QUALITY OF COOKIES AS AFFECTED BY DOUGH MIXING TIME, CORN MEAL ADDITION AND MICROWAVE HEATING AFTER CONVENTIONAL BAKING.

AMAL, A. EL-HOFI, HENAR, A. SELEEM AND SOHER, N. ABD EL-RAHMAN.

Food Technology Research Institute, ARC, Giza, Egypt.

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Abstract

The present investigation was carried out to study the influence of dough mixing time, corn meal addition at 10, 20 and 30% and the association of conventional and microwave heating processes on quality of cookies. The addition of different levels of corn meal to wheat flour (72% extraction rate) increased ash and oil percentages. Arrival time, weakening and liquefaction No. and decreased protein, total soluble sugar, wet and dry gluten, water absorption percentages and falling number. Thickness of cookie significantly increased with increasing the rate of corn meal till 20%and then it decreased with more of addition of corn meal. Diameter and spread ratio increased with increasing corn meal addition. Thickness and diameter decreased while spread ratio increased with increasing mixing time, furthermore thickness and spread ratio increased and diameter decreased with increasing microwave power treatments. Adding corn meal to cookies formula improved sensory properties of cookies till 20% addition. Mixing time (3 min.) and high power of microwave treatment gave cookies with the highest scores as compared with other treatments.

Keyword. Microwave, cookies, corn meal.

INTRODUCTION

Cookies are a group of snack foods usually consumed by children and students because of the formers' high acceptability and content of the major required nutrients. The elastic recovery values indicated that the protein content develops with increasing mixing time. (Sai-Manohar and Haridas-Rao, 1997). Dough mixing is an important operation in the preparation of cookies. An optimum mixing period is required to reach the desired rheological properties (Wade, 1988). In conventional baking of cookies, heat induces chemical and physical changes in the

materials. Chemical changes include gas formation, protein denaturation, starch gelatinization, crust formation and browning. Physical changes include water evaporation, volume expansion, development of porous structure, and alternations in dimensions (Turhan and Ozilgen, 1991). The use of microwave heating for final baking of cookies results in a more uniform moisture distribution than does conventional method (Schifmann, 1992). Microwave cooking is unique and has gained acceptance for food preparation because of its convenience, efficiency, speed, and low operating costs. Microwave heating of food materials is caused by molecular fraction of electrical dipoles under an oscillating electric field of specific frequency. The great absorption of microwave energy by water molecules, which are the most abundant dipole component of foods, and other components (salt, fat, and protein), which also act as dielectric components, resulted in food heating (Mudgett, 1986). The principal differences between conventional and microwave ovens are that the products baked by microwave heating do not brown (Mudgett, 1989). However, microwave heating used in combination with other energy sources can obtain a desirable result (Decareau, 1986). The use of microwave heating, pre or post conventional baking process has been successfully applied in bread making (Mudgett, 1989). These combined processes decrease the system cost when compared to single heating systems (heated air-infrared, vapor, etc.) due to a synergistic effect (Schifmann, 1992). Treatment at high power decreases moisture content and produces products with excellent physical properties and no cracking. The removal of the residual moisture during microwave also increased produced weight losses (Bernussi et al., 1998). The objective of this research was to study the effects of dough mixing time, the influence of corn meal addition and the association of conventional and microwave heating processes for baking on quality of cookies.

MATERIALS AND METHODS

Materials:

Wheat flour (72% extraction rate) was obtained from Egyptian Milling Company, EL-Malik Fisal St., Giza.

Corn grain was obtained from Corn Research Dept., Field Crops Res., Institute, A.R.C. Giza, Egypt. These Corn grains were milled using Brabender Duisburg (in Agriculture Research Center, Giza, Egypt).

Methods:

Chemical analysis:

Wheat flour (72% extraction rates), corn meal and their blends with wheat flour at 10%, 20% and 30% were analyzed for moisture, ash, protein and oil contents according to the methods outlined in the A.O.A.C. (1990) .Total soluble sugars were determined by using phenol sulphoric method described by Montgomry,(1961).

