not vary during storage.

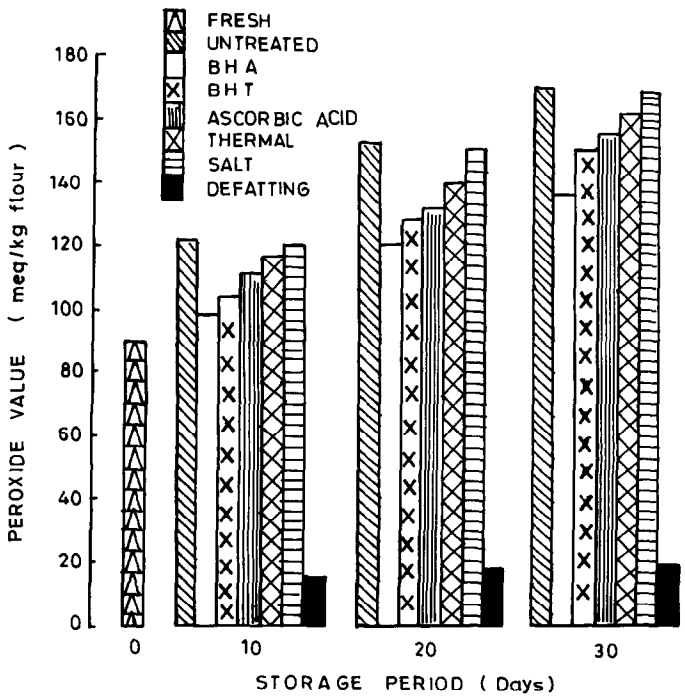

Fig. 1. Effect of different treatments on peroxide values of pearl millet flour (meq/kg dry flour).

Among the antioxidants, no significant differences were observed at 10 days, while at 20 and 30 days' storage periods peroxide formation in BHA-treated flour was significantly ($P < 0{\cdot}05$) lower than the BHT- and ascorbic acid-treated samples. BHA has been reported to be more effective than BHT in inhibiting the oxidation in mackerel skin lipids (Ke *et al.*, 1977). Also BHA prevented the development of peroxides in potato chips better than ascorbic acid (Kim & Kim, 1972).

Fat acidity

There was a significant ($P < 0{\cdot}05$) increase in fat acidity values during storage, the increase being more in untreated, BHT-, ascorbic acid- and salt-treated flour samples, and less in BHA- and thermal-treated samples (Fig. 2). The fat acidity values of BHA- and thermal-treated samples at all the three storage periods were significantly ($P < 0{\cdot}05$) lower than that of untreated and other treated (except defatted) samples. Since fat acidity is the measure of free fatty acids, the smaller increase in BHA- and thermal-treated flour samples shows that these treatments also retarded the hydrolytic rancidity

