Pak J Sci Ind Res 2002 45 (2) 124-129

Wheat Flour Preservation by Means of Packaging and its Statistical Evaluation

A D Khan, Nusrat Ejaz, M Yasin, Naheed Abdullah and Akmal Javed*

Biotechnology and Food Research Centre, PCSIR Laboratories Complex, Lahore 54600, Pakistan

(Received 17 September 1998; accepted 27 December 2001)

The wheat flour (atta) stored in conventional packaging materials i.e. jute (gunny), cloth, woven polyethylene threads bags which were in contact with air deteriorated more quickly than the wheat flour stored in air tight polyethylene acetate bags containing free oxygen absorber (FOA). The colour, taste, texture, flavour, acidity, organoleptic evaluation, insect and bacterial count remained acceptable for two months in polyethylene-acetate coated impermeable bags containing FOA and insect infestation was zero. These changes were due to anaerobic fermentation of starch in wheat flour. The statistical presentation of the data has been carried out.

Key words: Wheat flour, Storage, Packing material, Polyethylene, Statistics.

Introduction

Wheat is an important cereal and staple food for Pakistani people. This provides more than 70% of the total energy required in common man's diet. Thus it becomes major supplier of energy and protein. It is commonly ground into flour called "Atta" and other products such as fine flour, semolina etc. before being prepared as food. Thus wheat flour becomes an essential and important commodity for every house. The storage of wheat flour affects its nutritional value and bread quality (Green *et al* 1954), because if the wheat flour is stored improperly, it is liable to infestation by weevils and gets rancid due to fat. The moisture present in wheat flour environment and oxygen play an important role in development of rancidity in wheat flour (Rothe 1953). In our homes usually the wheat flour is stored for a shorter period and consumed within 15-30 days. But during emergency or people living in hilly areas at high altitude or far flung areas need storage of wheat flour for longer time. On prolonged storage of wheat flour it changes its colour and taste. Insect infestation also destroys wheat flour. The chemical changes coupled with insect infestation make the wheat flour unedible.

This project was started to increase the storage life of wheat flour by controlling the chemical changes and insect infestation. The objective was to provide such a packaging material which is easy to handle and increase the shelf life of wheat flour without destroying its nutritional value. Free Oxygen Absorber (FOA) (Mitsubishi 1998; Tanaka *et al* 2000) accomplishes the purpose of preserving the food quality by a simple method of merely placing the FOA within the packaging system (Saito 1979). It quickly removes oxygen from the pouch and protects the food from oxidation, insect attack and aerobic microorganisms. In the present study conventionally used wheat flour packging material i.e. cloth bags, gunny bags (jute bags), polyethylene, polypropylene with or without FOA were used. The study period lasted for eight months. The stored wheat flour was evaluated on the basis of acidity, colour, taste, texture, insect counts and total bacterial count, insect number and organoleptic evaluation during the study period.

*Author for correspondence

Materials and Methods

a) Materials. (1) Packaging materials used included cloth bags, jute bags (gunny bags), polyethylene bags, (purchased from local market), polyethylene chloride coated and oriented polypropylene (imported from Japan). (2) Wheat flour was purchased from a local flour mill. (3) Free oxygen absorbers (FOA) namely S-200 and Z-200 (imported from Japan) were used. Weighed quantity of wheat flour was packed in each bag upto 8 months, the air in each bag was expelled and packed by sewing the bag with cotton thread. Polyethylene and polypropylene bags were sealed hermetically after placing FOA packet in each bag.

The bags were stored in a well ventilated room, under natural conditions of temperature, humidity, light and ventilation.

b) Analysis. The analysis was carried out under the following parameters. (1) Physical analysis (2) Chemical analysis (3) Microbiological analysis (4) Organoleptic evaluation.

Physical analysis of the wheat flour samples was conducted including colour, texture, counting of eggs, larvae and adult weevils visually according to the methods as described by the Committee on Sensory Evaluation of Food (1964).

