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Effect of Water Activity (a_w), Moisture Content and Total Microbial Count on the Overall Quality of Buns

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Abstract. A study was conducted on the effect of moisture content, water activity (a_w), and total microbial count on the overall quality of branded buns (S_1, S_2, S_3) and buns produced by cottage bakeries (S_4, S_5, S_6), over a period of 5 days. The samples were stored at 12-25 °C and evaluated for water activity, moisture content and total microbial count, fortnightly. The percent moisture content of S_1 (35.5), S_2 (33.0), S_3 (36.5), S_4 (34.3), S_5 (34.8) and S_6 (36.5) increased to 43.3, 37, 40.7, 44.2, 40.5 and 42.2%, respectively, while the a_w values of these increased from 0.950 to 0.988 during storage. Minimum microbial growth was observed in S_2 (42.6 cfu/g), while maximum in S_4 (147.6 cfu/g). The branded bun S_2 had the highest overall acceptability with regard to its organoleptic quality. Statistical analysis showed that storage had a significant effect ($p < 0.05$) on a_w, moisture content, microbial growth and organoleptic quality of the two categories of buns studied.

Keywords: bun, water activity, microbial growth, cottage bakery, industrial bakery

Introduction

Buns, a rich source of carbohydrates, proteins and vitamins, are a sweet dough product fermented with yeast (*Saccharomyces cerevisiae*). The dough is sweeter and richer than the one used for soft rolls. Its richness may vary from one bake shop to another, and the naturally richer dough results in a bun of better quality. It is used for burgers in the fast food outlets in many countries (Sultan, 1976). A bun weighing 100 g, generally contains 8 g protein, 1 g fat, 56 g carbohydrates, 490 mg sodium, 115 mg potassium, 24 mg calcium, 109 mg phosphorus, 0.7 mg iron, 70 μg vitamin B_1, 35 μg vitamin B_2, and 0.9 mg niacin, yielding about 265 kcal energy per 100 g bun (Pomeranz, 1987).

Water, whether in free or bound state, is present in buns at levels that may vary with different techniques of production. The free water content of foods accounts for the survival and growth of microorganisms leading to their deterioration. It is well known that a highly reduced water regime is a form of preservation, as foods with high water content are liable to undergo deteriorative changes. Many earlier reports of the correlation between water activity (a_w) and food deterioration are available in literature (Breene *et al.*, 1988; Labuza *et al.*, 1972; Chichester *et al.*, 1963). Food does not spoil from microorganisms when the a_w is controlled around or below 0.7. To successfully preserve a food product, the a_w must be lowered to a range of 0.67-0.57 to minimize other deteriorative reactions (Ayub and Shah, 2002).

The present study was undertaken to draw a comparison between industrially produced branded products and the buns prepared locally by different cottage-scale bakeries in Peshawar, Pakistan. The study considered such aspects as the sensory qualities and microbial load with respect to its moisture content and a_w, to beware the consumers on the nutritive and hygienic quality, and shelf-stability of the products that they consume.

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Materials and Methods

Fresh buns produced on industrial scale (S_1, S_2, S_3, respectively, Wonder bun, Morning bun, Dawn bun), and by the local cottage bakery (S_4, S_5, S_6, respectively, Man-o-Salwa, United Bakers, Shireem Mehal Bakers) were collected from the market for different physicochemical analyses. Water activity (a_w) of the selected fresh buns and after storage was determined in accordance with Landrock and Proctor (1951). Saturated salt solutions of KNO_3, $BaCl_2$, $ZnSO_4$, $K_2Cr_2O_4$, $(NH_4)_2SO_4$, NaCl, NaBr and $MgCl_2$ were prepared. The bun samples were equilibrated for 48 h against the saturated salt solutions at 25 °C in equilibration cells (Zeb, 1998; Lang *et al.*, 1981). The a_w of the bun samples was determined by recording data of water loss or gain per g sample. The graphic interpolation of the data at zero gain or loss gave a_w of the product. Moisture content was determined using the air oven method at 105±1 °C (AOAC, 1984). The total fungal count was done by the total plate count method (Diliello, 1982). The buns were evaluated for colour, flavour and texture by a panel of ten judges. Flavour was detected as described by Mayer (1960), while sensory evaluation was carried out on the 9-point Hedonic Scale (Larmond, 1977). The data obtained were statistically analysed using the three factor factorial design according to Steel and Torrie (1980).

Results and Discussion

Results of the present study showed that the moisture content of all the bun samples increased significantly ($p < 0.05$) from 35.14% to 41.37% during 5 days of the storage (Table 1). Minimum increase was observed in sample S_3 (11.73%) followed by sample S_2 (12.12%), while maximum increase was observed in sample S_4 (29.02%) followed by sample S_1 (22.73%). Minimum mean values for moisture content (Table 2) were observed in sample S_2 (34.76) followed by sample S_5 (37.36), while maximum mean values were observed in sample S_4 (40.49) followed by sample S_1 (39.23). In a similar study Pomeranz (1987) reported that bun moisture content increases during storage from 32 to 35%.

