EFFECT OF PARTIAL SUBSTITUTION OF WHEAT AND SOYBEAN FLOURS FOR MAIZE ON THE CHARACTERISTICS OF PRODUCED TORTILLA

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Abstract

In the present study, Egyptian yellow and white maize were used to prepare tortilla by cooking methods in the presence of 1% (w/v) Ca $(OH)_2$. A trial was carried out to increase torilla nutritive value by adding wheat flour and soybean flour. The produced tortilla was subjected to panel test and chemical analysis. Addition of 25% wheat flour and 15% soybean flour and 25% wheat flour + 10% soybean flour gave good tortilla. Dry matter losses during cooking and washing of nixtamal were determined in the two corn varieties.

INTRODUCTION

Maize (*Zea mays* L.) ranks as the second most important cereal in the world from the stand point of the total production. In Egypt, because of the limited area of cultivated land, wheat is imported to cover the demand for bread consumption. To reduce the amount of imported wheat the introduction of tortilla as a substitute for wheat breed has been tried. Tortilla are an unleavened flat bread produced by cooking corn in alkali Ca (OH)2 followed by steeping, and washing the cooked corn (nixtamal). Then the nixtamal is ground into masa, formed into thin flat dough pieces and baked into tortilla. Shuey and Keith (1980) mentioned that during lime treatment of corn, calcium diffuses to the center of grains and play an important role in gelatinization and the slurry prepared from this grain exhibits characteristics similar to starch that has been chemically crossbonded. Griensen (1981) reported that addition of full fat-soya (8%) to corn increased the quality and quantity of protein because soya flour adds tryptophan and lysine which are deficient in corn. Sanchez-Marroguin *et al.* (1987) prepared tortilla with traditioal method by treating flour with lime. They found that the protein efficiency ratio and net protein ratio were improved with no change in the sensory characteristics. Lysine content decreased slightly in the processed samples. Improvement in tortilla protein was observed (9.2 to 12%), fat (1.8-4.91), .P (231-370

mg/100g) and linoleic acid (41-6.8%) with soybean fortification. Barron and Espinoza (1993) fortified maiza tortilla with alkali treated chickpea flour at the levels of 5, 10, 15, 20 and 25% by weight. The alkali treated chickpea showed highest digestibility and reduced trypsin inhibition activity. Fortified tortilla showed a significant increase in nutritive value with improved color and texture when compared to the maize tortilla. Yau *et al.* (1994) studied the effects of food additives on storage stability of corn tortilla. They found that the storage stability was extended for up to nine days by incorporating a mixture of 0.5% sodium carboxymethyl cellulose (CMC), 2% gluten and 3% sorbitol into the dough during processing.

The aim of the present investigation is to evaluate the tortilla produced from alkali treatment of corn grains blended with wheat flour and soya flour.

MATERIALS AND METHODS

Yellow corn grains (*Zea mays* L. variety Amon), white maize (*Zea mays* L. Single Hybrid 10) and wheat grains (*Triticum aestivum* variety Giza 164) were obtained from the Field Crops Res. Inst., ARC, Giza, Egypt. The wheat grains were conditioned to 14% overnight and milled in quadramat mill to obtain wheat flour 72% extraction. Defatted soy flour was obtained from Soybean Factory, Food Technology Research Institute, ARC, Giza, Egypt.

Preparation of tortillas

The method reported by Feria-Morales and Pangborn (1993) was used with some modifications as follows: Corn grains (200 g) were boiled for 60 min in Ca (OH)2 solution (400 ml, 1%, w/v). The treated corn grains (nixtamal) was washed with tap water to remove excess alkali, then boiled in 800 ml tap water for 90 minutes (white variety) and 180 minutes (yellow variety). The product was ground in blender to form masa The produced masa was divided into four portions. The first was used as a control, the second was mixed with wheat flour (72% extraction) at 25 and 50% levels. The third portion was mixed with defatted soybean flour at the ratios of 5,10 and 15%. The fourth was mixed with wheat flour (72%) at 25% and defatted soy flour at 10%. The products were then divided into 50 g portion and each portion was shaped into thin flat dough (15 cm diameter) and baked at 250 ^{o}C for 5 minutes. The produced loaves were left to cool at room temperature, packed in polyethylene bags and

stored at 4 °C until subsequent analysis.

Chemical analysis

The raw materials as well as the produced tortilla were analyzed for moisture, crude protein, hexane extract, and ash according to the methods outlined in A.O.A.C. (1980), while total carbohydrates were calculated by differences. Calcium content of the above mentioned materials was determined after ashing using Pye Unicam SP 19000 Atomic Absorption Spectrophotometer according to the method outlined in A.O.A.C. (1980).