Wet and dry gluten:

Wet and dry gluten of all samples were determined according to A.A.C.C. (1994).

Rheological properties:

Farinograph parameter:

Farinograph parameter was determined according to A.A.C.C. (1994).

Falling and liquification:

Falling No. was determined according to the A. A. C. C. (1994 liquification No. (L.N.) was calculated according to the following equation:

$$\text{L.N.} = \frac{6.000}{FallingNo. - 50}$$

Cookies preparation:

Cookies formula and ingredients:

Cookies were prepared according to the method described by (Sai-Manohar and Haridas-Rao 1997). The wheat flour used in the formula of Cookies (which used as control) was substituted with corn meal at 10, 20 and 30%. Other ingredients were as follows: flour 300.0 gm, sugar 90 gm, shortening (Halop) 60 gm, sodium chloride 3 gm, sodium bicarbonate 1.5 gm, ammonium bicarbonate 3gm, baking powder 0.9 gm, skimmed milk powder 7.5 gm, and requirements of water (16-20 ml).

Preparation of cookies dough:

Sugar and fat were creamed in a mixer for 2 min. at 61 rpm. Dough water containing sodium bicarbonate, ammonium bicarbonate and sodium chloride was

added to the cream, and mixed for 5 min. at 125 rpm to obtain a homogeneous cream. Finally, the twice sieved flour was mixed with baking powder for varying periods (3 and 6 min.) at 61 rpm. Dough was sheeted to a thickness of 3mm. Cookies were shaped with a cutter (5.0 cm. diameter).

Conventional and Microwave Processes in Cookies Baking:

Cookie samples were pre baked in conventional oven at 240°C for 4 min., followed by final baking in a microwave oven .The power output of the magnetron specified by manufacturer was 800w, and the operating frequency was 2.450 MHz. The microwave oven was used at high and medium power settings for 30 sec. The produced cookies were cooled and packed in cellophane which covered with aluminum foil and stored for 3 months at room temperature (30+/-2 °c).

Evaluation of Cookies:

Physical characteristics:

Cookies diameter and thickness were measured for groups of 10 Cookies. The spread ratio (the ratio between diameter and thickness) was obtained according to Bernussi et al, 1998.

Sensory evaluation:

The organoleplic properties of the baked Cookies were measured by ten personal trained judges. The judges were asked to give a score as reported by Wade (1988).

Peroxide value:

The peroxide value of oil extracted from Cookies during storage was determined according to the method outlined in A.O.C.S. (1993).

Statistical analysis:

All sensory evaluation was statistically analyzed for least significant (L.S.D) at 0.05 levels according to the method described by Snedecor and Cochran (1969).

RESULTS AND DISCUSSION

Chemical composition:

Result in Table (1) show that adding corn meal to wheat flour (72% extraction rate) from 10% to 30% increased ash content from 0.67% to 1.00% and oil percentage from 1.10% to 1.40% and decreased protein from 9.01% to 8.11%

and total soluble sugar percentage from 1.32% to 0.92%. These results are in harmony with the results obtained by Mohesn et al., (1997) and Seleem (2000). From the previous results all wheat-corn blends contained more ash and oil contents and fewer rates of protein and total soluble sugar as compared with wheat flour composition.

Table (1): Chemical composition of wheat flour 72% extraction and their blended with different levels of corn meal.

Corn meal (%)	Selected chemical composition g/100g sample			
	Ash	Protein	Oil	Total soluble sugar
Control (zero)	0.56	9.55	0.82	1.55
10	0.67	9.01	1.10	1.32
20	0.82	8.53	1.32	1.10
30	1.00	8.11	1.40	0.92

Wet and dry gluten and Farinograph parameters of dough:

Data in Table (2) show that wet and dry gluten contents decreased with increasing corn meal addition from 10% to 30% in the range of 23.71% and 18.70% for wet gluten and 9.70% to 8.52% for dry gluten. So, addition of corn meal appeared to have negative effect on wet and dry gluten contents of the used blends.

