

FORTIFICATION OF MAIZE TORTILLA WITH SOME SPROUTED AND COOKED LEGUMES SEED MEAL MIXTURE

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Abstract

This work aims to produce gluten free tortilla from white maize flour fortified with sprouted and cooked legumes seed meal mixture (SCLM), (weet lupin, chickpea and fenugreek) to increase its biological value and to improve its technological and sensory characteristics. The studies were extended to chemical, technological and sensory characteristics to determine the best treatment or best fortification of tortillas compared with the control (tortilla made from maize only).

Chemical studies cleared that, essential amino acid lysine increased by increasing fortification with sprouted and cooked legumes meal mixture (SCLM). Essential amino acid lysine increased by 150, 187.5 and 225.0% at 5, 10 and 15% fortification respectively compared with tortilla made from maize only. Minerals content (Ca, Mg, Fe, Zn, Mn and vitamin A) increased in fortified tortilla. All chemical, technological and sensory studies indicated that, the best fortified tortillas was produced from maize flour fortified with 10% (SCLM). This level of fortification also significantly improved taste, color and appearance (94.0 total scores compared with the control (70.0 total scores).

INTRODUCTION

Tortillas, an unleavened bread prepared from maize or wheat bread (Holt *et al.*, 1992). Tortilla made of maize are considered an excellent source of calories due to its high starch content. In addition, they are a good source of calcium due to lime added for cooking. Lime cooking also increase the bioavailability of niacin one of the most important B vitamins, (Serna-Saldivar *et al.*, 1991, 1992). Unfortunately tortilla are not a perfect food because they lack good quality protein and adequate levels of iron, zinc and vitamins A, D, E, and B₁₂. From a practical point of view the consumption of tortilla without high quality protein food caused (*kwashiorkor*) in infants due to the lack of two essential amino acids, lysine and tryptophan, (Stylianopoulos *et al.*, 2002). Also tortilla is a functional bread concerning celiac disease. Tortilla is very appropriate for celiac disease it has no gluten in its protein and has easily digested carbohydrates (Jujral *et al.*, 2003) Tortilla is an excellent mean for increasing the nutritional of poor population. Previous attempts have been made to obtain gluten-free bread of high nutritive values and acceptable quality for bread organoleptic characteristics.

Legumes are economical sources of protein, calories vitamins and minerals (El-Kady *et al.*, 1991 Pollared *et al.*, 1993, Trugo *et al.*, 1993 and Reyes-Moreno *et al.*, 2004). Germination and / or cooking of legumes is the main process for degradation antinutritional factors (Muzquiz *et al.*, 2004). By combination legumes with different cereal it may be possible to improve functional and physico-chemical properties and nutritional quality of baked products. Legumes are known to have high lysine. Cereal which are low lysine can be improved nutritionally by fortification with legumes flour. Combination of legume and cereal would provide protein of high biological values in diet of people in many developing countries at low cost (Cardenas *et al.*, 2003). The improvement of tortilla nutrition, technological and organoleptic quality can be achieved through the addition of legumes. This work aims to produce tortilla with high nutritive values through fortification of maize tortilla with 5, 10 and 15% sprouted and cooked legumes seed meal mixture (SCLM) and to find out the most suitable treatment giving fortified tortilla with high biological value and good quality, values.

MATERIALS AND METHODS

Materials

Different legumes seeds included, Lupin (*lupinus* spp.) sweet variety, chick pea (*Cicer arietinum*) and fenugreek (*Trigonella foenum graecum* L.) variety Giza-2 were obtained from legume Breeding Res. Sec. Field crops Res. Inst. Agric. Res. Cent. Giza Egypt. White Mize grains (*Zea maize* L. single hybrid 10) were obtained from maize breeding Res. Sec. field crops Res. Institute, Agric. Res. Cent. Giza, Egypt.

Methods

1- Preparation of sprouted and cooked legumes meal mixtures (SCLM)

Seeds of every legume were sprouted separately at 20-25 C° in dark for 24hr, then cooked by heat steam for 1 hour. After these treatments, legumes were dried using oven air drier (50-55C°) over night (14 hours). Legumes were separately ground using laboratory mill (Model 3100 which is a hummer type mill) and equipped to obtain granules size (0.150 – 0.450 mm.). Lupin, chick pea and fenugreek flour were mixed by (3:1:1 ratio) to prepare sprouted and cooked legumes flour mixture (SCLM). These ratios offered the advantages of increasing protein content and improving the quality of produced tortilla.

