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PRODUCTION OF EXTRUDED (PUFFED) SNACK FOOD WITH HIGH BIOLOGICAL AND QUALITY VALUES

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ABSTRACT

In this work many efforts were done to produce extruded snack (puffed) from yellow corn grits fortified with sprouted legumes seeds mixture (SLM); (Sweet lupins, chickpeas, faba bean and lintils) to increase its biological value and to improve its technological and sensory characteristics. The studies were extrended to chemical, technological and sensory characteristics to determine the best treatment or best fortification of snack compared with control (extruded corn snack).

Chemical studies cleared that, essential amino acid lysine increased by increasing fortification with sprouted legmes mixture (SLM). Essential amino acid lysine increased by 148%, 180% and 229% at 5, 10 and 15% fortification respectively. Also minerals (Ca, K, Mg, Mn, Zn, and Fe) increased in fortified snack by increasing sprouted legumes mixture (SLM). Iron increased by 34%, 67.1% and 100% at 5, 10 and 15% fortification respectively. Finally it may be concluded that, all chemical, technological and sensory studies indicated that, the best fortified snack was produced form corn grits blended with 10% (SLM). Because 10% fortified corn snack significantly increase in biological values with improved taste, texture, color, and flavour (91.3 total scores) compared with the control (85.4% total scores) .

INTRODUCTION

It may be said that malnutrition in childhood represent the most dangerous problem in many parts of the world. This due to inadequate intake of protein and micronutrients.

Snack baised on cereals are the most widely consumed snack food items, and many of these are in low in nutrient density and high in calories and or fat content, (Park *et al.,* 1993). Corn is an excellent source of carbohydrates with low crude fiber levels. The protein content is low and of poor quality because of low levels of the essential amino acids lysine and tryptophan, which represent the most limiting amino acids, (James *et al.,* 2004). Legumes are an important source of plant protein for human nutrition. Although legumes protein are low in some essential amino acids (Sulfer amino acids), they are the main protein intake in parts of the world where animal protein is limited, (Bahnassy *et al.,* 1986).

Germination of legume seeds was used to improve nutritional quality, further more, it is possible to decrease significantlv antinutritional factors, *e.g.,* protease inhibitor, phytic acid, tannin content and flatulence-producing factors, (Muzquize *et al.,* 2004).

Sprouted legumes, baised on its nutritional and physico-chemical properties may be considered for fortification of widely consumed cereal-based food products for human consumption, (Moreno *et al.,* 2004).

Iron is a key element in metabolism for all organisms with respect to many basic functions. It may be said that iron in diet must be in available form to be absorbed in blood circulation from intestine (Andrad *et al.,* 2004). It should be considered also that, digestive utilization of calcium and magnesium for common beans is significantly improved by soaking in different pH solution and cooking (Aranda *et al.*, 2004).

In the extruder, the raw material is subjected to mechanical processes (heating, compression and chear), that completely disorganized the orginal structure of the raw material. Thus extrusion cooking could be expected to affect some physico-chemical and function properties as indicated in some studies on dry edible legumes (Phillips *et al.*, 1984).

However raw legume have tripsin inhibitors as hemaglogglutinin and other factors. Several auther described use of cooking extrusion to inactivate inhibitors (Mustakas *et al.*, 1970).

By combining legumes with different cereals it may be possible to improve functional and physico-chemical properties and nutritional quality of extrudates. Legumes were know to have high lysine, cereals which are low in lysine can be improved nutritionally by fortification with legume flour. Combination of legumes and cereals would provide protein of high biological values in diet of people in many developing countries at low cost, (Gujska and Khan 1991).

It would be logical to offer enriched snack mainly to children and students for lowering risk of malnutrition deseases. Therefore our main target was to blend 5 , 10 and 15% of sprouted legumes mixter (seed grits) with yellow corn grits to indicate the most suitable treatment giving extrudate snack (Puffs) with high biological and quality values.

