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EFFECT OF DIFFERENT TECHNOLOGICAL PROCESSING METHODS ON THE QUALITY AND SHELF-LIFE OF MAIZE BREAD

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Abstract

White maize (Giza-2 variety) was used in this investigation. Six-Hundred g of sample were placed in1800 ml alkaline water (containing 6 gm of $Ca(oH)_2$ were autoclaved at 1.0 kg/cm^2 and 1.5 kg/cm^2 for 30, 6O, 90 and 120 min). The third treatment was soaking of maize kernels for 24hr. before autoclaving at 100°C without pressure for (30, 60, 90 and 120min).

Chemical analysis of the produced bread showed that , protein, fiber and ether extract were decreased comparing to that of the raw materials, while ash content of bread was increased comparing with that of the raw materials specially calcium content of the ash.

Organoleptic properties of the produce bread showed that the best cooking treatments, which gave bread the excellent score, were cooking at 1.0 kg/cm^2 for 90 min., 1.5 kg/cm^2 for 60 min. and for 120 min. with steam and stream without pressure.

The staling value of the above three recommended treatments for produced bread show that cooking at 1 kg/cm^2 for 90 min. gave the most superior value (48 hr. freshness).

The best condition to produce maize bread is cooking maize kernels by autoclave at 1.0 kg/cm^2 for 90 min., or 1.5 kg/cm^2 for 60 min. and/or by pre-soaking before autoclaving with steam and stream without pressure for 120 min. Also, the anti-microbial effect of some preservatives was studied. The effect of 0.2% potassium sorbate was the superior bread treatments than calcium propionate or mixture of both when packaged bread was stored either at room temperature or in refrigerator 5°C and extended the shelf-life of bread.

INTRODUCTION

When producing bread from the whole maize kernel, several cooking methods had to be made. The most important step in these methods is the gelatinization process of maize starch to obtain the appropriate dough consistency for shaping process.

Serna-Saldivar *et al.*, (1988) used steam jacket cooker in cooking maize, whole and pearled sorghum. The parameters of H_2O: grain (weight basis), Ca $(OH)_2$ (% grain wt.), cooking time (min.) and steeping time (min.) were 3 : 1, (1, 0.8, 0.2), (60, 35, 5) and 120 min. for maize, whole and pearled sorghum, respectively. The cooked grains (nixtamal) were ground in a stone grinder and masa was sheeted (2mm thickness) and baked on a hot griddle (288 °C) for 1-5 min. for each side.

Hegazy *et al.*, (1996) reported that, viscoamylograph values (B.U.) for white and yellow corn before and after lime treatment were 87.5, 86.0, 84.5 and 82.5 for pasting temperature of white corn (control) and yellow corn (lime treated), respectively, while, peak viscosity (B. U) was 320, 300, 360 and 430 respectively. Also, viscosity at 50 °C (B.U) was 450, 460 , 480 and 490 respectively, setback (B.U) was 190, 235, 210 and 230 respectively.

Khorshid *et al.*, (1997) found that, alkaline water retention capacity (AWRC) of tortilla decreased progressively during storage which reflects progression of staling. Also, moisture contents of tortilla bread decreased during storage. The fresh unpacked (control) tortilla bread showed the greatest decrease in moisture (from 35.5% in the 1^{st} day to 25.5% in the 4^{th} day).

Friend *et al.*, (1995) studied the effect of anti-microbial agents and acidulate and found that, effectiveness of anti-microbial agents increased as the pH of maize bread decreased. Shelf-life of maize bread without anti-microbial agent was 4-5 days. The shelf-life of wheat flour bread was extended to > 16 days using calcium propionate at pH 5.5 or potassium sorbate at pH 6.0, subsequently, dough pH was lowered by fumaric, citric or malic acids to 5.5 for experiments using calcium propionate and to 5.8 for experiments using potassium sorbate as the antimicrobial agent. Use of these pH targets assured effectiveness at pH 5.5 compared with those of pH > 5.8.

Khorshid *et al.*, (1997) reported that, maize bread showed apparent microbial growth on the 5^{th} day of storage except when potassium sorbate was added and packaged in polyethylene bags which showed microbial spoilage on the 6^{th} and 7^{th} days of storage.

