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Effect of Chemical Preservatives on the Shelf Life of Bread at Various Temperatures

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Abstract: The study was conducted to evaluate the "effect of chemical preservatives on the shelf life of bread at various temperatures" at the Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam, in 2008. Two chemical preservatives i.e. calcium propionate (CP) and calcium lactate (CL) at (14±1), (22±1) and ambient temperature (32±2°C) were assessed for their effect on keeping quality of bread. The results conclude that effects of CP and CL at 14, 22 and (32±2°C) were equally significant at ($p<0.01$) for all chemical characteristics of bread. CP was more effective than CL such as moisture, protein, ash, TSS and carbohydrates were found 37.75 and 36, 9.24 and 8.75, 1.28 and 1.24, 5.10 and 4.71 and 47.75 and 47.01% with CP and CL respectively. Among the storage temperatures, 14°C demonstrate superior performance by increasing shelf life up to a maximum level i.e. 370 h/15.44 days followed by 22°C for 197 h/8.21 days and (32±2°C) for 123 h/5.12 days in decreasing order.

Key words: Bread, calcium propionate, calcium lactate

INTRODUCTION

Bread is the most important article of food. History reveals its use thousands of years even before the Christian era. Despite its importance as a food item, bread making on scientific lines has received due studies for quality and shelf life in the country. Bread is made from wheat flour or other cereals by addition of water, salt and ferment (Yeast). Wheat flour is best adopted for bread making, as it contains gluten in the right proportion to make the spongy loaf. Being deficient in fat, wheat bread is a preferred food. Bread has played a key role in the development of mankind and is one of the principal sources of nutrition. The history of bread is lengthy and largely obscure. Clearly, bread was being consumed long before recorded history. The quality of bread making is contingent upon availability of cereal flours to the consumer in an attractive, palatable and digestive form (Ammirati, 1999). People all over the world eat bread as it provides energy and protein. To make bread one has to bake dough that consists of flour or grain meal. The flour or grain meal is mixed with water or milk. The people in many Western countries mainly bake loaves or rolls made with wheat flour. However, some people prefer to eat crispy and thin sheets of bread called flat bread in many parts of the world. Flat bread is made from grains like barley, corn, oats, rice, rye, wheat, or flour made from combination of these grains. Flat bread does not have yeast or other leavening agents to make it rise. Some people make bread by hand. In commercial bakeries bread is made by machine (Hillers, 1993).

Making of bread has come down through the ages from the simplest methods to the more elaborate processes of the present day. It has been noted that bread prepared by adding baking powder has a very short shelf life. As it contains water after preparation which become the cause of fungal infestation. To extend shelf life of bread there are some chemicals which are being indiscriminately added to prolong the shelf life of bread. Bread should be stored with original package at room temperature and be used within 2-3 days. However, bread stored in the refrigerator will have a longer shelf-life due to delayed mold growth. Whole wheat flour may be stored in the refrigerator or freezer to retard rancidity of the natural oils (Trager and James, 1995). Shelf life extension of bread may be obtained using a single ingredient or process change or a combination of many alternative changes according to food legislation, ingredient availability and cost, consumer acceptance and social trends (Cauvain and Young, 2000). Deterioration of bread includes staling, moisture loss or gain and microbial spoilage. The most common source of microbial spoilage is mould growth (Pyler, 1988; Legan and Voisey, 1991). Viable vegetative moulds and mould spores are destroyed by the heat of the baking process and their subsequent thermal inactivation. However, post baking contamination occurs from the mould spores present in the atmosphere, during handling operations such as cooling, finishing and wrapping (Doerry, 1995; Yang, 1998). Besides mould, bacterial and yeast spoilage can also occur (Grundy, 1996; Pateras, 1999). Thus, it is evident that shelf life

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prolongation of bread is of great importance since it is related to the maintenance of fresh-keeping properties of bread and the productivity and profitability of a company.