2- Preparation of tortillas from white maize grains

Samples of maize grains 300 gm. were boiled in 900 ml Ca (OH)₂ solution 2% (grain weight basis) for 1 hour. The boiled grains were steeped overnight (14 hour) in the boiled solution, then the boiling solution was discarded. The cooked steep maize grain (nixtamal) was washed three times with tap water to remove bran and excess

lime. Nixtamal was ground into a masa using electric grinder. Masa was divided into 50 gm. portion. Each portion was shaped into roller shape (2.0mm thick and 15.0 cm diameter) and baked in electric oven at 250C° for 5min., then air cooled, packed in polyethylene bags and stored at 5C° until subsequent analysis.

3- Preparation of fortified tortilla with (SCLM)

Fortified tortilla were prepared from masa mixed with 5, 10 and 15% sprouted and cooked legumes flour mixture (SCLM), (on dry weigh basis of maize). The dough of each treatment divided into 50 gm pieces. Then every treatment pieces of dough shaped, into roller shape (2mm thick and 15 cm diameter) and baked in electric oven at 250 C° for 5 min. Then air cooled, packed in polyethylene bags and stored at 5 C° and 60% RH until subsequent analysis.

4- Chemical analysis

Protein, hexane extract, crude fiber, and ash were determined according to AOAC (1990). Mineral contents (Ca, Mg, Fe, Zn, Mn.) were determined by using a pye Unicomp sp 1900 atomic absorption spectroscopy technique as described by AOAC (1990). Amino acids content were determined, other than tryptophan by mean of Beckman Automatic Amino Acid Analyzer (Model 6300, Beckman instrument, palo Alto, CA) at Central Laboratory for Food and Feed, Agriculture Research Center (ARC), Giza, Egypt. Total carbohydrate was determined by difference. Total calories were calculated by multiplying protein and total carbohydrates by 4.0 and fat (hexane extract) percentage by 9.0.

5- Determination of vitamin A

Vitamin A in produced tortilla was measured using high-performance liquid chromatography (HPLC) at Food Technology Res. Inst. ARC. Giza-Cairo According to the method described by Feldman *et al.*, (1982).

6- Sensory evaluation

Tortilla was evaluated for general appearance, roundness, separation layer, color, taste and odor by 20, 10, 10, 20, 20, and 20, degree respectively with total scores (100) by a trained taste panel (n/10) of Food Technology Research Institute, ARC, Giza Egypt.

RESULTS AND DISCUSSION

From Table (1). It is clear that maize flour has lower protein content (9.5%) than lupin, Chickpea and fenugreek flour. They have 41.8, 26.3 and 29.1% respectively. This means that these legumes have high nutrition quality. Also lupin, chickpea and fenugreek flour contained 7.0, 7.4, 7.4 and 6.8% hexane extract, while maize flour contained 4.7% only. Concerning ash content and crude fiber it was observed that

lupin, chickpea and fenugreek flour contained 4.6, 4.8, 4.1% ash and 18.7, 6.8 and 17.6% crude fiber, respectively, while maize flour contained 1.8% ash and 3.3% crude fiber. In regard to total carbohydrate and total calories the maize flour had the highest amount of both, it contained 80.7% total carbohydrate and 403.1 total calories/100 gm., while lupin, chickpea and fenugreek flours contained (27.9, 54.7 and 42.4% total carbohydrates) and (341.8, 385.2 and 347.2 total calories/100 gm) respectively. Pollore *et al.*, (2002) reported that, nutritional quality of various food products could be improved by supplementation with grain legumes to increase protein content and to improve the balance of essential amino acids.

Table 1. Chemical composition of raw materials used for tortilla preparation (on dry basis).

Material	Chemical analysis					Total calories /100 gm
	Pro-tein	Hexane extract	Ash	Crud fiber	T. carbohydrate	
	%	%	%	%	%	
White maize	9.5	4.7	1.8	3.3	80.7	403.1
Lupin (sweet variety)	41.8	7.0	4.6	18.7	27.9	341.8
Chickpeas	26.3	7.4	4.8	6.8	54.7	385.2
Fenugreek	29.1	6.8	4.1	17.6	42.4	347.2

Data from Table (2) show that maize tortilla (control) had the lowest contents of protein (10.50%), hexane extract (3.6%), ash, (1.4%), crude fiber (1.8%) and total calories (401.2/100gm), while it had the highest content of total carbohydrates (81.7%) compared with tortilla fortified with 5, 10 and 15% sprouted and cooked legumes mixture (SCLM). Fortification maize tortilla with 5, 10 and 15% sprouted cooked legumes mixture (SCLM) increased protein, hexane extract, ash, crude fiber percentages and total calories by 12.20, 13.95 and 15.68% protein, 3.83, 4.98 and 5.12% hexane extract, 1.63, 1.86 and 2.1% ash, 404.7, 408.8 and 407.2% total calories/100 gm, respectively. These data were supported by Cardenas *et al.*, (2003) who reported that legumes seeds have been used as an excellent source of protein for bread and tortilla fortification.