Water activity. The water activity (a_w) plays an important role in bakery products. Each microorganism has its own range of a_w for growth under a given setup of environmental conditions. Our results showed that a_w increased in all samples during storage. The overall mean values increased from 0.950 to 0.988 in all samples (Table 1). Minimum mean a_w values were recorded in sample S_2 (0.950, Fig. 1a), S_1 (0.960, Fig. 1b) and S_3 (0.962, Fig. 1c), (Table 2), while maximum mean values were recorded in S_5 (0.991) followed by S_6 (Table 2). Maximum increase in a_w values were recorded in sample S_3 (6.55%) followed by S_2 (5.41%). Buns having low a_w range (0.942-0.95) are less susceptible to the growth of microorganism (Fett, 1973). The a_w of bun can be reduced from 0.96 to 0.949 by adding some water binding solutes or increasing salt content from 8 g to 24 g/kg in the flour (Lambard *et al.*, 2000).

Microbial count. The total fungal count of treatment S_1 increased from 0 cfu/g to 183 cfu/g. Treatment S_2, S_3 and S_4 also showed an increase from 0 to 91, 178 and 291 cfu/g respectively during storage. Same increase in microbial population was observed in sample S_5 (12-279 cfu/g) and sample S_6 (28-239 cuf/g). Comparatively sample S_2 had lowest microbial population (43.6 cfu/g) followed by S_1 (81.6), and S_3 (87.8) (Table 2). Maximum increase in microbial population was

Table 1. Average mean values of buns during five days storage study

	Day 1	Day 2	Day 3	Day 4	Day 5
Moisture (%)	35.14^{e}	36.73^{d}	38.06^{c}	39.62^{b}	41.37^{a}
Water activity (a_w)	0.95^{d}	0.963^{c}	0.969^{bc}	0.978^{b}	0.988^{a}
TMC (cfu/g)	6.66^{e}	48.66^{d}	99.16^{c}	157.83^{b}	210.16^{a}
Colour	7.933^{a}	7.533^{b}	6.95^{c}	6.4^{d}	5.483^{e}
Texture	7.967^{a}	7.467^{b}	6.95^{c}	6.383^{d}	5.517^{e}
Flavour	7.85^{a}	7.25^{b}	6.717^{c}	6.167^{d}	5.35^{e}

figures in rows with different small letters are significantly different ($p < 0.05$); TMC = total microbial count (cfu = colony forming units)

Table 2. Average mean values of buns for all treatments

Treatments (→)	S_1	S_2	S_3	S_4	S_5	S_6
Moisture (%)	39.23^{b}	34.76^{e}	38.22^{c}	40.49^{a}	37.36^{d}	39.07^{b}
Water activity (a_w)	0.960^{d}	0.950^{e}	0.962^{d}	0.973^{c}	0.991^{a}	0.982^{b}
TMC (cfu/g)	81.6^{b}	43.6^{c}	87.8^{b}	147.6^{a}	131.2^{a}	135.2^{a}
Colour	7.28^{a}	7.5^{a}	6.66^{bc}	6.82^{b}	6.52^{bc}	6.38^{c}
Texture	6.84^{bc}	6.96^{b}	7.54^{a}	6.68^{bc}	6.56^{c}	6.56^{c}
Flavour	7.04^{ab}	7.12^{a}	6.46^{cd}	6.72^{bc}	6.24^{d}	6.42^{cd}

figures in rows with different small letters are significantly different ($p < 0.05$)