Several methods of bread preservation are mentioned in the relevant literature including mould inhibitors (propionates, sorbates, dimethyl fumarate, acetates and ethanol), modified atmosphere packaging, pasteurization, infrared and ultraviolet irradiation, freezing etc. (Islam, 1982; Pyler, 1988; Matz, 1989a,b; Legan, 1993). Selection of appropriate ingredients and adjustment of their levels in a bread recipe is a powerful tool which leads to a significant inhibition of bread mould or microbial growth and therefore, extension of bread Mould-free Shelf Life (MFSL) can be achieved (Cauvain and Young, 2000; Doulia *et al.*, 2000a). Therefore, the manipulation of the levels of ingredients used in a bread recipe affects the shelf life. Sucrose is a very important ingredient in bread recipes because it is very effective in binding moisture as well as acting as an anti-staling agent. Doerry (1995) reported that salt on the other hand has powerful water-binding properties because of its ionic structure. Even a relatively small quantity of salt could affect significantly the MFSL. However, there is a limit to the salt's quantity because of its strong effect on flavour, its negative effects on processing (e.g. changes in viscoelastic properties of gluten and inhibition of yeast in bread dough) and the social trend to unsalted or low-salted foods for potential health benefits. The amount of salt is self-limiting in the range of 1.5-2.5% of the total flour weight.

The use of preservatives in bread is common and extensive all over the globe because of their effectiveness in preventing or inhibiting microbial spoilage in general and mould growth in particular (Doerry, 1995). Preservatives do not significantly affect water activity and their action depends on the product's pH, product's composition, storage temperature and water activity (Davidson, 2002). Potassium sorbate and calcium propionate are among the principal mould inhibitors used in bread and their inhibitory action has been extensively studied (Legan, 1993; Grundy, 1996). Potassium sorbate is effective up to pH 6. At higher pH levels, its effectiveness decreases significantly (Sofos, 2000). Calcium propionate is the most commonly used chemical antimicrobial and it is ideal for yeast-leavened bakery foods as it is most effective at pH levels below 5.5. It is also very effective against spoilage caused by rope spores from bacteria *Bacillus subtilis*, surviving the baking process. The recommended level is within 0.19-0.32 g per 100 g flour. At higher application levels, calcium propionate imparts a distinct acid taste to bread (Doerry, 1995). Ethanol, a strong bactericide, has recently been used for its effective preservative action in bread (Matz, 1989a,b; Cauvain and Young, 2000). The addition of ethanol at levels 0.5% and 3.5% of loaf leads to a substantial extension of the shelf life of bread (Doulia *et al.*, 2000b).

MATERIALS AND METHODS

The present study was carried out to investigate the effect two different types of chemical preservatives on the shelf life of bread at various temperatures. The types of chemicals calcium propionate (Merck Germany) and calcium lactate (Merck Germany) procured from the local market of Hyderabad were used. They were added as an ingredient to create wheat flour at the time of dough preparation and development. The study was carried out in Bakery Technology Laboratory of Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam during 2008. The details of treatments are given are as under:

- Preparation of dough with addition of Calcium propionate at the rate of 0.4 g kg^{-1} of flour
- Preparation of dough with calcium propionate at the rate of 0.8 g kg^{-1} of flour
- Preparation of dough with addition of calcium lactate at the rate of 0.4 g kg^{-1} of flour
- Preparation of dough with addition of calcium lactate at the rate of 0.8 g kg^{-1} of flour
- Preparation of dough without addition of any chemical preservative (control)

The separate batches of dough were prepared by adding two types of chemical preservatives and breads were baked on the same day to evaluate their effect on the quality and storage period. The Sensory parameters were evaluated by panel of judges by scoring quality on score card for each parameter. The following sensory parameters were recorded.

Determination of moisture: The moisture percentage of bread was determined according to the method of AOAC. The sterilized empty flat bottomed dish was weighed on balance machine and weight was recorded. Fifteen grams sample in dish was placed in an oven at 70°C for 24 h then dish was removed and cooled in a desicator and weight was recorded. Sample was placed again in oven at 70°C for another two hours. The moisture % was calculated according to the following formula:

$$\text{Moisture \%age} = \frac{\text{Weight of fresh sample} - \text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

Determination of total ash: The Ash percentage was determined by using gravimetric techniques according to the method of AOAC (2000c).