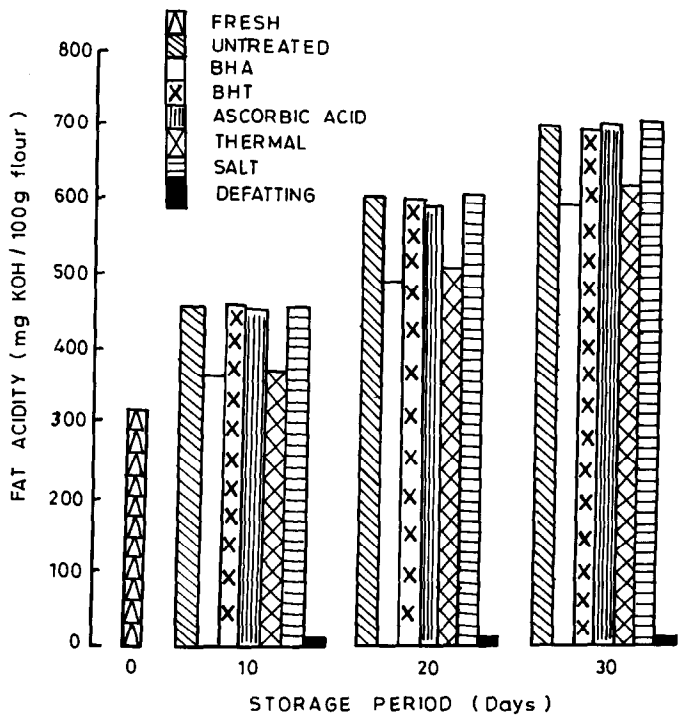

Fig. 2. Effect of different treatments on fat acidity values of pearl millet flour (mg KOH/100 g dry flour).

TABLE 1
Effect of Different Treatments on Fatty Acid Composition of Pearl Millet Flour
(% of free lipids)*

Fatty acids	*Fresh*	*Untreated*			*BHA*			*BHT*			*Defatting*		
		a	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
Saturated fatty acids													
Palmitic	21·9	23·1	25·4	26·9	22·8	23·2	24·5	22·9	23·1	24·2	22·2	21·8	21·8
Stearic	4·2	5·9	5·7	5·4	4·9	5·5	5·2	5·0	4·8	5·6	4·2	4·3	4·2
Total saturated fatty acids	26·1	29·0	31·1	32·4	27·7	28·7	29·6	28·1	29·0	31·0	26·5	26·2	26·1
Unsaturated fatty acids													
Oleic	27·8	27·3	26·6	26·9	27·4	27·3	27·4	27·5	27·2	26·6	28·6	28·5	27·8
Linoleic	41·4	40·1	38·9	37·9	40·7	40·5	39·7	40·5	40·2	39·0	40·3	40·7	41·3
Linolenic	4·5	3·4	3·2	3·0	4·0	3·3	3·1	3·9	3·4	3·2	4·4	4·4	4·6
Total unsaturated fatty acids	73·8	70·9	68·8	67·5	72·2	71·1	70·3	71·9	70·8	68·9	73·4	73·7	73·8

a 10 days' storage.
b 20 days' storage.
c 30 days' storage.
* The values are the average of three determinations.

during storage. These treatments do not appear to affect the rate of increase in fat acidity but rather decrease the absolute values by a fixed amount.

The lower fat acidity values in BHA-treated, compared with those of untreated flour, may be due to its antioxidant action, as BHA functions by donating its hydrogen atom to the free radicals formed during the initiation process of oxidation reactions (Dugan, 1976). This inhibits the subsequent formation of first oxidation products (hydroperoxides) which are further cleaved to hydroxy acids, keto acids, aldehydes and free radicals. The low value may be attributed to the decreased production of these acids. The other possibility of its retarding the lipolysis may be through its action as an antifungal agent. As is evident from Table 2, fungal count in BHA-treated flour was significantly ($P < 0.05$) lower than in untreated flour. The role of fungal lipases in carrying out the hydrolysis of fat in food products has been well established (Alford *et al.*, 1971). Similarly, lower values in thermal-treated flour may be due to partial inactivation of lipase responsible for hydrolysis of triglycerides. A smaller increase in free fatty acids during 8 weeks of storage has also been reported in pearl millet flour heated at 100°C for 2 h before storage (Pruthi, 1981).

Fatty acid composition

Linoleic, oleic and palmitic acids were the principal fatty acids in pearl millet flour (Table 1). Small quantities of linolenic and stearic acids were found and

TABLE 2
Effect of Different Treatments on Microbial Count of Pearl Millet Flour (number of colonies/g dry flour)