Doughs of wheat flour and its blends with corn meal were tested by Farinograph apparatus to determine water absorption (%), arrival time (min.), dough stability (min.), and dough weakening (B. U.). For wheat flour dough (72%) the previous characters values were 60.0%, 0.75 min., 5.50 min. and 85 B. U., respectively. Adding corn meal to wheat flour dough at rates from 10% to 30% decreased water absorption and dough stability to the lowest values with increasing corn meal addition i.e. 59.0% to 56.8% and 4.75 min to 3.50 min., respectively. On the other hand arrival time and dough weakening increased with the increment level of corn meal to wheat flour dough from 1.25 min to 2.00 min and 90 B.U. to 120 B.U., respectively.

Table (2): The effect of different levels of corn meal on the tested parameters

Corn meal (%)	Tested parameters							
	Wet gluten (%)	Dry gluten (%)	Water absorption (%)	Arrival time (min.)	Stability (min.)	Weakening (B.U.)	Falling No. (Sec.)	Liquefaction No.
Control (zero)	26.64	11.10	60.00	0.75	5.50	85	317.00	22.47
10	23.71	9.70	59.00	1.25	4.75	90	298.00	24.19
20	20.62	9.00	57.40	1.50	4.00	100	277.00	26.43
30	18.70	8.52	56.80	2.00	3.50	120	254.00	29.41

These effects could be attributed to the chemical constituents and the reduction in and protein quality and its content of these blends. These results are in line with those obtained by (Unver and Domolds 1976) who found a significant positive correlation between water absorption and protein content, (Seleem 2000) also mentioned that water absorption and dough stability decreased and dough weakening increased with increasing corn meal addition to wheat flour dough because of the protein and gluten reduction in the used blends.

Falling number and liquefaction number:

In the same table results show that falling number (sec) decreased from 298 to 254 sec while liquefaction number increased from 24.19 to 29.41 with increasing corn meal addition to wheat flour dough from 10% to 30%. Falling No. is considered the major factor for amylase activity in wheat flour dough since the α–amylase enzyme synthesized in grain has the ability to liquefy starch. There was a relation between falling No. and liquefaction No. , because of liquefaction No. is proportional to α – amylase activity and falling No. and maximum dough viscosity. Similar conclusion was obtained by (Seleem 2000) who reported that the liquefaction No. was reased by increasing the addition of corn meal. This means that increasing the

addition of corn meal increased the amylolytic activity of the dough and consequently decreased the maximum viscosity.

Effect of interaction between corn meal, mixing time and baking treatment on physical properties of cookies:

The results reported in Table (3) show the effect of the interaction of corn meal level, baking treatment and mixing time on thickness (T), diameter (D) and spread ratio (diameter/thickness) of produced cookies. Thickness of cookie significantly increased with increasing the rate of corn meal till 20% and then decreased due to more addition of corn meal (30%), also significantly decreased with increasing mixing time, but significantly increased with increasing the microwave power treatments.

The lowest value of thickness was obtained by adding 30% of corn meal to cookie formula followed by control (without corn meal addition), when these formulas received 6 min. mixing time and baked under conventional oven. The highest thickness value was obtained using formula contained 20% followed by 10% of corn meal additions under 3 min. mixing time and baked in microwave of high power treatment.

Diameter of the produced cookies significantly increased with increasing corn meal adding rates and /or decreased with increasing mixing time. (Sai-Manohar and Haridas-Rao, 1997) found that the diameter of cookie decrease with increasing dough mixing time because of excessive development of gluten. Also the diameter significantly decreased with increasing microwave power treatment. Hoseney and Rogers (1994) found that final cookie diameter was controled by cookie spread rate. Cookie spread rate appears to be controlled by dough viscosity.

The highest diameter value of cookie was obtained from formula contained 30% of corn meal, received 3 min. mixing time and baked in conventional oven, while the lowest diameter rate was obtained in cookie formula without corn meal addition (control) received 6 min .mixing time and baked under high microwave power treatment. (Bernussi *et al.*, 1998) found that there was a decrease in diameter and increase in the thickness of the cookies baked using microwave heating compared to the control (conventional oven) .

