PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 9 (11): 1078-1083, 2010
ISSN 1680-5194

Bacteriological and Physico-Chemical Quality of Wheaten White Bread Flour Made for Nigerian Market

A.R. Akpe[1], P.O.A. Usuoge[2], O.I. Enabulele[3], F.I. Esumeh[1], H.A. Obiazi[1], I.N. Amhanre[1] and O.M. Omoigberale[1]
[1]Department of Microbiology, Ambrose Alli University, PMB 14, Ekpoma, Edo State, Nigeria
[2]Bendel Feed and Flour Mill, Ewu, Edo State, Nigeria
[3]Department of Microbiology, University of Benin, Benin City, Edo State, Nigeria

Abstract: Bacteriological and physico-chemical quality changes in wheaten white bread flour made for Nigerian market were investigated during storage at room temperature for four months. During storage, bacterial count decreased; between day 15 and day 105, count decreases from 45.0 X 10^3 cfu/g to 1.0 X 10^3 cfu/g for flour brand 1 and between day 60 and day 105, count decreases 12.5 X 10^3 cfu/g to 3.5 X 10^3 cfu/g for flour brand 3. Statistically, bacterial counts in the different brands of flour during storage show a significant difference. Total coliform count in flour brand 1 decreases d from 4.60 MPN/g (day 15) to zero (day 105) in storage. Significant count in coliform count was obtained for flour brand 1 and flour brand 2 but no significant difference was observed for flour brand 3 and 4 during storage. *Staphylococcus albus*, *Klebseilla pneumoneae* and *Bacillus subtilis* were detected and isolated. Lower pH of below pH 6.0 were recorded at day 105 for flour brands 1, 2 and 4 and the ash content of the various brands of flour was above 0.65% recommended for Nigerian flour with effect from day 90 of storage. Protein, gluten, fat, moisture, and carbohydrate contents were within the acceptable limit values for Nigerian flour.

Key words: Bacteriological, physico-chemical, wheaten, flour, bread

INTRODUCTION

Wheat flour is the clean, soft and dry product derived from milling or grinding of clean fully moistured wheat (*Triticum* species) grains (SON, 2000). Wheat is unique among the grain because it has the potential to produce gluten, a protein that gives dough its strength and elasticity; so it is an important element in the texture of baked food products.

More than 90% of the wheat flour we eat is white or refined flour, which consists of only the ground endosperm of the wheat kernel (Badsha *et al*., 2005). White flour is popular because it produce lighter baked good that whole-wheat flour and has unequaled ability to produce gluten.

There are several commercial grade of flour and flour is made from different blends of wheat. The composition of flours is therefore variable and varies from one region (country) to another. The 'all purpose' white flour, which is common in most countries, may differ according to geographic region, milling process and quality of the wheat (Quaglia, 1984).

The quality of the flour and storage condition after milling is very important in the shelf life of the flour. Wheaten white flour being, a food product with high nutritional content can harbour a variety of bacteria including pathogenic and non-pathogenic forms. As the vigorous cleaning processes to which wheat is subjected in the mill cannot remove all the bacteria, wheaten flour invariably possess a bacterial population derived from the grain. The number of bacteria present will be related to the bacteriological status of the wheat but also depends on the grade of the flour; high grade wheat flour (white flour) produced from the endosperm near the center of the kernels and which are soon removed from contact with the outer skin of the original site of the bacteria will contain significantly fewer bacteria than the low grade flours (Kent-Jones and Amos, 1967). Flour is susceptible to spoilage especially when stored improperly or for too long, it can develop an off flavour or even result in low quality product when used for baking. Hence most flour produced in temperate regions are required to be stored for short periods, for example, the shelf life used by most flour producing industries ranges between 3-4 months (Mashood *et al*., 2005). Changes in the physico-chemical properties of flour during storage have been widely documented (Sur *et al*., 1993; Kent-Jones and Amos, 1967; Hruskova and Machova, 2002). There is very little or no information on the Bacteriological and physico-chemical quality of flour in the Nigerian market. This survey is intended to augment the scarce information on the bacteriogical and physico -chemical quality of Nigerian flour.