Moisture and percentage acidity (as lactic acid) was determined according to the methods of AOAC (1984). Microbiological examination of wheat flour was conducted for total viable count and molds. Total viable count was conducted on nutrient agar medium while molds were examined on malt extract agar medium (*Detroit 1948 a, b*).

For organoleptic evaluation, chapaties were cooked and taste evaluation was made by panel of six persons (Amerine *et al* 1965).

Moisture. The moisture content of all the samples was determined by drying in an oven at 105°C until constant dry weight was obtained.

Bacterial count. Saline solution 0.9% was prepared by dissolving 9.0 grams of sodium chloride in 1000 ml of distilled water. Nine ml of this solution was taken in test tubes and plugged. This solution was sterilized at 15 pounds pressure for 15 minutes at 120°C.

Preparation of inoculum. 1.0 gram of the sample was introduced in 9.0 ml of sterilized saline solution and was shaken well to dispense the microbes present in the sample in saline solution. 1.0 ml of this suspension was transferred aseptically to the next tube containing another 9.0 ml of saline solution, mixed thoroughly and marked. 1.0 ml of this suspension was transferred to the next 9.0 ml saline solution, mixed thoroughly and marked. Such three dilutions of each sample were prepared. 1.0 ml of each suspension was poured in duplicates in sterilized petri-dishes containing selective medium for bacterial count and mold count separately. The media were allowed to solidify and put in the incubator at 37° and 30°C for bacterial and mold growth respectively.

Acidity of flour. Acidity of flour initially and after storage period of packaging systems was determined by titration of water extracts.

Eighteen grams of flour were shaken with 200 ml. of CO_2 free water in a conical flask and placed in a water bath at 40°C for one hour with the flask loosely stoppered and then filtered. 10 ml of clear filtrate was titrated with 0.05 M sodium hydroxide solution using phenolphthalein as indicator. The acidity was calculated as lactic acid or potassium dihydrogen phosphate (1 ml 0.05 M, NaOH = 0.0068 g KH_2PO_4).

Statistical analysis. The data of the study was subjected to statistical analysis using the analysis of variance techniques using Completely Randomized Block Design (CRBD) according to methods of Steel and Torrie (1986), by two way classification i.e. effect of packing material and storage time on various parameters of stored wheat flour. The random observations thus obtained were assumed to follow the statistical model given below.

$$X_{ij} = \mu + D_i + e_{ij}$$

Where i = 1,2,3..... (number of packing material)
j = 1,2,3..... (number of stored months)
X_{ij} = jth observation on ith packing material
μ = Population mean
D_i = Effect of ith ration
e_{ij} = The random error associated with jth-observation on ith treatment.

It was further assumed that $e_{ij} \approx$ NID (0.62). The comparison of means was done by Duncan's multiple range test (Duncan 1955) at 5 percent level of significance.

Results and Discussion

Results of the study and the statistical analysis are shown in Tables 1, 2 and 3 and presented in Figs 1-6 showing the interaction of packaging material and storage time on various parameters of stored wheat flour.

Effect on colour of wheat flour. The variation in colour of wheat flour stored in various packing materials (1-7) is shown in Fig 1. The colour of wheat flour stored in conventional packing material i.e. gunny, cloth, polyethylene bags (PM1 to PM4) deteriorated more quickly than that stored in acetate coated polyethylene bags with oxyen absorber (PM5-PM7) over a period of eight months. When the data of colour were subjected to analysis of variance (ANOVA), significant (< 0.01) difference in colour preservation was observed (Table 1) due to packing material (PM), storage time (ST) and interaction of PM and ST (< 0.05). On DMR test, PM4 to PM7 showed non significant difference (NSD) in colour between these PM while SD in colour from other PM. PM1, PM2 showed NSD in colour, whereas PM3 showed poor quality colour than all packing materials.