Cookie spreading ratio (D/T) significantly increased with increasing corn meal level adding to its formula and /or mixing time period, but significantly decreased with

increasing microwave power treatment. The value of the expansion factor (diameter / thickness) for the control cookies was higher than that baked by the combined conventional and microwave processes, showing that microwave heating resulted in shrinkage of the product, although the difference was slight. This could explain that the cookies romained soft and flexible when they left the conventional oven and residual moisture was rapidly removed in microwave oven (Bernussi *et al.*, 1998). In conclusion, adding corn meal in the rate of 20% and decreasing mixing time of cookies dough significantly improved the spread rate of the produced cookies, while using microwave at high power rate reduced it.

The lowest spread rates were obtained in cookies with or without 10% corn meal addition which received 3 min. mixing time and baked under high power of microwave oven. The highest spread ratios were in cookies contained 30% and / or 20% corn meal addition with 6 min. mixing time and baked in conventional oven. The last treatment (20% corn meal) improved the final product of cookies.

Table (3): Effect of interaction between corn meal level, mixing time and baking treatment on physical properties of cookies.

Oven and Microwave	Physical properties & Mixing time / Corn meal (%)	Thickness (cm)		Diameter (cm)		Spread ratio D/T	
		3 min.	6 min.	3 min.	6 min.	3 min.	6 min.
Conventional oven	Control (zero)	0.58	0.53	5.60	5.46	9.57	10.20
	10	0.60	0.55	6.07	5.68	10.12	10.23
	20	0.61	0.56	6.17	5.75	10.20	10.27
	30	0.53	0.48	6.18	5.48	11.55	11.86
Medium power	Control (zero)	0.59	0.53	5.55	5.44	9.40	10.16
	10	0.61	0.55	6.02	5.67	9.87	10.22
	20	0.62	0.56	6.13	5.74	9.89	10.25
	30	0.55	0.53	6.15	5.75	11.18	10.85
High power	Control (zero)	0.59	0.53	5.52	5.30	9.35	10.00
	10	0.61	0.56	5.93	5.61	9.64	10.02
	20	0.63	0.56	6.10	5.70	9.68	10.09
	30	0.55	0.50	6.13	5.72	11.15	11.44
L.S.D at 5%		0.02		0.02		0.17	

Effect of corn meal on sensory characteristics of cookies:

The results in Table (4) show the effect of treatments (corn meal with different levels) on sensory properties of cookies such as appearance, color, texture, cracking, flavor, bite and chewing and total scores.

With respect to the adding corn meal with 10% and 20% it significantly increased the rate of all previous characteristics, except the color of cookies, as compared with control or 30% corn meal treatments. The highest rates were obtained in cookies supplied with 20% followed by 10% corn meal treatments. Increasing corn meal level till 20% resulting in a significant increase in these characteristics. Adding 30% of corn meal during cookie making resulted in the lowest values of the above mentioned characters, but showed significant increment over control.

Cookie color score increased gradually with increasing corn meal percentage till 30% which was added to the cookies during the present study.

The increment of character scores are in harmony with those obtained by Seleem (2000). She found that weakening (B.U) of dough was increased by increasing the level of added corn meal which could be attributed to the reduction in protein and consequently gluten in blends. This weakening in dough may be the important factor in improving cookie characteristics.

Concerning the effect of adding corn meal flour in different levels on total scores of cookie characteristics, the results indicated that 10% and 20% corn meal treatments significantly increased cookie total scores than control, 30% corn meal treatment showed the lowest total score (Seleem, 2000).

Concerning cookie sensory characters, i.e. appearance, color, texture, cracking, flavor and bite and chewing, data in Table (4) show the effect of mixing time on these characters. The values of the previous cookie characters were significantly higher when using the short mixing time (3min) then when using the long mixing time (6min). Similar conclusion was obtained by Sai-Manohar and Haridas-Rao (1997) who found that texture of Cookies made from dough mixed for 300 sec. was harder .Also, Gaines (1991) reported that there was an increase in the hardness of cookie with the increase in the degree of mixing.