Table 2. Chemical composition of tortilla produced from maize or maize fortified with sprouted and cooked legumes flour mixture (SCLM), (on dry weight basis).

Treatments	Protein	Hexane extract	Ash	Crude fiber	Total carbohydrates	Total calories
	%	%	%	%	%	%
Maize (M)* control	10.50	3.60	1.4	1.8	81.7	401.2
5% SCLM**+ 95% M*	12.20	3.83	1.63	2.12	80.35	404.7
10% SCLM + 90% M.	13.95	4.98	1.86	2.45	77.04	408.8
15% SCLM + 85% M.	15.68	5.12	2.1	2.80	74.6	407.2

* M = Maize tortilla

** SCLM = sprouted and cooked legumes flour mixtures

Table (3) show the proportion of the various essential and non-essential amino acids in maize tortilla and maize tortilla fortified with sprouted and cooked legumes flour mixture (SCLM). It is clear that, in maize tortilla the first limiting amino acid was lysine, but there were several amino acids that were insufficient to meet the requirements for growing infants (threonine, valine isoleucine plus Histidine). Similar results were found by James *et al.*, (2004).

Table 3. Amino acids of tortilla produced from maize and maize fortified with sprouted and cooked legumes flour mixtures (SCLM), (on dry weight basis).

Amino acids	Tortilla samples							
	Control 100% cooked maize		5% SCLM		10% SCLM		15% SCLM	
	gm./100gm	Initial	gm./100gm	Increase%	gm./100gm	Increase%	gm./100gm	Increase%
Essential amino acids :								
Lysine	0.106	100	0.040	150.0	0.046	187.5	0.052	225.0
Leucine	0.098		0.144	47.0	0.165	64.5	0.185	88.8
Isoleucine	0.025		0.043	72.0	0.049	96.0	0.055	120.0
Valine	0.034		0.054	58.8	0.061	79.4	0.069	103.0
Methionine	0.017		0.018	6.0	0.021	16.7	0.024	33.3
Threonine	0.024		0.048	100.0	0.054	125.0	0.061	154.2
Phenyl alanine	0.039		0.061	56.4	0.070	79.5	0.078	100.0
Histidine	0.024		0.046	91.7	0.053	120.8	0.060	150.0
Arginine	0.043		0.112	160.5	0.128	197.7	0.144	234.0
Non-essential amino acids:								
Aspartic acid	0.053	100	0.096	81.1	0.110	107.5	0.124	134.0
Glutamic acid	0.152		0.279	83.6	0.319	110.0	0.359	136.2
Proline	0.075		0.110	46.7	0.126	68.0	0.141	88.0
Serine	0.032		0.059	84.4	0.071	122.0	0.075	134.4
Glycine	0.025		0.049	96.0	0.056	124.0	0.063	152.0
Alanine	0.051		0.074	54.1	0.085	66.7	0.096	88.2
Cysteine	0.016		0.017	6.3	0.020	25.0	0.022	37.2

Fortified tortilla by 5, 10 and 15% (SCLM) showed that, lysine increased by 150.0, 187.5 and 225.0%, respectively. All essential amino acids increased highly by 6.0% for methionine to 160.5% for arginine at 5% (SCLM) fortification. While essential amino acids increased by 16.7% for methionine to 197.7% for arginine at 10% (SCLM) fortification. Moreover at 15% (SCLM) fortification, all essential amino acids increased by 33.3% for methionine to 234.0% for arginine. Then fortified tortilla including highest contents of lysine, threonine, histidine, arginine and other essential amino acids Table (3), hexane extract, fiber and total calories Table (2), minerals and vitamin A Table (4) compared with common commercial tortilla (maize tortilla).

From Table (4), it may be concluded that by increasing fortification ratio with 5, 10 and 15% (SCLM) Ca, Mg, Fe, Zn, Mn, and vitamin A increased by 25.9, 46.8 and 67.2% Ca, 13.8, 25.4 and 34.1% Mg, 15.4, 25.9 and 37.1% Fe, 7.9, 11.0 and 13.6% Zn, 176.7, 344.2 and 516.3% Mn and 3.6, 7.3 and 10.9% vitamin A respectively. This means that fortification of maize tortilla lead to improve its nutritive value.

Table 4. Minerals and vitamin A content of tortilla produced from maize and maize fortified with sprouted and cooked legumes flour mixtures (SCLM) (on dry weight basis).