Viscosity measurement of corn flour using Brabender amylograph

A sample of corn flour (50 gm Egyptian white maize) was suspended in 450 ml water. The suspension was placed in the amylograph ball, the temperature was raised at the rate of 1 °C/min with constant stirring. The sample was then held at 95 °C for 20 minutes and the viscosity was recorded. The experiment was repeated by suspending the flour (50 g) in 450 ml water containing 1% $Ca(OH)_2$ (Tonela *et al.*, 1983).

Determination of dry matter loss

A sample of each corn variety (100 g) was treated with $Ca(OH)_2$ solution, then with water as mentioned in the preparation of tortilla. The extract was transferred to 200 ml volumetric flask and completed to volume using distilled water. An aliquot of the extract was placed in a weighed porcelain dish and evaporated to dryness on a water bath, then heated in an oven at 60 °C until constant weight.

Determination of masa/dry corn ratio

A sample of corn (200 g) was treated with $Ca(OH)_2$ solution, then with water as described in preparation of tortilla. The masa weight was determined and the ratio of masa to dry corn was calculated.

Organoleptic evaluation of produced tortilla

Tortilla were evaluated for general appearance, roundness, separation of layers, color, taste and odor. The quality scores were evaluated by10 experienced panelists. Score of each parameter was used as reported by El-Farra *et al.* (1982). All sensory parameters were statistically analyzed according to the method described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

The results in Table 1 show the chemical composition of materials used in tortilla, i.e. Egyptian yellow and white maize, wheat flour 72% extraction, and defatted soybean flour. From these data, it can be observed that yellow maize was characterized by slightly high protein content (11.17% on dry basis) followed by white maize (10.13%). An opposite trend was observed for total carbohydrates where it varied from 81.58% for white maize to 80.12% for the yellow corn. Lipid, ash and Ca showed very close results between different varieties. The data are in agreement with the findings of Mestres *et al.* (1991). Analysis of wheat flour showed 9.9% for protein and 87.81% for total carbohydrates. Results are as found by Abdel latif (1990) and Abdel-Kader (1995). For defatted soybean flour, the protein content amounted 50.5%. The relatively high amount of ash (7.4%) is due to the removal of lipid which led to the relative increase in ash. The results are in accordance to those reported by El-Amry (1981) who found that defatted soybean flour contained 45.7% total carbohydrates and 43.7% protein.

Table1. Chemical composition of materials used for tortilla preparation (on dry basis).

Materials	Protein	Hexane extract	Ash	Fiber	T.C	Ca mg/100g
Yellow corn	11.17	3.48	1.63	3.60	80.12	0.004
White corn	10.13	3.40	1.83	3.07	81.57	0.005
Wheat flour (72%)	9.90	1.04	0.88	0.37	87.81	0.004
Defatted soy flour	50.50	2.80	7.40	1.70	37.60	0.045

Chemical composition of corn varieties compared to the produced tortilla

In order to obtain more information about the chemical composition of tortilla, it was found necessary to determine the total hydrolyzable carbohydrate in raw corn and tortilla. The loss which occurred in dry substance of corn during tortilla preparation must also be taken in consideration. From Table 2, it can be observed that total hydrolyzable carbohydrates increased in tortilla by 3% as compared to the raw corn. This apparent increase is due to the loss in dry substances during tortilla preparation. This loss include fibers and lipids which were removed during processing. The loss in dry matter was 10.3 and 19.8% for the yellow and white corn, respectively. The loss in dry mat-

ter was reported by Katz and Hediger (1974) to vary from 5-14% during conversion of the corn into nixtamal by traditional village method. On the other hand, Bedolla *et al.* (1983) found that starch amounted to 76% in the corn grains and increased to 80% in tortilla.

Table 2. Chemical composition of corn varieteties in comparison to the produced tortilla and dry matter loss.

Corn variety and Produced tortilla	Protein %	Hexane extract %	Ash %	Fiber %	T.C. %	Loss in dry matter (%)
Yellow corn	11.17	2.48	1.63	3.60	80.12	-
Tortilla	11.76	2.14	2.17	1.24	70	10.3
White corn	10.13	3.40	1.83	3.07	81.57	-
Tortilla soy flour	11.30	1.68	2.63	0.88	77	19.8

*T.C. = Total hydrolyzable carbohydrate determined by the method of Montgomery (1961).