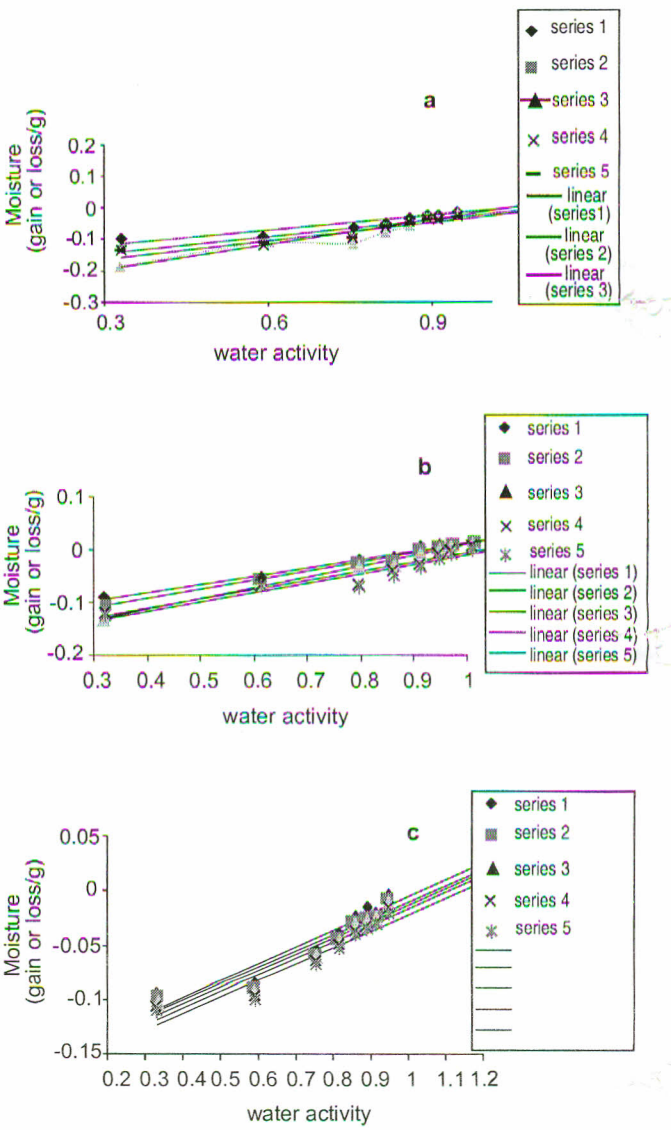

Fig. 1. Water activity of branded buns: **a** (S_1), **b** (S_2), **c** (S_3); series 1, 2, 3, 4 and 5, respectively for the data obtained on day 1, 2, 3, 4 and 5.

recorded in sample S_4 (2810%), while minimum in sample S_3 (368.42%). In a similar study Sumner *et al.* (1993) observed around 105 cfu/g of *Staphylococcus aureus* in bakery items held at 25 °C during 48 h. In another study of Carrasco *et al.* (1992), analyzed microbiologically 40 samples of different bun and pastry products manufactured and sold in Cordoba, Spain. The number of mesophilic bacteria ranged from 500 to 1000 cfu/g in these products.

Colour. The mean score of ten judges significantly ($p < 0.05$) decreased from 7.93 to 5.48 during five days storage (Table 1). Minimum decrease in colour score was noted in sample S_2 (24%) followed by S_1 (25%), while maximum in S_3 (37.5%) followed by S_6 (35.53%). Maximum score for colour was observed in sample S_2 (7.5) followed by sample S_1 (7.28), while minimum mean score was observed in sample S_6 (6.38) followed by sample S_5 (6.52) (Table 2).

Flavour. During storage the changes in flavour also were occurred. Our results showed that the overall mean score significantly ($p<0.05$) decreased from 7.85 to 5.35 (Table 1). Maximum decrease in flavour score was recorded in sample S_5 (38.96%) followed by S_6 (34.21%), while minimum in sample S_2 (27.16%) followed by S_1 (27.5%). Maximum mean score for flavour was observed in sample S_2 (7.12) followed by sample S_1 (7.04), while minimum mean score was observed in sample S_5 (6.24) followed by sample S_6 (6.42) (Table 2).

Texture. The mean score for texture significantly ($p<0.05$) decreased in all samples from 7.96 to 5.51 during storage (Table 1). Maximum decrease in texture score was observed in sample S_6 (37.97%) followed by S_2 (34.21), while minimum decrease was observed in sample S_3 (20.02%) followed by S_1 (27.84%). Maximum mean score for texture was observed in sample S_3 (7.54) followed by sample S_2 (6.96), while minimum mean score was observed in sample S_6 and S_5 (6.56) followed by sample S_1 (6.84) (Table 2). The colour, texture and flavour are sensory criteria mostly used by the consumer to evaluate acceptability of bread and other bakery items (Pomeranz, 1987). The product prepared in industries was comparatively better in quality than the product prepared with conventional methods in local bakeries by unskilled labour. The statistical analysis showed that storage intervals and treatments had a significant effect ($p < 0.05$) on moisture content, water activity, total fungal count and overall acceptability of bun.

Conclusion

It can be concluded on the basis of the results given above that more increase in the moisture content, a_w, and microbial population was recorded in the locally prepared buns in comparison with the products prepared by industries during the period of 5-day storage. Overall acceptability of these products showed that the buns prepared in different industries (S_1, S_2 and S_3) were superior in quality than the products (S_4, S_5 and S_6), prepared in local bakeries using conventional methods. Our results showed that a_w, moisture content and total microbial count of food products are correlated and may be used as index for quality determination. It is recommended that bakery products should be prepared with great care and stored under good sanitary conditions and in moisture controlled environment. Proper handling can reduce microbial population in these products.

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