Tortilla samples	Minerals and vitamin A contents mg/100gm.											
	Ca		Mg		Fe		Zn		Mn		Vit.A	
	Initial	Increase %	Initial	Increase %	Initial	Increase %	Initial	Increase %	Initial	Increase %	Initial	Increase %
Maize (M) control	85.3	0.0	13.8	0.0	14.3	0.0	19.1	0.0	4.3	0.0	0.55	0.0
5%SCLM** + 95%M*	107.4	25.9	15.7	13.8	16.5	15.4	20.6	7.9	11.9	176.7	0.57	3.6
10%SCLM + 90%M.	125.2	46.8	17.3	25.4	18.0	25.9	21.2	11.0	19.1	344.2	0.59	7.3
15%SCLM + 85%M.	142.6	67.2	18.5	34.1	19.6	37.1	21.7	13.6	26.5	516.3	0.61	10.6

* M = Maize tortilla.

** SCLM = sprouted and cooking legumes flour mixtures.

Table (5) show sensory evaluation of maize tortilla and maize tortilla fortified with 5, 10 and 15% (SCLM). Clear improvement occurs in fortified tortilla. The highest improvement occurs in tortilla fortified with 10% (SCLM) which has 94% of total scores of sensory evaluation compared with the maize tortilla (70% total scores). It

may be observed that when 15% SCLM were added sensory evaluation values decreased due to decreasing in layer separation and loaf diameter and increasing in hardness. Finally the fortified tortilla with 10% SCLM was the best treatment due to its higher freshness, layer separation and brighter color with improvement of appearance, odor and taste values.

Table 5. Sensory evaluation of tortilla produced from maize and maize fortified with sprouted and cooked legumes flour mixture (SCLM), (values mean of three replicate).

Tortilla samples	Appear- ance	Layer separation	Rolla- bility	Odor	Taste	Color	Total scores
	20	10	10	20	20	20	100
Maize (M) * control	14.0	3.2	3.1	15.5	15.8	17.4	70.0
5%SCLM** + 95%M.	17.3	7.4	7.5	18.0	18.2	18.3	86.7
10%SCLM + 90%M.	19.6	9.2	8.3	18.6	19.5	18.8	94.0
15%SCLM + 85%M.	16.5	5.6	6.4	18.0	18.0	17.0	81.5

* M = Maize tortilla.

** SCLM = sprouted and cooked legumes flour mixtures.

CONCLUSION

Maize tortilla were fortified with 5, 10 and 15% sprouted and cooked legumes flour mixture (SCLM) to maximize essential amino acids, mineral (Ca, Mg, Fe, Zn, Mn) and vitamin A. Results of this study cleared that, the best fortified tortilla was produced from maize tortilla fortified with 10% SCLM. Because 10% fortified tortilla significantly increase in biological values with improved taste, odor, color and appearance (94 total scores) compared with the maize tortilla (control) which had (70 total scores). Therefore it should be advised to produce this type of fortified tortilla to use it as a therapeutic foods.

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تدعيم تورتيلا الذرة بمطحون خليط من البقوليات المستنبتة و المطبوخة

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يهدف هذا البحث إلى إنتاج تورتيلا منتجة من حبوب الذرة المدعمة بمطحون بذور بعض البقوليات المستنبتة والمطبوخة بالبخار (ترمس حلو- حمص - حلبة) بنسب ١٥، ١٠، ٥ % بغرض تحسين القيمة البيولوجية والجودة التكنولوجية والحسية واختيار أفضل منتج من هذه المعاملات مقارنة بعينة المقارنة (تورتيلا مصنعة من حبوب الذرة فقط)

وكانت نتائج الدراسة كما يلي :

أولاً : أوضحت نتائج الدراسات الكيماوية أن الحامض الأميني الأساسي ليسين يزداد بزيادة تدعيم تورتيلا الذرة بمخلوط مطحون حبوب البقوليات المستنبتة المطبوخة . وان الزيادة في الحمض الأميني الأساسي الليسين كانت ١٥٠، ١٨٧، ٥، ٢٢٥ % عند التدعيم بـ ٥، ١٠، ١٥ % مخلوط بقوليات على الترتيب مقارنة بالتورتيلا المصنعة من حبوب الذرة فقط وأيضاً وجد أن معادن الكالسيوم ، والمغنسيوم ، الحديد ، الزنك ، المنجنيز وفيتامين أ ازدادت بزيادة تدعيم تورتيلا الذرة بمخلوط مطحون البقوليات المستنبتة المطبوخة .

ثانياً : أوضحت الدراسات الكيماوية ، التكنولوجية والحسية أن تورتيلا الذرة المدعمة بـ ١٠ % مخلوط مطحون بذور بقوليات مستنبتة مطبوخة هي أفضل منتج بما يمتاز به من قيمة بيولوجية عالية وتحسن في صفات الطعم واللون والمظهر (٩٤ % جودة حسية) مقارنة بالتورتيلا المصنعة من حبوب الذرة فقط (٧٠ % جودة حسية) .