MATERIALS AND METHODS

Materials:

Different legumes seeds lupin (lupinus SPP) sweet variety, chick pea (cicer arietinum), faba bean *(Vicia faba)* and lentils (lens esculenta) were obtained from legume Breeding Res. Sec. field crops Res. Institute Agric. Res. Center, Giza, Egypt. Yellow corn grits was obtained from food technology Res. Institute, ARC, Giza, Egypt.

Method :

Germination procedure:

Every legume seeds (500 gm.) were sprouted for 48hr at room temperature 22-25C$^{\circ}$. After sprouted period seeds were dried by oven aire drier (50-55C$^{\circ}$) over night. Then legumes were separately ground using laboratory mill (Model 3100 which is a hummer type mill) and equipped to obtain grits size (0.150-0450 mm). also yellow corn grits was prepared at granule size between 0.150-0.450 mm.

Preparation of extrudate samples:

Four sprouted legumes grits (Lupin, chick pea, faba bean and lentils) were mixed by equal ratio (1: 1 : 1 : 1) to obtain required sprouted legumes mixture (SLM). Sprouted legumes mixture (SLM) was added to yellow corn grits by 5 , 10 and 15 % to prepare extrudate snack (Puffs) samples.

Extruded puffs:

A control extruded puffs product was made from yellow corn grits (20% moisture and 9.8 protein on dry weight baisis (D. W. b.). Experimental treatments contained 5 , 10 and 15% sprouted legumes mixture. Products were extruded through a C.W. Brabender (South Hacken sack, NJ) laboratory-scale extruder with a ¾ - in diameter, barrel at 160C° screw speed was 150 rpm and 20% moisture. The die was 3mm.

Physical properties of extrudate:

Puff ratio : Puff ratio was calculated by taking the average product diameter, d, squaring it and then dividing by the square of the die diameter. Puff ratio = d^2 / (die diameter)^2 , (Buck *et al.,* 1987).

Expansion Ratio:

The diameter of 20 extrudates was measured. Each value was average of three readings. The degree of expansion was calculated as the ratio of extrudate diameter to die diameter (Pan *et al.*, 1998).

Bulk Density:

The bulk density of extrudates was measured following the method of (Pan *et al.*, 1998). The volume of the expanded sample was measured by using a 100-ml graduated cylinder by rapeseed displacement. The volume of 20-gm randomized samples was measured for each test. The ratio of sample weight and the replaced volume in the cylinder was calculated as bulk density (w/v).

3- Functional properties of extrudate:

Water absorption index (WAI) and water solubility index (WSI) were measured according to a modification of the method of Anderson *et al.,* (1969). The extrudate was ground to pass through a 60-mesh screen. A 20gm dry basis) ground extrudate sample was mixed with 25ml of water and put in a centrifuge tube with a vortex mixer. After heating for 30 min. in a water bath at 30°C, the heated solution was centrifuged at 3.000xg for 10min. The WAI and WSI were determined as : WAI (%) = wt of sediment/wt of dry sample solid; WSI (%) = wt of dissolved solids in supernatant/wt of dry sample solids in the orginal sample ×100

4- Sensory evaluation:

Yellow corn grits was enriched with sprouted legumes mixture by 5, 10 and 15% and used for making extruded snack (puffs) which were evaluated by a trained taste panel (n/10) of the food Technology Research Institute. For taste (30), texture (30), color (20), flavour (20) with total scores (100).

5- Chemical analysis:

Protein, ash and oils (Polar and non-polar) according to methods AOAC (1990). Mineral contents (K, Ca, Mg, Mn, Zn and Fe) were determined by using a pye Unicom sp 1900 atomic absorption spectroscopy technique as described by AOAC (1990). Amino acids content were determined other than tryptophan by means of Beckman Automatic Amino Acid Analyzer (Model 6300, Beckman Instrument, palo Alto, CA) at central Labortory for food and feed, ARC, Giza, Egypt

RESULTS AND DISCUSSION

Protein plays an important role in all bi ochemical and physiological processes in human body.