MATERIALS AND METHODS

Materials

White maize kernels (Giza-2) were obtained from Field Crops Research Institute; Agriculture Research Centre; Giza, Egypt.

Preparation of maize dough (masa):

The maize dough (masa) was prepared by cooking in the autoclave under different pressures and periods as well as by means of using steam without pressure. The first treatment was prepared by placing maize kernels samples of 600g / 1800 alkaline water (1.0% $Ca(OH)_2$ into stainless steel jar then autoclaved at 1.0 kg/cm^2 (120 °C) and 1.5kg/cm^2 (125 °C) for 30, 60, 90 and 120 min. respectively. The second cooking treatment of maize kernels was soaking for 24hr. before autoclaving. Then the presoaked samples were autoclaved with steam and stream at 100 °C without pressure.

Then the cooked maize was washed with tap water to produce nixtamal and the nixtamal was grinded by stone mill to obtain the maize dough (masa). The produced masa was shaped into round bread (2 mm thickness, 18cm diameter and 40g wt.) then baked at 420-450 °C for 40 sec.

- Water uptake and the dry matter losses were determined according to Morad *et al.*, (1986).
- Determination of maize starch characteristics by viscoamylograph was carried out according to the method described in A.A.C.C. (1983).
- Determination of gelatinized starch percentage by glucoamylase and *O*-toluidine was carried out according to the method described by Chiang and Johnson (1977).

preservatives of maize bread:

Potassium sorbate (PS) 0.2%, calcium propionate (CP) 0.2% and a mixture of both (PS) and (CP) (0.1% + 0.1%), were added to produce masa at pH 5.5. Polyethelene bags (1 mm thick) were used in packaging each for three loaves, then stored at room temperature or in 5°C. refrigerator.

- Duplicate bags from each group were assayed for pH, aerobic plate count (APC), mold and yeast count (M& Y), coliform bacteria (Staphylococcus aureus), and shelf-life. The assay was carried out at zero time and after storage for 48 hours.

- Microbiological examination; the medium was prepared for the microbiological assay according to A.O.A.C. (1990).

- Organoleptic evaluation; the produced bread was organoleptically evaluated for general appearance, color, taste, rollability, odor and layer separation by using 6 experienced panelists, from the staff of the food technology. The quality scores of the evaluated bread loaves were according to El-Farra (1973).

RESULTS AND DISCUSSION

Chemical composition of raw maize kernels (Giza-2 variety):

From the obtained results in table 1 it is clear that the major chemical components of the kernel were, carbohydrates 82.70%, protein 8.7%, ether extract 5.0%, ash 1.46% and fiber 2.14%. These findings are similar to that obtained by Khorshid *et al.*, (1996), who reported that, protein, carbohydrate, oil, ash and fiber of commercial maize (Giza-2 variety) were 8.4%, 79.3%, 5.53%, 1.70% and 2.52%, respectively.

Water absorption and dry matter losses (DML) during alkaline cooking:

The water absorption mechanism of maize kernels during cooking depends on used heat and pressure. From table 2 it is clear that, water uptake was increased. The resulted weights of maize after cooking for 120 min. at 1.0 kg/cm^2, 1.5 kg/cm^2 and without pressure were; 1220, 1790 and 1700 g, respectively. While the weight of maize samples cooked for 90 min. were 1640, 1670 and 1691 g, respectively. It could be said that the cooking under pressure for 90 min. increased the initial weight for about 175%, while Khorshid *et al.*, (1996) mentioned that, cooking (without pressure) for 90 min. increased the weight for about 100% only.

From these results it is clear that the sample which was cooked for 120 min. at 1.5 kg/cm^2 gave the highest weight among the other treatments.

The lowest dry matter losses percentage after 120 min. of cooking was noticed in treatment without pressure, as it reached 7.73 % compared to 13.91% in case of cooking at 1.5 kg/cm^2 for 120 min.