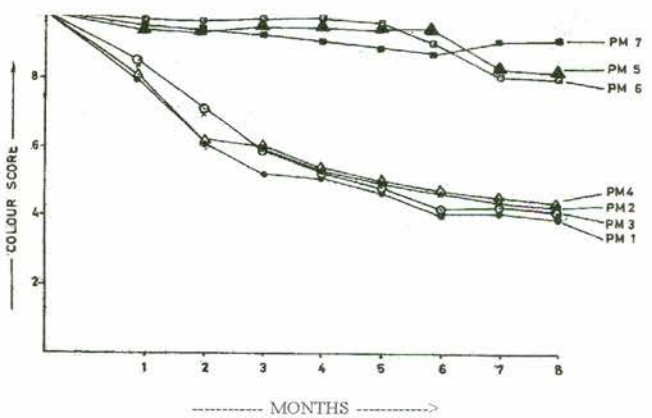
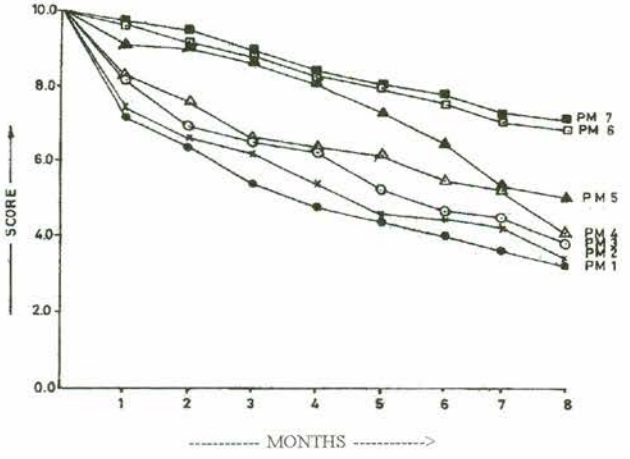


Fig 1. Colour score of wheat flour packed in various packing materials.

The results indicated that colour of wheat flour packed in conventional PM, which were in contact with atmosphere discolored. The PM which were impermeable showed better colour of wheat flour. Whereas all the PM which were impermeable and contained free oxygen absorber (FOA) namely S,F,Z showed best colour of wheat flour after eight months ST. The results of the study are in line with Barbera *et al* 1998.

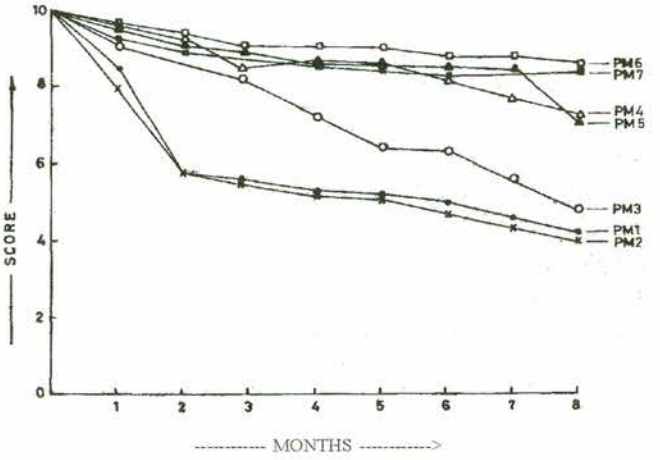
Effect on flavor of stored wheat flour. Results of the flavor of wheat flour packed in various PM are shown in Fig 2. Flavor of the wheat flour began to deteriorate in PM material PM1- PM4, after two months of storage. However wheat flour packed in PM6 and PM7 did not show rapid fall in flavor as compared to other PM. The data when subjected to ANOVA showed SD ($\leq 0.01\%$) in flavor due to PM, ST and PMxST (Table 1). The DMR test is shown in Table 3. Flavour of the wheat flavour packed in impermeable PM containing FOA retained good flour upto three months, whereas flavor of the wheat flour packed in all the other PM dropped rapidly, so much that after the third month the flavor of wheat flour was not good. This might be due to oxidation and heat damage to the starch and fat.

Effect on texture of stored wheat flour. Texture (Fig 3) of the stored wheat flour in packing material 4 to 7 scored the maximum point during storage period of eight months. The PM1 - PM3 showed poor texture during storage. The data of texture of wheat flour when subjected to ANOVA showed significant (≤ 0.1) differnece in texture due to PM, ST and PMxST (Table 1). The DMR test of means (Table 3) showed that the texture of the wheat flavour stored in packing materials 5, 6 and 7 were statistically non significant and significantly different from PM 4, 3, 2 and 1. Texture of wheat flour in PM1 and PM2 was similar and deteriorated more quickly than all other packing materials.