Table (1) represent composition of sprouted legumes mixture (SLM), corn their blends. It is clear that (SLM) has the highest values of protein, ash and oils (30.6 , 3.37 and 4.10%, respectively). Blending corn grits with 5, 10 and 15% (SLM) increased protein, ash and oils content by 10.82, 11.87 and 12.20% protein, 3.56, 3.59 and 3.63% ash and 1.4 , 1.51 and 1.60% oils, respectively. These results are in agreement with Gujska and Khan (1991). From Table (2), the same trend was noticed.

Table (1): Chemical composition of raw materials uses for making extruded snack (puffs) (on dry weight bases).

Samples	Protein %	Ash %	Oil %		
			Polar	Non-polar	Total
Sprouted legumes mixture (SLM)	30.6	3.57	3.286	0.824	4.110
Corn grits	9.8	1.30	1.90	2.140	3.530
5% SLM*	10.82	1.40	1.485	2.073	3.558
10% SLM	11.87	1.51	1.579	2.008	3.587
20% SLM	12.90	1.60	1.674	1.944	3.618

*** SLM = sprouted legumes mixture. Values mean of three replicates.**

Table (2): Chemical composition of extruded snack (puffs) made with varyin levels of sprouted legume mixture and corn grits (on dry weight bases).

Samples	Protein %	Ash %	Oil %		
			Polar	Non-polar	Total oil
Control (100% corn grits)	6.8	0.40	0.292	0.460	0.752
5% SLM*	8.0	0.73	0.359	0.536	0 900
10% SLM	9.4	1.05	0.418	0.740	1.158
15% SLM	10.6	1.38	0.479	0.880	1.211

*** SLM = sprouted legumes mixture. Values mean of three replicates**

The nutritional values of puffed snack produced increased as the fortification ratio with (SLM) increased. When snack fortified by 5 , 10 and 15% (SLM) protein increased from 6.8% at control (corn snack) to 8.5, 9.4. and 10.6% respectively.

Ash content increased from 0.40% at control snack to 0.73, 1.05 and 1.38%. Also oil content increased from 0.75 at control snack to 0.90, 1.16 and 1.21% in fortified snack by 5 , 10 and 15% (SLM), respectively. Similar results were found by Zbigniew *et al.,* (1993). It may be said that when (SLM) addition increased polar oils was increased. This indicated that, the polar fraction of oils is the unique fraction of oil which make complexes formation with amylase helices in starch granules. This assure the improvement of reheological properties, sensory, and technological properties of fortified extrudate snacks.

From Table (3) it may be concluded that, by increasing fortification ratio with 5 , 10 and 15% (SLM) iron increased in produced extruded snack by 34.0, 67.1 and 100% compared with corn snack (control). This means that fortification corn snack with (SLM) is the main therapeutic agent as antianimic factor. Also Zn, Mn, Mg, Ca, and K increased by increasing (SLM) in extrudate snack. Therefore these mineral will be playing an important role in building of bones, blood in human metabolim. Rude *et al.,* (2001) assured the above mentioned results by indicating that, dietary mg deficiency caused impaired growth, skeletal fragil and osteoporosis.

Table (3): Mineral content of extruded snack (Puffs) made with varying levels of sprouted legumes mixtures and corn grits (on dry weight bases).

Samples of snacks	Mineral contents mg/100gm											
	K		Ca		Mg		Mn		Zn		Fe	
	Mg/100 gm	Increasing %	Mg/100 gm	Increasing %	Mg/100 gm	Increasing %	Mg/100 gm	Increasing %	Mg/100 gm	Increasing %	Mg/100 gm	Increasing %
Control (100% corn grits)	149.00	00.00	253.15	00.00	60.25	00.00	72.50	00.00	36.13	00.00	0.70	00.00
5% SLM*	152.00	2.0	288.25	13.9	61.30	1.7	73.88	1.9	37.55	3.9	0.94	34.0
10% SLM	156.20	4.8	323.34	27.7	62.33	3.5	75.30	3.9	39.10	8.2	1.17	67.1
15% SLM	160.00	7.4	358.43	41.6	63.35	5.4	76.60	5.7	40.50	12.1	1.40	100.0

* SLM = sprouted legumes mixture. Values mean of three replicates.