Treatments	*Bacterial count* ($\times 10^4$) *Storage period (days)*			*Mould count* ($\times 10^4$) *Storage period (days)*		
	10	*20*	*30*	*10*	*20*	*30*
Fresh flour		1·26			0·02	
Stored flour						
Untreated	2·80	3·24	4·30	0·14	0·74	3·80
BHA	2·00	2·24	3·50	nil	0·07	0·10
BHT	2·90	2·80	4·20	0·11	0·61	1·50
Ascorbic acid	1·60	1·46	2·60	nil	0·72	1·20
Thermal	2·00	2·18	3·40	0·09	0·30	1·10
Salt	2·20	2·29	2·80	0·13	0·63	2·40
Defatting	0·12	0·57	0·84	0·02	0·03	0·83
SEM	0·85	0·75	0·90	0·02	0·18	0·40
CD ($P < 0.05$)	2·4	2·18	2·81	0·07	0·54	1·2

traces of palmitoleic acid were also detected. During storage there was a gradual decrease in the unsaturated fatty acids in all flour samples except defatted. Since the fatty acid composition was determined on the basis of relative proportion of these fatty acids, the decrease in unsaturated fatty acids resulted in the relative increase in saturated fatty acids. The reductions in unsaturated fatty acids are indicative of oxidative changes.

The loss of unsaturated fatty acid was slightly less in flour treated with BHA and BHT. These treated flour samples also showed qualitative changes in fatty acid composition during storage. In BHA-treated flour, an unidentified peak (appeared after linolenic acid) was detected after all the three storage periods. The flour treated with BHT was found to contain small quantities of myristic acid after 20 and 30 days' storage, while it was not detected after 10 days' storage. The reasons for the qualitative changes in BHA- and BHT-treated flour samples cannot be explained. The changes in fatty acid compositions were similar in other treated (ascorbic acid, thermal and salt) flour.

Microbiological examination

Microflora affect the quality of cereal grains during storage. The possible roles of micro-organisms in bringing about hydrolytic and oxidative changes in food have been well established (Alford *et al.*, 1971).

Bacterial counts in untreated flour remained almost constant until 20 days but showed a significant ($P < 0{\cdot}05$) increase after 30 days of storage (Table 2). Except for defatting, the treatments had no significant ($P < 0{\cdot}05$) effect on bacterial growth. Mould count increased significantly ($P < 0{\cdot}05$) in untreated, BHT- and salt-treated flour at 10 to 30 days of storage. However, BHA and defatted flour had significantly ($P < 0{\cdot}05$) lower mould counts than did untreated flour after 10 to 30 days of storage whereas ascorbic acid showed an inhibitory effect until 10 days only. Thermal treatment also showed some inhibitory trend but it was not significant.

BHA has been reported to be effective in preventing mould growth (Branen *et al.*, 1980). At 0·02% BHA totally inhibited mould growth in low-fat products such as apple sauce or agar (Ahmed, 1979). The low microbial count in defatted flour may be due to washing and killing of microbial flora during the defatting procedure and, also, defatted flour may not be a suitable medium for the growth of micro-organisms.

CONCLUSION

The results of the present study reveal that the storage of pearl millet flour under studied conditions resulted in rapid alterations in lipid components

which increased with the increase in storage period and fungal growth. BHA treatment was able to retard both hydrolytic and oxidative decomposition, as is evident from the lower values of fat acidity and peroxide in BHA-treated samples. Thermal treatment was also found to be as effective as BHA in retarding hydrolytic decomposition. The other treatments, except defatting, had no effect in retarding the hydrolytic rancidity. The antioxidants inhibited the development of peroxides and BHA showed the maximum effect. No significant inhibitory effects were observed in thermal and salt treatments. BHA and ascorbic acid showed inhibitory effects against fungal growth. The defatted flour had the lowest values for fat acidity, peroxide, bacterial and fungal counts. Thus, of all the treatments, defatting was found to be best, followed by BHA and thermal treatment, in retarding the lipid degradation but it is not a practical proposition as it will involve the tedious procedure of removing the oil and will add to the cost of the product. Other treatments did not show any marked effects. The results further show that defatted flour could be stored up to 30 days without deterioration in keeping quality. BHA and thermal treatments were able to maintain the keeping quality of flour up to 10 days only.

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