Starch gelatinization (%):

Starch gelatinization percentage in nixtamal of corn flour (NCF) was determined and results were represented in table 3. It is obvious from the represented data that, starch gelatinization is increased as cooking pressure is increased. The increase of gelatinized starch was parallel to the increase of water absorption during cooking. When maize kernels were cooked at 1.0 kg/cm^2, starch gelatinization was 62% for 30 min. cooking period, while it increased up to 82% by increasing of cooking period to 120 min.

These results agree with that reported by Gomez *et al.*,(1991) who mentioned that starch gelatinization was incomplete because the starch granules are within endosperm cells and exposed to very limited amounts of water during the shorter cooking period and steeping operation. When the cooking occurred at 1.5 kg/cm^2, the starch gelatinization was increased from 64% to 94%, for cooking periods 30 and 120 min., respectively.

From the above results it could be said that, the treatment with 1.5kg/cm^2 for 120 min. gave an excess gelatinization of starch which is considered over-cooked and causing troubles to dough handling and shaping. While the treatments 1.0 kg/cm^2 for 120 min., 1.5 kg/cm^2 for 90 min. and cooking without pressure for 120 min. gave the best percentage of gelatinized starch being 82%, 83% and 84%, respectively.

Effect of autoclaving maize kernels on the viscosity of produced maize flour pastes:

From table 4, the paste of first group (1.5kg/cm^2) cooked for 30 min. gave 75°C gelatinization temperature, while at 120 min., it gave 67.5°C. Simultaneously, starch gelatinization percentage in the original nixtamal maize flour was 62% and 82%, respectively.

In the second group (1.5 kg/cm^2) the results gave the same trend as mentioned above, together with the third group (steam and stream) without pressure.

These results agree with that of Khan *et al.*, (1982) who found that, the amylograph peak viscosity was expected to be decreased by increasing gelatinization of starch in maize. Gomez *et al.*, (1992) found that starch crystallinity decreased during autoclave treatments because partial gelatinization took place and the initial temperature decreased.

The changes in set-back of the tested samples may be due to the increase of hydrogen bonding. Which was inforced to be reoriented within starch granules "the starch matrix."

Sensory evaluation of maize bread:

It may be said from data in table 5 that, the highly accepted maize bread produced from the different cooking treatments of maize under investigation were; cooking at 1.0 kg/cm^2 for 90 min., cooking at 1.5 kg/cm^2 for 60 min. and pre-soaking without pressure for 120 min. which gave total score of 90.1, 90.8 and 93.1%, respectively.

Alkaline Water Retention Capacity (AWRC):

As illustrated in the above results, only three cooking treatments of maize gave high total score, table 6. AWRC was determined to test these three treatments in order to select the excellent treatment which gave maize bread with high total score and high freshness during storage.

Table 6 show that, after 48hr. of baking a sharp decrease in freshness took place in the pre-soaked treatment, which reached 67.9%. The decreasing was about 21%, while in the other treatments and after 48hr. of baking the decrease was about 12-13% i.e., from 84% to 72% and from 81.9 to 68% in case of 1.0 kg/cm^2 for 90 min. and 1.5 kg/cm^2 for 60 min., respectively.

These findings agree with Khorshid *et al.*, (1997) who mentioned that, alkaline water retention capacity of maize bread decreased progressively during storage which reflects progression of staling.

The highly freshness value was obtained in case of cooking treatment at 1.0 kg/cm^2 for 90 min. The above treatment was selected for microbiological tests.

Effect of adding preservatives on the shelf-life:

Limited shelf-life and rapid staling are major problems affecting the commercial distribution of maize bread. Tortillas bread are prone to microbial spoilage because of their high moisture (38-46%).

Furthermore packaging create an appropriate environment for microbial growth. The purpose of preservatives and acidulants is to retard spoilage by inhibiting mold growth Tellez *et al.*, (1988).

Table 7 show the anti-microbial effect on mold and yeast growth in maize bread loaves acidified with 0.35% citric acid and stored at room-temperature and (5°C) refrigeration.

The obtained results agree with that mentioned by Tellez *et al.*, (1988), who illustrated that, tortilla stored at 28°C, substantially increases shelf-life by acidification (0.45% fumaric acid) plus potassium sorbate or calcium propionate, but particularly by combination of these two anti-microbial agents.