Table (4) shows the proportion of the various essential amino acids in extruded corn snack and tested fortified extruded snack. It is clear that, the essential amino acid lysine was the most limiting amino acid in corn snack. Fortified snack by 5, 10 and 15% (SLM) showed that, lysine increased by 148, 180 and 220%, respectively. This means that, the fortifican of extruded snack with (SLM) lead to produce extruded snack with high biological values, due to balance occurring between all essential amino acids. On the other hand enzymes and hormones consist only of essential amino acids. These enzymes and hormones regulate anabolism and catabolism of human body. This leads to the organization of human body growth. These results were supported by Muzquiz *et al.*, (2004) and FAo/Who (1991).

It may be concluded that, sprouting legumes based on its nutrition may considered for fortification of widely consumed cereal-based extruded snack (Puffs) for human consumption to lower malnutrition diseases.

Table (5) shows the physical properties of extrudate snack (Puffs) produced from corn grits (control) and corn grits/sprouted legumes mixture. It is clear that puffing ratio and expansion index decreased by increasing (SLM) addition in extruded snack produced. This may by due to the increasing of protein content by increasing (SLM) addition. Puffing properties is one of the most important physical properties which was 10.5, 10.0 , 9.8, and 8.6 for control and corn snack fortified by 5, 10 and 15% (SLM) respectively. Density increased by increasing (SLM). This may be due to the increasing of protein which leads to decrease expansion index (Puffing).

Regarding to functional properties we said that, water absorption index (WAI) highly increased by increasing (SLM) ratio addition in produced snack. This may be due to the increasing of hydrophilic groups which bind water molecules. Meanwhile water soluble index (WSI) decreased by increasing (SLM) ratio addition, indicating denturation, and insolubilization of the protein fraction. Finally it may be concluded that, fortified snack with good physical and functional properties was produced from corn grits fortified by 5-10% (SLM).

Table (4): Amino acids of extruded snack (Puffs) made with varying levels of sprouted legumes mixture (SLM) and corn grits (on dry weight baisis).

Amino Acids	Extruded snack (Puffs) samples							
	Control 100% corn grits		5% SLM*		10% SLM		15% SLM	
	gm/100 gm	Intial	gm/100 gm	Increasing %	gm/100 gm	Increasing %	gm/100 gm	Increasing %
Essential Amino acids:								
Valine	0.022	100.0	0.034	54.5	0.040	81.8	0.045	104.5
Leucine	0.063		0.090	42.9	0.105	66.7	0.119	88.9
Isoleucine	0.016		0.029	81.3	0.034	112.5	0.038	137.5
Thrionie	0.016		0.026	62.5	0.030	87.5	0.034	112.5
Methionine	0.012		0.015	25.0	0.017	41.7	0.020	66.7
Lysine	0.010		0.024	148.0	0.028	180.0	0.032	220
Phenyl alanine	0.025		0.040	60.0	0.047	88.0	0.053	112.0
Histidine	0.016		0.026	62.5	0.030	87.5	0.034	112.5
Arginine	0.028		0.053	98.3	0.062	121.4	0.070	150.0
Non-essential amino acids:								
Aspartic acid	0.034	100.0	0.066	94.1	0.078	199.4	0.088	158.8
Glutamic acid	0.099		0.153	54.5	0.180	81.8	0.202	104.0
Proline	0.048		0.066	37.5	0.077	60.4	0.087	81.3
Serine	0.020		0.034	70.0	0.040	100	0.045	125.0
Glycine	0.016		0.029	81.5	0.034	112.5	0.038	137.5
Alanine	0.033		0.047	42.4	0.055	66.7	0.063	91.0
Cysteine	0.012		0.016	33.3	0.019	58.3	0.021	75.0

* SLM = Sprouted legumes mixture. Values mean of three replicates.

Table (5): Physical and functional properties of extrudate (Puffs) made from corn and corn blended with sprouted legumes mixture (SLM).

Samples	Physical properties			Functional properties	
	Puffing ratio (PR)	Expansion Index (EI)	Density g/cm^3 (D)	Water absorption index (WAI)%	Water soluble index WSI%
Corn snack	10.5	3.23	0.077	196.8	5.77
5% SLM*	10.0	3.17	0.087	416.2	4.94
10% SLM	9.8	3.13	0.100	460.7	4.92
15% SLM	8.6	2.93	0.115	490.0	4.80

* SLM = Sprouted legumes mixture. Values mean of three replicate.