MATERIALS AND METHODS

Sample collection: Freshly milled wheaten white flours ready for packaging were collected from four mills

Corresponding Author: A.R. Akpe, Department of Microbiology, Ambrose Alli University, PMB 14, Ekpoma, Edo State, Nigeria

located at Lagos, Sapele, Ewu and Kano, all in Nigeria. Two samples were collected from each location in clean polythene bags and properly sealed. The samples were taken to the laboratory where they are maintained at 28°C±2 and analyses at 15days interval for a period of 4 months to determine their bacteriological qualities and physico-chemical properties. This period was based on the assumed shelf-life of 3-4 months of the flour by the millers.

Bacteriological analysis: The various types and numbers of bacteria associated with wheaten white bread flour were enumerated and quantified according to the method described by Harrigan and McCane (1976). Ten fold serial dilutions were carried out and 1 ml of appropriate dilutions was aseptically plated on nutrient agar (Biotec) using the pour plate technique for total aerobic bacterial count. Emerging colonies were recorded as colony forming unit per gram.

The Most Probable Number (MPN) of coliforms in the samples were determined by weighing 10 grams of into 90ml of sterile distilled water from which the 3 sets of tubes of 10 ml MacConkey broth (double strength) were inoculated with 10 ml flour suspension, 3 sets of 5 ml MacConkey broth (single strength) with 1 ml flour suspension and another 3 sets of 5 ml MacConkey broth (single strength) with 0.1 ml of the flour suspension. All media were incubated at 35°C for 24 h. Positive tubes were noted and Most Probable number of coliform estimated using McCrady's probability table and recorded as MPN/10 g of sample. Emerging colonies on the nutrient agar were recorded as colony forming unit per gram (cfu/g).

Positive MPN tubes were subcultured onto fresh McConkey broth and Peptone water and incubated at 44°C for 24 h to detect the presence of *E. coli*. Indole test was carried out on the peptone water culture thereafter.

Characterization and identification isolates: Positive MPN tubes were subcultured to MacConkey agar and incubated at 37°C for 24 h. Thereafter discrete colonies from these and nutrient agar plates were characterized and identified using colonial, morphological and biochemical characteristics described by Vanderzannt and Splittoesser (1993).

Determination of physico-chemical properties of flour

pH: A pH meter (JENWAY 3310) was used to determine the pH of 10% suspension of flour in water after standardizing with buffer at pH 7. A standard buffer 7 powder was prepared into 200 ml solutions with distill and ionize in a volumetric flask. The buffer solution was poured into a beaker and the pH electrodes immersed in and regulated to stabilize at pH 7. There after, the electrodes were removed and introduced into the filtrate from the 10% flour suspension and allowed to stabilize and the final pH reading to be taken.

Moisture: Moisture content was determined using the dry oven method (Polmeranz and Meloan, 1996).

Gluten: Extraction of gluten was done according to the ICC (international cereal chemistry) -Standards No 106/1.

Protein: Analysis of protein content was done using the Kjeldahl method. The sample was heated in sulphuric acid and digested until the carbon and hydrogen are oxidized and the protein nitrogen is reduced and transformed into ammonium sulphate. The concentrated sodium hydroxide is added and the digest heated (distillate) to drive off the liberated ammonia into a known volume of standard acid solution. The unreacted acid is determined and the results are transformed by calculation with factor 5.7 into a percentage of protein in the flour sample.

Carbohydrate: This was estimated according to the ICC -standard No. 123, method for the determination of starch content by hydrochloric acid dissolution.

Fat: Extraction of fat was performed by the Soxtec method in automatic fat extraction unit using diethyl ether.

Ash: Determination of flour ash was carried out according to the ICC-standards No. 104, for the determination of flour ash at 900°C.

Statistical analysis: Changes in bacteriological and physico-chemical qualities over the duration of storage for the different flour brands were analyzed for statistical significance using the chi-square goodness of fit. Differences in the above qualities among the different flour brands were tested for statistical significance using the Single Factor Analysis of variance (ANOVA). Where significant differences were detected, the Duncan's Multiple Range (DMR) test was used to separate means on the basis of significance. All statistical tests were carried out using the "SPSS10.0 package".