The decrement in the values of these characters when using 6 min. as mixing time caused from increasing gluten with increasing mixing time. The protein

continued to develop with increasing mixing time. However, such development of gluten is not desirable for cookie (Sai-Manohar and Haridas-Rao, 1997).

Regarding the effect of baking treatment on sensory characteristics of the tested parameters, It was considered to study the effect of microwave power setting baking treatments (microwave treatments) on cookie appearance, color, texture, cracking, flavor, bite and chewing as well as total scores, the data in Table (4) indicate clearly that conventional oven treatment did not exert any marked effect on these characters of cookies. Microwave treatments (microwave power setting baking treatments) increased all the previous characteristics as compared with conventional oven treatment. High power microwave treatment produced cookies with the highest scores as compared with the other treatments. It is worth to mention that decreasing cookies moisture resulted in improving of all mentioned characteristics. Bernussi et al., (1998) showed that microwave heating could be introduced successfully in the final stages of cookie baking, producing products with excellent sensory characteristics and reduced their cracking.

Table (4): Sensory characteristics of cookies as affected by the applied technological treatments

Corn meal %	Sensory Characteristics						
	Appearance (20)	Color (10)	Texture (30)	Cracking (10)	Flavor (10)	Bite and Chewing (20)	Total Scores (100)
	Corn meal additions						
Control (Zero)	16.21	6.92	23.04	7.08	7.04	16.08	76.37
10	17.21	7.58	24.08	7.88	7.75	17.00	81.50
20	18.17	8.08	25.50	8.96	8.50	17.92	87.13
30	15.17	8.92	22.00	6.71	7.17	15.38	55.55
L.S.D at 5%	0.67	0.58	0.85	0.25	0.53	0.67	4.36
	Mixing time of dough						
3 min.	17.23	8.13	24.79	8.00	7.88	17.06	83.09
6 min.	16.15	7.63	22.52	7.31	7.35	16.13	77.09
L.S.D at 5%	0.47	0.41	0.60	0.18	0.37	0.48	4.40
	Conventional and microwave baking process						
Conventional oven	15.75	7.28	21.47	6.81	6.88	15.44	73.63
Medium power (30sec.)	16.53	7.88	23.13	7.59	7.56	16.59	79.28
High power (30sec.)	17.78	8.47	26.38	8.56	8.41	17.75	87.35
L.S.D at 5%	0.58	0.51	0.74	0.22	0.46	0.59	4.11

Effect of interaction between mixing time, corn meal and baking treatment on sensory characteristics:

With respect to all cookie sensory characteristics except its color, it is clear from data in Table(5) that the highest significant increase of these characteristics were recorded in cookies made after 3 min. mixing time blended with 20% corn meal followed by cookies of the same mixing time but contained 10% corn meal and baked under high microwave power treatment .The lowest significant decrease were noticed for cookies of 6 min. mixing time contained 30% corn meal in its formula and baked in conventional oven. The values of cookies indices were significantly higher in produced cookies after 3 min. mixing time under all various corn meal additions as compared with 6min. cookies mixing time after baked under high microwave power treatment. Cookies baked under higher microwave power treatment have higher scores as compared with medium microwave power treatment or conventional oven. Concerning cookie color, the interaction between the highest corn meal levels (30%), mixing time of 3min and baked under high power treatment produced cookies with the higher color value than other formulas. Total scores follow the same trend which reflects the sensory evaluation of the characteristics under study.

Moisture content after baking:

The main values for moisture content during application of conventional and microwave heating to bake cookies at high and medium microwave power settings for 30 sec are shown in Table(6) .

All microwave treatments produced cookies with lower moisture content than control sample baked by conventional process. Microwave at high power setting produced cookies contain the lower moisture content as compared with the other baked process.