Determination of protein: The protein percentage was determined by using method of British Standard

Table 1: Effect of different chemical preservative on the moisture, protein, ash, TSS, carbohydrate content of bread

Chemical preservatives	Moisture	Protein	Ash	TSS	Carbohydrates
Control	36.50[b]	7.42[e]	1.14[d]	4.46[c]	43.44[d]
Calcium propionate 0.4 g	33.25[d]	8.34[c]	1.14[d]	4.30[d]	45.40[c]
Calcium lactate 0.4 g	37.75[a]	8.19[d]	1.24[b]	4.35[e]	45.27[c]
Calcium propionate 0.8 g	36.00[b]	9.24[a]	1.18[c]	4.71[b]	47.01[b]
Calcium lactate 0.8 g	35.25[c]	8.75[b]	1.28[a]	5.10[a]	47.45[a]
SE	0.1670	0.0274	0.0071	0.0400	0.0640
LSD AT 1%	0.7215	0.1183	0.0306	0.1728	0.2766
LSD AT 5%	0.5147	0.0844	0.0218	0.1233	0.1973

Table 2: Effect of chemical preservatives on the cold storage (14±1°C) of bread (h/days)

	Storage (Hours/Days)				
Chemical preservatives	R1	R2	R3	R4	Mean
Control	264.00 (11.00 days)	270.00 (11.25 days)	274.00 (11.41 days)	268.00 (11.16 days)	269.00[e] (11.21 days)
Calcium propionate 0.4 g	336.00 (14.00 days)	330.00 (13.75 days)	345.00 (14.37 days)	342.00 (14.25 days)	338.00[c] (14.09 days)
Calcium lactate 0.4 g	312.00 (13 days)	318.00 (13.25 days)	320.00 (13.33 days)	325.00 (13.54 days)	318.00[d] (13.28 days)
Calcium propionate 0.8 g	360.00 (15.00 days)	368.00 (15.33 days)	372.00 (15.56 days)	381.00 (15.87 days)	370.00[a] (15.44 days)
Calcium lactate 0.8 g	359.00 (14.95 days)	363.00 (15.12 days)	367.00 (15.29 days)	370.00 15.41 days)	364.00[b] (15.19 days)

SE = 0.8597; LSD at 1% = 3.714; LSD at 5% = 2.649

Institution (BSI), 1990 prepared with two types of chemical preservatives. The small bread samples were digested using micro kejldhal digester in the presence of Catalyst (0.2 g) copper sulphate and 2 g sodium sulfate/potassium sulfate or catalyst tablets and sulfuric acid (30 ml). They were used as an oxidizing agent. The digested samples were diluted with distilled water (250 ml) and 5 ml portion from the diluted samples were mixed with NaOH (40%) using micro-Kjeldhal distillation unit. Where steam was distilled over 2% boric acid (5 ml) containing an indicator for 3 min.

The ammonia trapped in boric acid was determined by titrating with 0.1 N HCl. The nitrogen percentage was calculated using the following formula:

$$N\% = \frac{1.4\,(V1 - V2)\,x\,\text{normality})}{\text{Wt of sample}}$$

While protein percentage was estimated by conversion of nitrogen percentage to protein, assuming that all the nitrogen in bread was present as protein i.e

Protein % = N% x Conversion factor

Where:
Conversion factor = 100/N (N% in fruit products) as suggested by Trager and James (1995).

Determination of carbohydrates (Anthrone method): Carbohydrates were determined by the method of Bajaracharya (1999).

RESULTS AND DISCUSSION

The data collected on moisture content of bread prepared with different chemical preservatives indicated that highest moisture percentage of 37.75 was recorded in the bread prepared by CP 0.8 g concentration followed by the bread prepared under control treatment where percent moisture was recorded as 36.50. Whereas the lower moisture percentage was recorded as 33.25 in the bread prepared with CL at concentration of 0.4 g. The data showed high protein content with CP at 0.8 g concentration and was recorded 9.24 percent on an average. The bread prepared with CL at 0.8 g concentration ranked second in protein content of 8.73 percent. The lowest protein content of 7.42 was noted in bread prepared in control treatment. CP and CL at 0.4 g ranked 3rd and 4th in protein content of bread as values were recorded 8.34 and 8.19% respectively (Table 1-4). Results at Table 1-4 further indicate highest ash content of 1.28 in bread prepared with CL at 0.8 g. The bread prepared with CL 0.4 g concentration ranked second in ash content of 1.24. The lowest ash content of 1.14 was noted in bread prepared in control treatment. CP at 0.4 and 0.8 g ranked 3rd and 4th in ash content of bread, with values of 1.14 and 1.18 respectively. Besides, it was further observed that the bread prepared with CL at concentration of 0.8 g recorded higher values of 5.10 for Total Soluble Solids of bread as compared to other chemical preservatives. CP at 0.8 g concentration ranked second in total soluble solids of bread with scores of 4.71. CP and CL at 0.4g concentration resulted in lower scores of 4.30 and 4.35 respectively. The data showed highest carbohydrate content of 47.45 percent