RESULTS

Results of the Bacteriological and Physico-chemical changes of wheaten white bread flour produced for Nigerian Market during storage are shown in Tables 1-11 below. Moisture content of the various brands of flour ranges between 11.97% (brand 3) to 13.56% (brand 4) (Table 11). Total aerobic bacterial counts of the individual brands of flour decreases during storage (Table 1). Flour brands 1 shows a decrease from 45.0 x 10^3 cfu/g at day 15 to 1.0 x 10^3 cfu/g at day 105. Bacterial counts in the flour brands during storage show significant difference but no significant difference ($p = 0.27$) was noticed in average aerobic bacterial count

Table 1: Total aerobic bacterial count (CFU/g X 10^3) wheaten white bread flour during storage

Flour	Storage Periods								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	6.25±0.0	45.0±0.0	21.5±1.5	15.0±0.0	2.0±0.0	1.5±0.5	1.0±0.0	1.0±0.5	p<0.001
2	13.5±1.5	15.5±0.5	6.5±1.5	2.0±0.0	0.002	15.5±0.5	7.0±1.0	2.5±0.5	p<0.01
3	15.1±1.5	5.0±1.0	12.0±0.0	3.5±0.5	12.5±0.5	6.5±0.5	5.0±1.0	3.5±0.5	p<0.01
4	15.6±0.4	28.0±1.0	8.5±0.5	1.0±0.0	5.5±0.5	8±0.0	9.0±1.0	2.0±0.0	p<0.001

Note: p<0.01 = significantly different, p< 0.001 = highly significantly different

Table 2: Total coliform count (mpn/g) wheaten white bread flour during storage

Flour	Storage Period								
brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	11.0±1.0	4.1±0.0	4.6±0.0	4.4±0.2	4.4±0.2	2.5±0.1	1.5±0.5	No Growth	p<0.05
2	1.3±0.2	10.0±0.0	2.55±0.15	2.4±0.0	No Growth	1.05±0.05	1.5±0.05	2.0±0.0	p<0.01
3	1.5±0.0	No Growth	1.00±0.0	4.7±0.0	1.0±0.5	0.35±0.05	1.5±0.5	2.5±0.05	p<0.01
4	1.5±0.0	1.75±0.25	1.4±0.0	2.4±0.0	2.3±0.0	2.35±0.05	No Growth	No Growth	p<0.001

Note: p<0.05 = significantly different, p<0.01 = significantly different, p<0.001 = highly significantly different

among the various flour brands. Average bacterial counts in the different brands of flour ranges from 7.813 x 10^3 cfu/g (brand 2) to 11.565 x 10^3 cfu/g (brand 1) (Table 12).

Average total coliform counts for the various brands of flour ranges from 4.06MPN/g (brand 1) to 1.57MPN/g (brand 2) (Table 11) but shows no significant difference (p = 1.80). coliform counts of the individual brands of flour during storage show significant difference for brand 1 (Chi^2 = 142.596) and brand 2 (Chi^2 = 18.727) but no significant difference was detected in brand 3 and 4 (Table 2). Three bacterial genera were isolated (Table 3). The difference in the moisture content of the individual brands of flour is highly significant (p = 21.966) but there is no significant difference in moisture content of flour during storage. There was no significant difference (p = 0.479) in pH of individual flour. The pH ranges from 6.03 (brand 1) to 6.12 (brand 3) (Table 11). Protein and gluten content of the individual flour shows highly significant difference (p = 18.517). Protein and gluten for brand 2 is 11.47% and 10.23% and for brand 4 is 10.24 and 8.64 respectively. Gluten content correlates with the protein content. Carbohydrate content was between 65-66% in all the brands of flour with no significant difference (p = 0.248). Ash content increases for the individual brands of flour during storage, but statistically, there is no significant difference (Table 9). However, there is a high significant difference (p = 7.297) in the ash of the different brands of flour with the range of 0.56% (brand 1) to 0.80% (brand 4) (Table 11). Fat content of the different brand of flour ranges from 0.92% (brand 3) to 0.98% (brand 4), no significant difference (p = 0.915) in the fat content of the various flour brands.

DISCUSSION

Wheaten white bread flour is industrially milled and is expected to contain minimal microbial load. The flour however is not usually treated with any ant microbial agent, but the wheat from which the flour is gotten and the flour itself is subjected to vigorous screening and conditioning during processing. The screening and passage of the flour through the Entelator reduces the levels of vectors such as weevils, ants and maggots.