During cookies baking process in conventional oven or in microwave, moisture content decreased with increasing corn meal addition, and increased due to using the long mixing time.

Table (5): Sensory characteristics of cookies as affected by interaction between mixing time, corn meal level and microwave treatment.

Oven treatment		Sensory characteristics	Appearance (20)		Color (10)		Texture (30)		Cracking (10)		Flavor (10)		Bite and chewing (20)		Total scores (100)	
		Treatment \ Mixing time	3 min.	6 min.	3 min.	6 min.	3 min.	6 min.	3 min.	6 min.	3 min.	6 min.	3 min.	6 min.	3 min.	6 min.
Conventional oven		Control (zero)	16.00	15.25	6.50	6.25	21.75	20.0	6.50	6.25	6.75	6.00	15.50	14.75	73.00	68.50
		Corn meal 10 %	16.75	16.00	7.00	7.00	23.00	20.75	7.50	6.75	7.25	6.75	16.25	15.25	77.75	72.50
		Corn meal 20 %	17.25	16.50	7.75	7.25	24.00	22.00	8.50	7.50	8.00	7.50	17.00	15.75	82.50	76.50
		Corn meal 30 %	15.00	13.25	8.50	8.00	21.25	19.00	5.75	5.75	6.75	6.00	15.00	14.00	72.25	66.00
Microwave	Medium power (30 sec.)	Control (zero)	16.75	15.00	7.25	6.75	23.25	21.25	7.25	6.75	7.25	6.50	16.50	15.00	78.25	71.25
		Corn meal 10 %	17.50	16.50	7.75	7.50	24.50	22.25	8.00	7.50	7.75	7.50	17.50	16.75	83.00	71.50
		Corn meal 20 %	18.50	17.75	8.25	7.75	27.50	23.25	9.50	8.75	8.75	8.25	18.50	17.50	91.00	83.25
		Corn meal 30 %	16.00	14.25	9.00	8.75	22.75	20.25	6.75	6.25	7.50	7.00	16.00	14.50	78.00	71.00
	High power (30 sec.)	Control (zero)	17.50	16.75	7.75	7.00	27.00	25.00	8.25	7.50	7.75	8.00	17.50	16.75	85.75	81.00
		Corn meal 10 %	18.75	17.75	8.50	7.75	28.00	26.00	9.25	8.25	9.00	8.25	18.50	17.75	92.00	85.75
		Corn meal 20 %	20.00	19.00	9.25	8.25	29.50	26.75	10.00	9.50	9.50	9.00	19.75	19.00	97.50	91.50
		Corn meal 30 %	16.75	15.75	10.00	9.25	25.00	23.75	8.75	7.00	8.25	7.50	16.75	16.00	85.50	79.25
L.S.D at 5%			N. S		N. S		1.53		0.64		N. S		1.09		3.62	

The difference in cookies moisture content between the conventional and microwave baking process can be related to the greater penetrating power of microwave heating. Forced-convection heating depends on the transfer of heat through the product from the surface. Also, microwave heating can do more effective job without the size restriction usually imposed by other heating systems (Jeppson, 1964). Bernussi et al., (1998) found that microwave baking significantly reduced the moisture content of cookies. Cookies baked at medium microwave power setting for 29 sec. produced the same moisture gradient as high microwave power setting for 29 sec. which was significantly lower than control which baked using traditional process.

Table (6): Moisture content of Cookies made of wheat flour and blends after baking.

Mixing time	3 min.			6 min.		
Conventional & microwave ovens / Corn meal (%)	Conventional oven	Medium power 30sec.	High power 30sec.	Conventional oven	Medium power 30sec.	High power 30sec.
Control (zero)	5.2	4.4	4.1	5.4	5.0	4.8
10	4.5	3.8	3.3	5.0	4.6	4.5
20	4.3	3.5	3.0	4.8	4.5	4.4
30	4.0	3.3	3.0	4.7	3.4	3.1

Peroxide value:

Data reported in Table (7) show the effect of mixing time, corn meal addition and microwave power treatment on peroxide value of butter oil extracted from cookies during 90 days of storage. The peroxide value of cookies mixed with 10%, 20% and 30% of corn meal and received 3 min. or 6 min. as mixing time ranged from 0.15 to 0.20, 1.09 to 3.65 and 3.11 to 5.99 for zero time, 45 days and 90 days of storage, respectively. Peroxide value of these cookies increased as storage period extended also with increasing the corn meal addition as well as when using the high power of microwave treatment.