Also, agree with that mentioned by Friend *et al.*, (1995) who illustrated that, effectiveness of anti-microbial agents increased as the pH of maize bread decreased.

Table 1. Chemical Analysis of raw white maize kernels % (on dry basis)

Sample	Protein	Ether extract	Ash	Carbohydrates*	Fiber
White corn (Giza-2)	8.7	5.00	1.46	82.7	2.14

• Carbohydrates calculated by difference.

Table 2. Water uptake (water absorbance) and dry matter losses (DML) during alkali cooking of maize by different treatments.

After lime cooking by Autoclaving				
Treatments	Time of treatments (mins)	Maize weight* (g)	Water uptake %	Dry Matter losses %
A**	30	1220	103.3	5.48
	60	1570	161.6	6.28
	90	1640	173.3	7.45
	120	1720	186.6	7.92
B**	30	1360	126.6	5.62
	60	1595	165.8	7.80
	90	1670	178.3	9.92
	120	1790	198.3	13.91
C**	30	1123	87.16	5.01
	60	1421	136.8	6.11
	90	1691	181.8	7.13
	120	1700	183.3	7.33

* Initial sample weight (600 g), Lime concentration 1% $Ca(OH)_2$

** (A): 1.0Kg/cm^2, (B): 1.5 Kg/cm^2 and (C): pre-soaking for 24hrs before autoclaving without pressure.

Table 3. Starch gelatinization (%) of Nixtamal corn flour (NCF).

Treatments	Time of treatment (mins)	Starch Gelatinization %
A *	30	62
	60	71
	90	80
	120	82
B * *	30	64
	60	79
	90	83
	120	94
C * * *	30	70
	60	75
	90	82
	120	84

* A: means 1.0 kg/cm^2.
* B: "1.5 kg/cm^2.
*** C: pre-soaking for 24 hrs before autoclaving without pressure.

Table 4. Effect of autoclaving maize kernels on the viscosity of produced maize flour pastes.

Treatments	Time of treatments (mins)	Transition temperature	Viscosity at 95°C (B.U.)	Viscosity after 15 min. (B.U.)	Set-back at 50°C (B.U.)
A *	30	75.0	330	400	660
	60	73.5	60	100	230
	90	69.0	20	40	100
	120	67.5	20	25	80
B * *	30	74.0	180	215	340
	60	72.0	140	180	300
	90	69.0	125	160	295
	120	67.0	120	140	230
C * * *	30	73.5	500	580	1000
	60	73.0	440	550	820
	90	70.5	330	420	660
	120	67.5	60	110	260

* A: means 1.0 kg/cm^2.
* B: "1.5 kg/cm^2.
*** C: pre-soaking for 24 hrs before autoclaving without pressure.

Table 5. Sensory evaluation of maize bread produced from white maize (Giza-2) by different cooking treatments.

Treatments	Time (mins)	Appearance	Layer separation	Rollability	Odor	Taste	Color	Total Score
		20	10	10	20	20	20	100
A *	30	13	2	-	18	15.8	14.5	63.3
	60	16	8	9	18	18	16	85.0
	90	18	9.1	10	18	18	17	90.1
	120	16	7.8	9	18	15	15	80.8
L.S.D. 0.05								2.0253**
B *	30	15	8	8	16	17	14.3	78.3
	60	18.8	10	10	18	19	15	90.8
	90	15	8	9.5	18	17	14	81.5
	120	12	6	6	16	16	11.6	67.6
L.S.D. 0.05								1.084**
C *	30	12	6	6	16	16	15	71
	60	16.3	8	8	17	16	15	80.3
	90	17	8	8.6	18	18	18	87.6
	120	18.1	10	10	18	18	19	93.1
L.S.D. 0.05								9.28**

* (A) means 1.0 kg/cm^2. (B) 1.5 kg/cm^2, (C) pre-soaking for 24 hrs before autoclaving without pressure.

Grades: 90-100 very good, 80-90 good, 70-90 satisfactory, less than 70 questionable.