Statistically, average total bacterial counts from the different brands of flour showed no significant different (p = 0.27) but there was significance in the counts during storage, with flour brands 1 and 2 having a decrease in total bacterial count from 45.0 x 10^3 cfu/g and 15.5 x 10^3 cfu/g at day 10 to 1.0 x 10^3 cfu/g and 2 cfu/g at day 105 respectively. This correlates previous studies that bacterial count and pH values decrease during storage, (Kent-Jones and Amos, 1967). The intermittent decrease in aerobic bacterial counts in the flour brands (2, 3 and 4) can be associated with the decrease in pH and the decimal reduction in the moisture content of the flour. The sudden drop in pH from 6.14 (day 45) to 5.94 (day 60) in Brand 2 (Table 5) resulted to very few bacterial count (Table 1) in flour brand 2 at day 60. At day 105, flour Brand 3 has the highest bacterial count of 3.5 x 10^3 cfu/g compared to the other Brands. This could be attributed to the high pH value (above 6) of Brand 3 compared to the other Brands with pH value lower than 6.0. Brand 1 with pH of 5.64 has the bacterial count of 1.0 x 10^3 cfu/g at day 105.

Bacterial counts of the various flours at later period of storage (from day 90) (Table 1) were in the acceptable limit of 10^4 cfu/g for Nigerian white flour (SON, 2000).

Three bacterial isolates were identified; *Bacillus subtilis, Klebseilla pneumoneae* and *Staphylococcus albus* (Table 3). *Bacillus subtilis* was present in all the Brands and throughout the storage period. This is in agreement with previous study of Sorokulova *et al*. (2003) where they reported that about 10 strains of *Bacillus subtilis* are capable of surviving storage of flour and could actually cause roping in baked bread. During baking of the

Table 3: Bacteria associated with whiten white bread flour during storage

	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105
	Brands	Brands	Brands	Brands	Brands	Brands	Brands	Brands
Bacterial Species	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Bacillus subtilis	+ + + +	+ + + +	+ + + +	± ± ± ±	- - ± ±	± ± ± ±	+ + + +	± + + +
Klebseilla pneumoneae	± + + +	± ± - +	+ + + +	+ + + +	+ - ± +	+ + ± ±	+ + + -	- + + -
Staphylococcus albus	+ + - -	- - - -	- - - -	- - - -	- - - -	- - + ±	- - - -	- - - -

+ = Present, ± = Relatively present, - = Absent

Table 4: Changes in moisture content (%) of wheaten white bread flour during storage

Flour	Moisture content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	12.92±0.02	12.85±0.01	12.48±0.37	12.26±0.06	12.92±0.05	13.03±0.00	13.16±0.06	12.97±0.16	p>0.05
2	13.00±0.06	12.67±0.04	12.53±0.19	12.15±0.01	12.79±0.02	12.98±0.09	13.00±0.01	13.00±0.01	p>0.05
3	11.93±0.08	11.89±0.31	11.25±0.05	11.60±0.44	12.02±0.05	12.27±0.40	11.91±0.10	11.92±0.08	p>0.05
4	13.65±0.08	13.23±0.01	13.19±0.01	13.22± 0.02	13.71±0.03	13.82±0.13	13.80±0.07	13.85±0.00	p>0.05

Note: p>0.05 = not significantly different

Table 5: Changes in ph of wheaten white bread flour during storage

Flour	pH of flour at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	6.45±0.02	6.00±0.00	6.01±0.00	6.10±0.05	5.76±0.03	6.07±0.15	6.20±0.01	5.64±0.02	p>0.05
2	6.20±0.01	6.01±0.01	6.01±0.01	6.14±0.01	5.94±0.01	6.14±0.04	6.18±0.01	5.77±0.01	p>0.05
3	6.21±0.01	6.03±0.01	6.0±0.00	6.04±0.06	6.11±0.01	6.21±0.04	6.27±0.01	6.05±0.03	p>0.05
4	6.05±0.02	6.00±0.00	5.95±0.00	6.13± 0.01	6.09±0.03	6.14±0.03	6.14±0.02	5.89±0.08	p>0.05

Note: p>0.05 = not significantly different

Table 6: Changes in carbohydrate content (%) of wheaten white bread flour during storage