Table (6) clears sensory evaluation of corn and corn / legumes extrudate snack (Puffs). Clear improvement occurs in fortified snacks at 5-10% sprouted legumes mixture. It may be observed that, when 15% sprouted legumes mixture (SLM) were added sensory evaluation values decreased due to increasing hardness and decreasing expansion, color and texture values. Finally the fortified snack with 10% SLM was the best treatment due to its higher fragility and brighter color with improvement of flavour and taste values.

Table (6): Sensory characteristics of extrudate (Puffs) made from corn and corn blended with sprouted legumes mixture (SLM).

Samples	Taste (30)	Texture (30)	Color (20)	Flavour (20)	Total scores (100)
Corn snack	26.0	26.3	17.8	15.3	85.4
5% SLM*	26.8	26.5	18.3	16.3	87.9
10% SLM	27.3	27.5	18.5	18.0	91.3
15% SLM	22.3	23.0	15.3	14.3	74.9

* SLM = Sprouted legumes mixture   Values means of three replicates.

CONCLUSION

Yellow corn grits and sprouted legumes mixture (SLM) were formulated to maximize essential amino acids and mineral content (Ca, K, Mg, Fe, Zn, and Mn) in extrudate snack (Puffs). Results of this study cleared that, the best fortified snack was produced from corn grits bleneded with 10% (SLM). Because 10% fortified corn snack significantly increase in biological values with improved, taste, texture, color and flavour (91.3 total scores) compared with corn snack (control) which had (85.4 total scores).

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إنتاج أغذية خفيفة عالية القيمة البيولوجية والجودة بطريقة البثق الحراري

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في هذا البحث بذلت محاولات بهدف إنتاج بعض الوجبات الخفيفة بطريقة البثق الحراري من حبوب الذرة الصفراء المجروشة المدعمة بمخلوط حبوب البقوليات المستنبتة المجروشة (ترمس حلو – حمص – فول بلدي – عدس) بنسب ٥ ، ١٠ ، ١٥% لرفع قيمتها الغذائية وجودتها .

وقد أجريت اختبارات كيماوية وتكنولوجية وحسية على الأغذية الناتجة من البثق الحراري للمعاملات السابقة لتحديد أفضل منتج أو أفضل معاملة مقارنة بالكنترول المصنع من جريش الذرة فقط .

وكانت نتائج الدراسة كما يلي :-

أوضحت نتائج الدراسات الكيماوية أن الأحماض الأمينية الأساسية في المعاملات التي تم بثقها حراريا تزداد بزيادة تدعيمها بمخلوط البقوليات المستنبتة . وقد وجد أن الحمض الأميني الأساسي الليسين يزداد بنسب ١٤٨% ، ١٨٠% ، ٢٢٠% عند التدعيم بـ ٥ ، ١٠ ، ١٥% على الترتيب مقارنة بالكنترول المنتج من الذرة فقط .

كما وجد أن معادن (الكالسيوم – البوتاسيوم – والمغنسيوم – والمنجنيز – والزنك والحديد) تزداد في المنتجات المنبثقة حراريا بزيادة التدعيم بمخلوط البقوليات المستنبتة . وقد وجد أن الحديد يزداد بنسب ٣٤% ، ٦٧% ، ١٠٠% عند التدعيم بـ ٥ ، ١٠ ، ١٥% على الترتيب كما أوضحت نتائج الدراسات الكيميائية والتكنولوجية ، الحسية أن المنتج من البثق الحراري لجريش الذرة المدعم بـ ١٠% مخلوط بقوليات مستنبتة هو أفضل منتج بما يمتاز به من قيمة بيولوجية عالية وتحسن في صفات الطعم والقوام واللون والنكهة (٩١,٣% جودة حسية) مقارنة بالكنترول المصنع من جريش الذرة فقط (٨٥,٤% جودة حسية).