Effect on taste of stored wheat flour. In the cooked chapaties from the wheat flour stored in various packing materials (Fig 4), the taste of the wheat flour remained good upto two months. Then it began to deteriorate slowly and unpleasant taste was developed during eight months storage period. The ANOVA Table reveals that the taste of wheat flour was significant (≤ 0.01) due to PM, ST and PMxST. The means of the taste of wheat flour packed in various packing materials were compared by DMR Test (Table 3). The results indicated that all PM showed non significant difference in taste except PM6 which was significantly different from all other PM. However the taste of wheat flour in PM6 was also unacceptable after two months of storage which may be due to anaerobic bacteria or wheat flour amylases as were observed by Devlieghere *et al* (2000) and were controlled by addition of potassium sorbate.

Number of insects in stored wheat flour. Number of eggs, larvae and adult weevils (*Tribolium castraneum*) increased



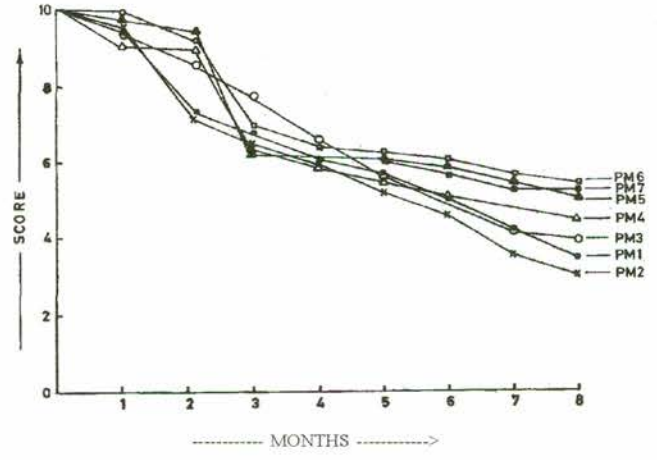


Table 1
Analysis of variance (ANOVSA) of wheat flour packed in various packing materials

Sr. No.	Source of variation	Degree of freedom	Mean Squares					
			Acidity (%)	Colour	Flavour	Taste	Texture	Bacterial count x 10^5
1.	Due to packing material (PM)	6	0.027**	81.305**	41.315**	4.946**	56.727**	32.788**
2.	Effect of storage time (ST)	7	0.013**	17.466**	31.586**	70.809**	13.707**	3.340**
3.	Interaction effect of PMxST	42	0.05*	0.912**	0.519**	0.681**	1.168**	1.534**
4.	Error	112	0.002	0.048	0.080	0.057	0.027	0.021

F & ab: C 0.01=3.18; C 0.05=4.11; * = significant $\leq$ 0.05; ** = significant $\leq$ 0.01

Table 2
Effect of storage period on acidity (lactic acid %), colour, taste, texture and bacterial count of wheat flour packed in various packing materials

Storage time	Acdity %	Colour	Flavor	Taste	Texture	Bacterial Count ($1x10^5$)
1 Month	0.0243 a	8.8810a	8.3667a	9.6095a	8.9571a	1.1381ab
2 Months	0.0310 a	7.8667 a	7.8143 ab	8.6619 b	8.2333 ab	0.9286 a
3 Months	0.0497 ab	7.4952 b	7.2286 bc	6.7571 c	7.8286 c	0.7286 a
4 Months	0.0357 ab	7.2476 b	7.7000 cd	6.2381 d	7.5810 c	0.8381 a
5 Months	0.0568 ab	6.9095 b	6.2810 cd	5.8048 e	7.4000 c	1.1381 ab
6 Months	0.0583 ab	6.7429 b	5.7714 e	5.3381 f	7.1190 c	1.6143 ab
7Months	0.0742 b	6.3000 b	5.4000 ef	4.7619 g	6.8905 c	1.5000 ab
8 Months	0.0985 bc	6.0333 e	4.7767 f	4.4286 g	6.3667 d	1.8476 b

Note: Same superscripts on means in a column show non-significant difference.