Flour	Carbohydrate content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	66.64±0.04	68.97±0.00	68.42±0.55	65.13±0.00	66.51±0.28	60.78±2.21	62.65±0.15	64.33±0.03	p>0.05
2	66.65±0.00	66.57±0.28	68.15±0.28	64.46±0.13	65.60±0.37	63.22±0.27	62.75±0.05	66.35±0.03	p>0.05
3	60.40±0.20	67.97±0.10	68.15±0.28	65.78±0.10	69.20±0.27	62.95±0.55	63.75±0.25	68.70±0.20	p>0.05
4	64.22±0.20	68.15±0.83	68.97±0.37	66.69±0.09	65.60±0.09	65.96±1.92	64.40±0.20	66.30±0.10	p>0.05

Note: p>0.05 = not significantly different

Table 7: Changes in protein content (%) of wheaten white bread flour during storage

Flour	Protein content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	11.65±0.04	11.27±0.03	11.55±0.00	11.45±0.05	11.49±0.02	11.46±0.06	11.44±0.05	11.38±0.02	p>0.05
2	11.35±0.00	11.60±0.07	11.64±0.05	11.45±0.03	11.45±0.05	11.50±0.02	11.34±0.04	11.45±0.05	p>0.05
3	11.10±0.05	11.24±0.13	11.41±0.06	11.48±0.08	11.18±0.02	11.21±0.01	10.98±0.01	11.03±0.02	p>0.05
4	9.93±0.08	10.09±0.01	10.36±0.01	10.12± 0.07	9.96±0.04	10.02±0.02	9.96±0.02	9.85±0.05	p>0.05

Note: P>0.05 = not significantly different

dough, the vegetative forms of bacteria that are present or all but a few of them will be killed in most circumstances. Bacterial spores are much more resistant and even when the middle of the loaf attains 110^{0}C the maximum, a significant number survives. When the bread is cold and conditions become favourable, the spores develop into vegetative forma and continue their activity and the bread will become 'ropy'. The stickiness and ropiness of the diseased bread is due to the production by the organisms of gums and sugars from the starch (Kent-Jones and Amos, 1967; Sorokulova *et al*., 2003).

There is no significant difference in the average total coliform counts in the different (p = 1.885) brands of flour (Table 11). Average total coliform counts for the different brands of flour ranges from 1.57MPN/g (brand 3) to 4.06MPN/g (Brand 1) (Table 11). However, there was intermittent decrease in coliform count in the flour brands. Brand 1 shows a decrease from 11.0MPN/g (day 0) to no growth at day 105. The gradual decrease in the total coliform count as the storage progresses corresponds with the previous study of Kent-Jones and Amos (1967) that during storage of flour, bacterial count decrease with the blood (Pathogenic) organisms dying off. Coliform is an indicator of contamination, findings revealed that the bulk of wheat imported to Nigeria for flour production are usually contaminated from the field and even the vigorous screening process of the wheat in

Table 8: Changes in gluten content of wheaten white bread flour during storage

Flour	Gluten content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	10.40±0.00	9.96±0.05	10.00±0.00	9.75±0.15	9.68±0.16	10.02±0.02	10.00±0.00	9.90±0.01	p>0.05
2	10.05±0.00	9.98±0.02	10.02±0.02	10.04±0.00	10.28±0.08	10.02±0.02	10.01±0.01	10.05±0.05	p>0.05
3	10.09±0.06	9.95±0.05	10.00±0.00	10.10±0.00	10.00±0.02	10.25±0.05	10.15±0.05	9.98±0.08	p>0.05
4	8.94±0.14	8.90±0.15	8.75±0.25	8.50±0.00	8.55±0.05	8.50±0.00	8.55±0.05	8.45±0.05	p>0.05

Note: p>0.05 = not significantly different

Table 9: Changes in ash on dry matter content of wheaten white bread flour during storage

Flour	Ash on dry matter content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	0.60±0.00	0.61±0.02	0.63±0.01	0.64±0.01	0.59±0.02	0.62±0.00	0.67±0.01	0.67±0.02	p>0.05
2	0.50±0.00	0.62±0.00	0.65±0.01	0.65±0.01	0.60±0.02	0.65±0.02	0.69±0.01	0.66±0.01	p>0.05
3	0.68±0.02	0.69±0.01	0.70±0.00	0.73±0.03	0.67±0.03	0.71±0.02	0.69±0.01	0.71±0.01	p>0.05
4	0.74±0.03	0.76±0.03	0.79±0.07	0.84±0.04	0.78±0.06	0.81±0.04	0.83±0.05	0.88±0.03	p>0.05