** The judges like in 90 mins treatment more than in 60 mins (90 mins > 60 mins > 120 mins > 30 mins), at 1.0 kg/cm^2.
The judges like in 60 mins treatment more than in 90 mins. (60 mins > 90 mins > 30 mins > 120 mins) at 1.5 kg/cm^2.
The judges like in 120 mins treatment more than in 90 mins. (120 mins > 90 mins > 60 mins > 30 mins).

All treatments

Time		L.S.D. 0.05	
30	70.89	1.212	C > B > A
60	85.5	1.559	B > A > C
90	86.44	1.089	A > C > B
120	80.55	1.479	C > A > B

L.S.D. 0.05 5.566

(90 mins > 60 mins > 120 min > 30 mins)

Table 6. Alkaline water retention capacity (AWRC) of the recommended maize bread produced by different treatments.

Treatments	Time of treatments (mins)	Total score	Staling rate				
			Zero-time	after 24hrs	freshness %	after 48 hrs	freshness %
A *	90	90.1	488	410	89%	306.5	0.72%
B * *	60	90.8	435	356	81.9	296	68.0
C * * *	120	93.1	457	407	89	309.3	67.9

* A: means 1.0 kg/cm^2.

* B: "1.5 kg/cm^2.

*** C: pre-soaking for 24 hrs before autoclaving without pressure.

Table 7. Effect of using preservatives at pH 5.5 on shelf-life of maize bread at room-temperature and under refrigeration.

	Storage periods (days)										
	0	2	4	6	8	10	15	20	26	28	30
Storage at Room-temper.											
A	-	(+)*									
B	-	-	-	-	(+)*						
C	-	-	-	-	-	(+)*					
D	-	-	-	(+)*							
Storage at 5°C											
A	-	-	-	-	-	-	(+)*				
B	-	-	-	-	-	-	-	-	-	(+)*	
C	-	-	-	-	-	-	-	-	-	-	(+)*
D	-	-	-	-	-	-	-	-	(+)*		

A Control
B 0.2% calcium propionate
C 0.2% potassium sorbate
D mixture of calcium propionate and potassium sorbate (0.1% + 0.1%)
* means that the availability of bread consumption is zero.

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تأثير العمليات التكنولوجية المختلفة على جودة ومدة حفظ خبز الذرة

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تم استخدام ٦٠٠ جم من صنف الذرة البيضاء (جيزة ٢) مع ١٨٠٠ مل محلول قلوى (يحتوى على ٦جم هيدروكسيد كالسيوم) وتمت عمليات الطبخ باستخدام الاوتوكلاف تحت ضغط ١كجم/سم٢، ١,٥ كجم/سم٢ لمدة ٣٠، ٦٠، ٩٠، ١٢٠دقيقة وفى المعاملة الثالثة تم نقع الحبوب لمدة ٢٤ ساعة قبل عملية الطبخ بالاوتوكلاف بدون ضغط (بخار جارى على ١٠٠°م) لنفس الفترات السابقة.

وتم عمل التحليل الكيماوى لحبة الذرة والخبز الناتج وكذلك التقييم الحسى حيث وجد أن أحسن المعاملات التى أنتجت خبزاً لاقى قبول المحكمين هو باستخدام الطبخ لمدة ٩٠ دقيقة على ١ كجم/سم٢، ١,٥ كجم/سم٢ لمدة ٦٠ دقيقة وكذلك الطبخ لمدة ١٢٠ دقيقة باستخدام البخار الجارى بدون ضغط.

وهذه المعاملات الثلاثة التى ننصح بها وجد أن أكثرها مقاومة لظاهرة البيات هى الطبخ لمدة ٩٠ دقيقة على ١كجم/سم٢ وكذلك وجد أن استخدام سوربات البوتاسيوم كمادة حافظة بتركيز ٠,٢٪ أطالت مدة حفظ الخبز بدرجة أكبر إذا ما قورنت باستخدام بروبيونات الكالسيوم أو خليط منهما بنفس التركيز وسواء تم التخزين على درجة حرارة الغرفة أو فى الثلاجة.