Table 3
Duncan's multiple range test (DMR) of wheat flour stored in various packing materials

Packing material (PM)	Acdity %	Colour	Flavor	Taste	Texture	Total Bacterial count ($1z10^5$)
Jute bags (PM1)	0.0849 b	5.5542 a	4.9583 d	6.0417 a	5.5500 a	3.4958 cd
Cotton bags (PM2)	0.1137 b	5.5125 ab	5.3625 cd	5.7250 a	5.400 a	1.8875 cd
Polythene bags (PM3)	0.0383 a	5.2458 c	5.7167 c	6.4167 a	7.1500 b	0.4750 a
Polyvinyl chloride coated (imported bags) (PM4)	0.0528 a	6.7125 d	6.1750 c	6.3667 a	8.3792 c	1.4167 b
Polyvinyl chloride coated (imported) + oxygen absorbers S-200 (PM5)	0.0294 a	9.0042 d	7.3500 b	6.7708 a	8.5750 d	3708 a
Polyvinyl chloride coated (imported) + oxygen absorber F-200 (PM6)	0.0278 a	9.1125 d	8.0870 a	6.9417 b	9.0917 d	0.5500 a
Polyvinyl chloride coated (imported) + oxygen absorber Z-200 (PM7)	0.0281 a	9.1500 d	8.1456 a	6.8875 a	9.6833 d	0.3208 a

Note: Same superscripts on means in a column show non-significant difference.

in conventional packing materials i.e. jute, cloth and plastic bags whereas the number of same insects decreased in airtight polypropylene packing material (PM 4-7). During the second month of storage the insect increased tremendously in conventional packing material. In the third month the population of these insects increased so much that they virtually spoiled all the wheat flour packed in the packing materials. The rest of packing materials showed zero growth of insects. They died in the airtight packing materials with oxygen absorbers.

The study was discontinued further because the results of three months storage clearly indicated that conventional packing material proved to be the best breeding place for wheat flour insects. Using mud bins for storage of wheat similar results were obtained by Shah *et al* (1989).

Total bacterial count (TBC). Total bacterial count of the wheat flour stored in various packing materials is shown in Fig 5. The TBC increased progressively with time (1-8 months) in packing materials 1, 2 and 4 whereas the wheat flour in PM 3, 5, 6 and 7 showed very little bacterial growth during storage period. On statistical analysis ANOVA (Table 1) the data showed significant (≤ 0.01) difference in TBC due to various packing material, storage time and packing material x storage time. The DMR test showed (Table 3), the TBC in materials 7, 6, 5 and 3 to be non significant and lower than other packing material, whereas maximum in the wheat flour packed in jute bags (PM1) and cotton cloth bags (PM2).

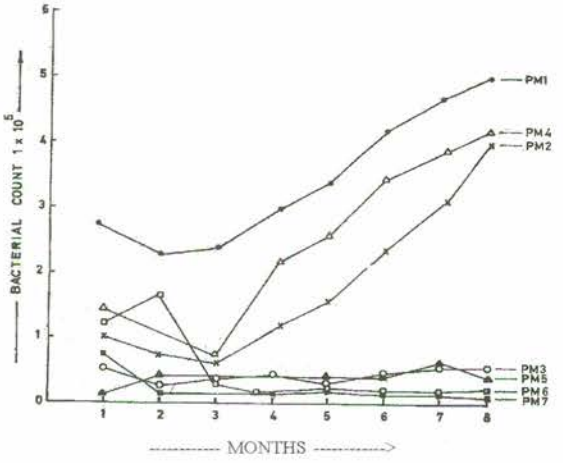


Fig 5. Total bacterial count ($1x10^5$) of stored wheat flour in various packing material.