Note: p>0.05 = not significantly different

Table 10: Changes in fat content (%) of wheaten white bread flour during storage

Flour	Fat content (%) at								
Brands	DAY 0	DAY 15	DAY 30	DAY 45	DAY 60	DAY 75	DAY 90	DAY 105	significant
1	0.92±0.00	0.94±0.04	0.93±0.01	0.95±0.01	1.08±0.01	0.84±0.03	0.92±0.01	0.93±0.01	p>0.05
2	0.95±0.01	1.04±0.01	0.85±0.01	0.87±0.01	1.08±0.02	0.95±0.04	0.86±0.01	0.88±0.03	p>0.05
3	1.07±0.00	0.86±0.04	0.83±0.03	0.81±0.01	1.05±0.01	0.89±0.06	1.02±0.03	0.84±0.02	p>0.05
4	1.02±0.02	0.95±0.02	0.94±0.03	0.94±0.02	1.02±0.02	1.02±0.02	1.04±0.01	0.94±0.02	p>0.05

Note: p>0.05 = not significantly different

Table 11: Average summary on quality evaluation of individual brands of flour

Parameters	Brand 1 Mean±SD	Brand 2 Mean±SD	Brand 3 Mean±SD	Brand 4 Mean±SD	significant
Moisture	12.82^{b}±0.11	12.77^{b}±0.31	11.97^{a}±0.58	13.56^{c}±0.29	p<0.001
pH	6.03±0.09	6.07±0.04	6.12±0.04	6.05±0.03	p>0.05
Carbohydrate	65.31±0.97	65.46±0.65	65.87±1.13	66.26±1.12	p>0.05
Protein	11.46^{b}±0.04	11.47^{b}±0.04	11.09^{b}±0.15	10.24^{a}±0.11	p<0.001
Gluten	9.96^{b}±0.08	10.23^{b}±0.37	10.28^{b}±0.48	8.64^{a}±0.19	p<0.001
Ash	0.56^{a}±0.07	0.63^{b}±0.06	0.69^{c}±0.07	0.80^{c}±0.02	p<0.001
Fat	0.94±0.02	0.94±0.03	0.92±0.04	0.98±0.11	p>0.05
Bacterial count (X 10^{3} CFU/g)	11.66±5.47	7.81±2.22	7.89±1.62	8.86±3.41	p>0.05
Coliform count (MPN/g)	4.06±1.15	2.60±3.10	1.57±1.48	1.59±1.03	p>0.05

Note: Those with similar alphabet are not significantly different from each other. p>0.05 = not significantly different, p<0.05 = significantly different, p<0.001 = highly significantly different

the mill may not be able to remove all the coliforms. Total coliform count for flour is expected not to be above 100cfu/g (SON, 2000).

The average fat content in the different brands flour shows no significant difference (p = 0.915) (Table 10). The value obtained for fat is acceptable as regarded <1.5% fat content for Nigerian white wheat flour (SON, 2000). Intermittent decrease was noticed in the protein content of the various brands of flour during storage. Flour brand 4 shows decrease in protein content from 10.02% (day 75) to 9.85% (day 105) and flour brand 2 shows a decrease in protein content from 11.64% (day 30) to 11.34% (day 90). The decrease noticed in the protein content of the flour corresponds with earlier reports that protein content flour decreases during storage (Sur *et al*., 1993; Hruskova and Machova, 2002). The changes in protein content of the flour was however not significant, but average protein content for the individual brands of flour shows highly significant difference (p = 18.517) with brand 1 having 11.46% and brand 4; 10.24% (Table 11). Gluten content was seen to correlate with the total protein content as it also decreased slightly with storage (Table 8 and 11). This finding corresponds with previous reports of Sur *et al*. (1993) and Hruskova and Machova (2002).