Chemical composition of tortilla prepared from corn mixed with wheat flour and defatted soybean flour

In the present investigation, an attempt was conducted to improve the nutritional value of tortilla. For this purpose, corn grains were converted to masa which was mixed with wheat flour (25 and 50%). Soybean flour (5, 10 and 15%) and a mixture of wheat flour and soybean flour at the amounts of 25% and 10%, respectively. The chemical composition of the different fortified tortilla is presented in Table 3. The data reveal that protein content slightly decreased in case of addition of wheat flour at 50% as compared to 25%. This is due to the fact that the protein percentage in wheat flour (72%) was Lower than in corn grains. On the other hand, addition of soybean flour resulted in gradual increase in protein content which reached maximum amounts at 15% addition. On the other hand, addition of wheat flour +soybean flour to masa highly increased the protein content of tortilla compared to the control. In this respect, Del Valle *et al.* (1976) reported that enriching corn with whole raw soybean flour at 10% level raised the cost of flour by 5% while using defatted soybean flour raised the cost by 40%. Tonella *et al.* (1983) added separately each of the following ingredients to corn for tortilla preparation, whole soybean flour (19.9%), chickpea flour (19.9%) or

whole sesame (15.9). Little amounts of lysine and methionine were added. They found that the nutritional value of fortified flour expressed as protein efficiency ratio (PER) was 0.9 in case of lime treated corn flour and 2.55 in case of soybean treated corn with the addition of methionine and lysine.

Table 3. Chemical composition of tortilia prepared from corn with the addition of wheat flour and defatted soy flour (on dry basis).

Formula of tortilla	Protein	Hexane extract	Ash	Fiber	T.C*	Ca^{++} mg/100g
Yellow corn	11.76	2.14	2.17	1.24	82.70	0.020
25% Wheat flour	11.27	1.74	2.10	1.00	83.90	0.023
50% Wheat flour	10.77	1.64	1.86	0.96	84.77	0.027
5% Soy flour	13.70	2.17	2.45	1.26	80.42	0.025
10% Soy flour	15.36	2.21	2.66	1.30	78.47	0.032
15% Soy flour	17.81	2.25	2.95	1.32	75.67	0.049
25% Wheat + 10% Soy flour	15.02	2.08	2.80	1.12	78.98	0.016
White corn	11.30	1.68	2.63	0.88	83.51	0.015
25% Wheat flour	10.86	1.20	2.37	0.70	84.87	0.021
50% Wheat flour	10.50	0.93	2.30	0.58	85.70	0.029
5% Soy flour	13.95	1.74	2.87	0.92	80.52	0.020
10% Soy flour	15.18	1.80	3.08	0.95	78.00	0.026
15% Soy flour	17.46	1.84	3.32	1.00	76.38	0.0.32
25% Wheat + 10% Soy flour	14.40	1.41	2.80	0.90	80.44	0.023

T.C. = Total carbohydrates was calculated by differences.

Water retention by corn varieties during tortilla preparation

The data presented in Table 4 show that white corn resulted in highest masa (486 g) compared to the yellow corn (426 g) due to water retention which amounted in 143 and 113. respectively. From the obtained data, it seems that the high amount of floury endosperm led to a high water retention and higher masa weight. The data are in agreement with Ramirezwon *et al.* (1994) who found that cooking time affected the masa moisture, water absorption index, enzyme susceptible starch and total amylose,

and masa weight.

Table 4. Water retention by corn varieties during tortilla preparation.

Corn variety	Weight of corn	Weigh of masa	Water retention
Yellow corn	200	426	113
Wheat corn	200	486	143

Amylograph characteristics of lime treated and untreated whole corn flour

The results presented in Table 5 show that the treatment of corn flour with Ca $(OH)_2$ decreased the temperature of initial viscosity by about 9^oC which means that Ca $(OH)_2$ impaired H_2O penetrating power into the starch granule, probably due to the decrease of hydrogen bond in the starch granule. It is also observed that addition of Ca $(OH)_2$ highly increased the corn flour viscosity from 790 B.u (untreated) to 1135 B.u. (lime treated flour). The temperature of the peak viscosity also decreased by 16.5^oC which also proved that Ca $(OH)_2$ helped loosen the starch granules. In this respect, Shuey and Keith (1980) reported that during tortilla preparation Ca $(OH)_2$ was added at 1% of the water used in the process. Calcium diffuses to the center of the starch granule and plays an important role in gelatinization and viscosity of the starch and improves the physical properties of tortilla. The obtained data concerning viscosity of treated and untreated corn flour are not in agreement with those reported by Tonella *et al.* (1983) who found that peak viscosity of untreated corn flour was 1350 B.u. while it amounts to 990 in lime-treated corn. This discrepancy is probably due to the protein quality and starch quality in the used corn grains.

Table 5. Amylograph characteristics of lime treated and untreated corn flour.

Sample	temp. of initial viscosity increase	Temp. of peak viscosity	peak viscosity (B. u)*
Corn flour (control)	77	98.0	790
Lime treated corn flour	68	81.5	1135

Characteristics of tortilla prepared from corn with the addition of wheat flour and soybean flour

Table 6 show the characteristics of tortilla prepared from either yellow or white maize separately and blended with wheat flour (25 and 50%), soybean flour (5, 10 and 15) or a mixture of wheat flour (25%) and soybean flour (10%). The data reveal that all addition significantly improved all properties except that of roundness and color. Regarding the total score, it could be concluded that the best tortilla was that prepared from white corn mixed with soybean flour (10%) followed by a mixture of wheat flour (25%) and soybean flour (10%).