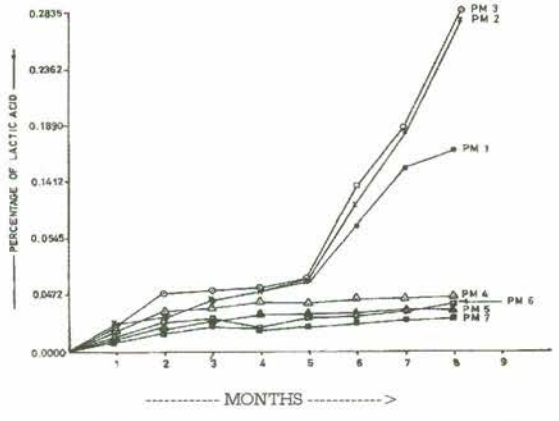


Fig 6. Percentage lactic acid in wheat flour store in various packing materials.

Development of acidity in stored wheat flour. The quantity of acid produced in wheat flour stored in various packing materials is shown in Fig 6. The data when subjected to statistical analysis ANOVA (Table 1) showed significant ($P<0.01$) difference in acidity due to various PM, ST and interaction of PMxST. The DMR-Test (Table 3) showed less acidity in all the polyethylene bags as compared to jute and cotton. The results indicated that contact of air with wheat flour was the main reason for acidity development. That is why the wheat flour stored in polyethylene and impermeable material and that containing FOA (PM5-7) developed less acidity as compared to all other PM. Conventional packaging material (PM1 to PM4) were not suitable for prolong storage of wheat flour or for easy transport, whereas polyethylen or acetate coated polypropylene with FOA showed better quality storage and shelf life. The insects and aerobic bacteria were well under control, as compared to conventional PM. But taste deterioration indicated that anaerobic bacterial fermentation of starch occurred.

References

AOAC 1984 *Official methods of Analysis,* Sidney William. Association of Offical Analytical Chemists, Arbington, Virginia **22** 200, 14th ed.

Amerine M A, Pangborn R M, Roessler E B 1965 *Principles of Sensory Evaluation of Food.* Academic Press Inc, New York.

Berbera Peres, Salvador, Artore Santaclren, Concepsion 1998 Bakery products with long shelflife. *Jpn. Kokai Tokkyo Koho JP* 1066, 503.

Committee on Sensory Evaluation of the Institute of Food Technologists USA 1964 *Food Technol (Chicago)* **18**. 1135.

Devlieghere F, Vermeiren L, Bockstal, Debevere J 2000 Study on antimicrobial activity of a food packaging material containing potassium sorbate. *Acta Aliment* **29**(2) 137-146.

Detroit 1948a *Difo Manual of Dehydrated Culture Media.* 8th ed, p 22-28.

Detroit 1948b *Difo Manual of Dehydrated Culture Media.*

8th ed, p 51-52.

Duncan D M 1955 New multiple range and multiple F Tests. Biometrics-II.

Green N, Jones C R, Moran T 1954 The quality of flour stored for periods upto 27 years. *Cereal Chem* **31** (50) 439.

Mitsubishi Gas Chemical Co. 1998 *Ageless oxygen absorber - A new age in food preservation.* Mitsubishi Gas Chemical Co Inc, Tokyo, p 1.

Saito M 1979 Food quality preservation by means of free oxygen absorber. *Soc for Study Food Quality Preservation* **1** 39.

Rothe M 1953 Bitterness of cereals; Lipids as reactants. *Fette U Seifen* **55** 877-880.

Shah F H, Shah W H, Kausar T 1989. Studies on the mudbin storage of wheat. *PJSIR* **32** 471.

Stanley D, Passpore R, Brock J G, Truswell A S 1975 *Human Nutrition and Dialetics.* The English Language Book Society, Churchil, Livingstone, 6th ed p 575.

Steel R G D, Torrie T H 1986 *Principles and Procedures of Statistics, a Biometrical Approach.* McGraw Hill Book Company, London, 2nd ed, 5th printing.

Tanaka, Hirokazer, Ishihara, Takao 2000 Packaging method for longer food preservation. *Jpn Kakai Tokkyo Koho Jp* 255, 647.