Conclusion: Dough functionality depends on its chemical composition as well as on the micro-floral activity (Vazquez-Chavez and Guerrero-Lagarreta, 2002). The acceptability of a food item depends on the availability of durable and measurable quality indices. The finding despite the effort put by the flour millers to observe the standards as recommended for Nigeria wheat flour grade, there seemed to be continuous problem of bacteriological and physico-chemical qualities. The data revealed that brand 4 is low-grade flour made from low-grade wheat, though it has physico -chemical properties other than ash within the acceptable limit value of Nigerian market.

Table 12: Summary on quality evaluation of individual brand of flour

Parameters	Brand 1 Mean±SD	Brand 2 Mean±SD	Brand 3 Mean±SD	Brand 4 Mean±SD	Significant
Moisture	12.82b±0.11	12.77b±0.31	11.97a±0.58	13.56c±0.29	P<0.001
pH	6.03±0.09	6.07±0.04	6.12±0.04	6.05±0.03	P>0.05
Carbohydrate	65.31±0.97	65.46±0.65	65.87±1.13	66.26±1.62	P>0.05
Protein	11.46b±0.04	11.47b±0.04	11.09b±0.15	10.24a±0.11	P<0.001
Gluten	9.96b±0.08	10.23b±0.37	10.28b±0.48	8.64a±0.19	P<0.001
Ash	0.56a±0.07	0.63b±0.06	0.69c±0.007	0.08c±0.02	P<0.001
Fat	0.94±0.02	0.94±0.03	0.92±0.04	0.98±0.02	P>0.05
Bacterial count	11.66±5.47	7.81±2.22	7.89±1.622	8.86±3.41	P>0.05
Total Coliform	4.06±1.15	2.60±3.1	1.57±1.48	1.59±1.03	P>0.05

Note: Those with similar alphabet are not significantly different from each other. P>0.05 = Not Significant. P<0.001 = Highly Significantly Different

The finding of *Bacilus* and *Klebseilla* species throughout the storage period revealed that more effort is required by the millers on their diligence to minimize microbial load and thus increase the shelf life of the bread flour. Adequate monitoring of wheat from source of purchase to delivery will go a long way on reducing the contamination of wheat before getting to the mill.

REFERENCES

Badsha, K. A., J. Abdul, K. Maazulla, B. Nizakat, C.M. Ashraf and K. Saeed, 2005. Evaluation of physical and chemical characteristics of newly evolved wheat cultivars. J. Sci. Food and Agric., 85: 1061-1064.

Harrigan, W.F. and M.E. McCane, 1976. Laboratory Methods in Food and Dairy Microbiology. Academic Press, New York, pp: 452.

Hruskova, M. and D. Machova, 2002. Changes of wheat flour properties during short-term storage. Czech J. Food Sci., 20: 125-130.

Kent-Jones, D.W. and A.J. Amos, 1967. Modern Cereal Chemistry. Food Trade Press, London.

Mashood, S.B., N. Muhammad, A. Saeed and S. Kamran, 2005. Effect of moisture and packaging on the shelf life of wheat flour. Int. J. Food Safety, 4: 1-6.

Polmeranz, Y. and C.E. Meloan, 1996. Food Analysis; Theory and Practice. Third Edition. CBS Publishers and distributions (India), pp: 575-684.

Quaglia, G.B., 1984. Scienza e Technologia della Panificazione. Pinerolo Chiriotti, Italia.

SON (Standards Organization of Nigeria), 2000. Standards for Wheat Flour. NIS: 121.

Sorokulova, I. B., O.N. Reva, V. Smirnor, I.V. Pinchuk, S.V. Lapa and M.C. Urdaci, 2003. Genetic diversity and involvement in bread spoilage of Bacilllus stria isolated from flour and ropy bread. Letters in Appl. Microbiol., 37: 169.

Sur, R., H.P. Nagi, S. Sharman and K.S. Sekhon, 1993. Storage changes in the quality of sound and sprouted flour. Plant Foods Hum. Nutr., 44: 35-44.

Vanderzannt, C. and O.F. Splittoesser, 1993. Compendium of Methods for the microbiological Examination of Foods. 3rd Edn. American Public Health, Washington, D.C., pp: 60.

Vazquez-Chavez, L. and I. Guerrero-Lagarreta, 2002. Microbial population and bread making properties of wheat-amaranth sour doughs. Food Microbiology-General 1: Annual Meeting and Food Expo. Anahein, California.