The highest peroxide value was obtained in cookies made from wheat flour blended with 20% and 30% of corn meal and baked at high power microwave treatment. The lowest peroxide value was found in cookies contained zero % and 10% of corn meal and baked under conventional oven. Medium microwave power lay in between .These results are true as the storage period was prolonged.

Table (7): Effect of mixing time, corn meal level and microwave treatment on peroxide value of butter oil extracted from cookies during storage.

Mixing time		3 min.			6 min.		
Oven and Microwave	Storage period (days) / Level of Corn meal (%)	Zero time	After 45	After 90	Zero time	After 45	After 90
Conventional oven	Control (zero) %	0.12	1.00	3.00	0.12	1.14	4.03
	Corn meal 10 %	0.15	1.09	3.11	0.15	1.21	4.13
	Corn meal 20 %	0.17	1.20	3.21	0.16	1.30	4.21
	Corn meal 30 %	0.19	1.31	3.35	0.18	1.39	4.35
Medium power	Control (zero) %	0.14	1.01	3.05	0.12	1.19	4.03
	Corn meal 10 %	0.16	1.11	3.22	0.14	1.31	4.21
	Corn meal 20 %	0.19	1.25	3.62	0.16	1.39	4.35
	Corn meal 30 %	0.19	1.35	3.95	0.19	1.43	4.49
High power	Control (zero) %	0.14	1.03	3.15	0.13	1.21	4.07
	Corn meal 10 %	0.17	1.15	3.87	0.15	2.05	4.37
	Corn meal 20 %	0.19	2.35	4.82	0.17	3.31	5.65
	Corn meal 30 %	0.20	2.55	4.97	0.19	3.65	5.99

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مدى تأثر جودة البسكويت بكل من زمن الخلط و إضافة دقيق الذرة و إستخدام الميكروويف

امال عبد الله الحوفى هينار عبد الفتاح سهير نظمى عبد الرحمن
معهد بحوث تكنولوجيا الأغذية- مركز البحوث الزراعية

أجريت هذة التجربه فى معهد بحوث تكنولوجيا الأغذية لدراسة تأثير زمن الخلط وإضافة ١٠% ، ٢٠% ، ٣٠% من دقيق الذرة إلى جانب تأثر الخبز فى الفرن العادى و الميكروويف على جودة البسكويت.

إضافة المعدلات ١٠%، ٢٠% ، ٣٠% من دقيق الذرة إلى دقيق القمح (إستخلاص ٧٢%) أدى إلى زيادة نسبة الرماد و الزيت و ضعف العجينه. و على العكس فقد أدى إلى إنخفاض نسبة البروتين و السكريات الكلية و الجلوتين الرطب و الجاف و إمتصاص الماء و رقم السقوط.

كان هناك زيادة فىسمك البسكويت مع زيادة الاضافة حتى ٢٠% ثم تتجه إلى النقصان بزيادة الاضافة. القطر ومعدل الفرد تزيد بزيادة الاضافة. السمك و القطر يقل بينما يزداد معدل الفرد بزيادة زمن الخلط. لكن السمك ومعدل الفرد يزداد بينما يقل القطر مع زيادة قدرة فرن الميكروويف أثناء الخبز.

إضافة دقيق الذرة حتى ٢٠% إلى عجينة البسكويت الناتج. إستخدام ٣ دقائق كزمن خلط مع الخبز فى الميكروويف على القدرة الأعلى أعطت أفضل النتائج بالمقارنة ببقية المعاملات.