Table 6. Characteristics (mean ± SD) of tortilla prepared from corn with the addition of wheat flour and defatted soy flour.

Tortilla	General appearance (20)	Separation of layer (10)	Roundness (10)	Odor (20)	Taste (20)	Color (20)	Total Score (100)
Yellow corn	17.63 ± 0.79	9.31 ± 0.26	9.70 ± 0.37	17.44 ± 0.82	17.75 ± 0.54	17.65 ± 0.50	89.49± 2.31
25% Wheat flour	18.68 ± 1.22	9.74 ± 0.44	9.60 ± 0.23	18.22 ± 1.36	18.27 ± 1.07	18.21 ± 1.33	92.72± 3.59
50% Wheat flour	18.96 ± 0.84	9.78 ± 0.44	9.88 ± 0.44	17.71 ± 0.44	18.10 ± 1.00	18.36 ± 1.19	92.79± 2.85
5% Soy flour	18.1 3± 0.79	9.94 ± 0.23	10.00 ± 0.00	18.20 ± 0.65	18.20 ± 0.65	18.38 ± 0.52	92.85± 2.14
10% Soy flour	18.86 ± 0.70	10.00 ± 0.0	10.00 ± 0.0	18.93 ± 0.54	18.86 ± 0.44	18.86 ± 0.46	95.51± 1.67
15% Soy flour	19.20 ± 0.96	10.00 ± 0.00	10.00 ± 0.00	19.10 ± 0.68	19.10 ± 0.42	18.88 ± 0.58	96.28± 2.19
25% Wheat + 10% Soy flour	19.48 ± 0.42	9.63 ± 0.42	9.57 ± 0.32	18.37 ± 1.12	18.91 ± 0.52	18.30 ± 1.37	94.26± 2.92
White corn	17.88 ± 0.52	9.44 ± 0.62	9.88 ± 0.23	17.44 ± 0.78	17.96 ± 0.68	17.25 ± 0.66	89.45± 1.50
25% Wheat flour	18.56 ± 0.53	9.56 ± 0.46	9.68 ± 0.26	17.92 ± 0.63	18.25 ± 0.13	18.28 ± 1.21	92.25± 2.27
50% Wheat flour	18.75 ± 0.41	9.70 ± 0.29	9.57 ± 0.27	16.85 ± 1.09	17.87 ± 0.98	18.52 ± 1.16	91.26± 3.32
5% Soy flour	18.56 ± 0.56	9.70 ± 0.26	9.94 ± 0.18	18.31 ± 0.59	18.44 ± 0.50	17.88 ± 0.44	92.83± 1.41
10% Soy flour	19.38 ± 0.52	9.81 ± 0.26	9.94 ± 0.18	19.25 ± 0.46	19.20 ± 0.46	18.94 ± 0.42	96.52± 1.77
15% Soy flour	19.75 ± 0.38	10.00 ± 0.00	10.00 ± 0.00	19.70 ± 0.37	19.70 ± 0.37	19.63 ± 0.35	98.778 ± 1.10
25% Wheat + 10% Soy flour	19.37 ± 0.58	9.43 ± 0.27	9.56 ± 0.42	18.40 ± 0.42	18.70 ± 0.9	18.50 ± 0.75	93.95± 2.91
LSD at 0.05 level	0.39	0.15	NS	0.40	0.37	NS	1.78

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تأثير الإحلال الجزئي للذرة الشامية بدقيق القمح والصويا على صفات خبز الطرطية

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أجرى هذا البحث بأستخدام الذره الصفراء والبيضاء المصريه فى أنتاج خبز الطرطيه بطريقه الطبخ فى وجود أيدروكسيد الكالسيوم بتركيز ١٪ وزن / حجم. أجريت تجربه لزيادة القيمه الغذائية للطرطيه بإضافة دقيق القمح ودقيق الصويا. ولقد تم اجراء الأختبارات الحسيه والتحاليل الكيماويه للطرطيه وكذلك المواد الخام المستخدمه فى أنتاجها. أدت اضافة القمح بنسبة ٢٥٪ ، الصويابنسبة ١٠ ، ١٥٪ وكذلك مخلوط من القمح (٢٥٪) + دقيق فول الصويا (١٥٪) الى أنتاج طرطيه جيده . تم كذلك تقدير الفاقد فى الماده الجافه أثناء الطبخ وكذلك ماء غسيل العجينه لكلا الصنفين من الذره.