Table 3: Effect of chemical preservatives on the cold storage (22±1°C) of bread (h/days)

	Storage (Hours/Days)				
Chemical preservatives	R1	R2	R3	R4	Mean
Control	160.00 (6.66 days)	167.00 (6.95 days)	172.00 (7.16 days)	166.00 (6.91 days)	166.25[d] (6.92 days)
Calcium propionate 0.4 g	192.00 (8.00 days)	188.00 (7.83 days)	186.00 (7.75 days)	190.00 (7.91 days)	189.00[c] (7.87 days)
Calcium lactate 0.4 g	187.00 (7.79 days)	189.00 (7.87 days)	188.00 (7.83 days)	186.00 (7.75 days)	187.50[b] (7.81 days)
Calcium propionate 0.8 g	200.00 (8.33 days)	194.00 (8.08 days)	198.00 (8.25 days)	196.00 (8.16 days)	197.00[a] (8.21 days)
Calcium lactate 0.8 g	196.00 (8.16 days)	194.00 (8.08 days)	190.00 (7.91 days)	197.00 (8.20 days)	194.25[ab] (8.09 days)

SE = 0.7781; LSD at 1% = 3.361; LSD at 5% = 2.397

Table 4: Effect of chemical preservatives at room temperature (h/days)

	Storage (Hours/Days)				
Chemical preservatives	R1	R2	R3	R4	Mean
Control	78.00 (3.25 days)	96.00 (4.00 days)	82.00 (3.41 days)	84.00 (3.50 days)	85.00[d] (3.54 days)
Calcium propionate 0.4 g	115.00 (4.79 days)	110.00 (4.58 days)	124.00 (5.16 days)	112.00 (4.66 days)	115.25[b] (4.80 days)
Calcium lactate 0.4 g	96.00 (4.00 days)	104.00 (4.33 days)	100.00 (4.16 days)	108.00 (4.50 days)	102.00[c] (4.25 days)
Calcium propionate 0.8 g	120.00 (5.00 days)	126.00 (5.25 days)	118.00 (4.91 days)	128.00 (5.33 days)	123.00[a] (5.12 days)
Calcium lactate 0.8 g	118.00 (4.91 days)	110.00 (4.58 days)	126.00 (5.25 days)	120.00 (5.00 days)	118.50[ab] (4.94 days)

SE = 1.436; LSD at 1% = 6.205; LSD at 5% = 4.426

in bread prepared with CL 0.8 g. The bread prepared with CP 0.8 g concentration ranked second in carbohydrate content i.e. 47.01 percent. The lowest carbohydrate content was recorded 43.44 percent in bread prepared as control. CP and CL at 0.4 g ranked 3rd and 4th in carbohydrate content of bread, where the recorded values were 45.40 and 45.27 respectively.

The data illustrates that the bread prepared with CP at 04. g, 0.8g and CL at 0.8 g concentration were not significantly different from each other but there was a significant difference in storage period of bread prepared with CL at concentration of 0.4 g and under control treatment. The longer storage period 370 h (15.41 days) was observed in bread prepared with CP at 0.8 g concentration, which was followed by 364 h (15.16) with CL 0.8 g. The lowest shelf life of 269 h (11.20) was recorded in bread prepared as control. The data further indicated that the bread prepared with CP at 0.8 g and CL at 0.8 g concentration were highly different from each other but there was less significant difference in CP at concentration of 0.4 g and calcium lactate 0.4 g. The longer shelf life of 197 h (8.20 days) was recorded in bread prepared with CP at 0.8 g concentration and the second shelf longer life 194.25 h (8.09 days) was recorded in bread prepared with CL 0.8 g. The lowest shelf life of 166.25 h (6.92 days) was recorded in bread prepared in bread labeled as control treatment. The data further elaborates that the bread prepared with CP at 0.8 g and CL at 0.8 g concentration recorded 117.02 h (4.87 days) and 116 h (4.83 days) respectively, as shelf life at the room temperature. Whereas the bread prepared with the addition of CP 0.4 g and CL 0.4, the shelf life observed was 123 h (5.12days) and 118.50 h (4.93 days) respectively. The lowest mean value 85 h (3.54 days) was recorded in control.

Conclusion: From the research, it may be concluded that fortification of CP and CL at 0.8 g under 14°C cold storage of bread showed better quality of bread with improved physico-chemical properties and extensive shelf life.

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