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PRODUCTION OF HIGH NUTRITIONAL VALUE SNACK FOODS FOR CHILDREN FROM GRAINS AND LEGUMES

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ABSTRACT

The present research work aimed to study the possibility of producing high nutritional value snack prepared from the mixture of raw materials 40% broken rice, 25%chickpeas,20%wheat germ, 10% naked barley and 5% milk powder, respectively. Been manufacturing three products in extrusion machine emissions , the first product is a yellow corn 100% without any additives and the second product was added the mixture of raw materials 35% and yellow corn 65% and the third product has been added the equal volume from the mixture of raw materials and yellow corn. Chemical constituents in raw materials, yellow corn and formulae were determined. Physical properties such as expansion ratio(ER), bulk density (BD), water absorption index (WAI) and water solubility index (WSI) were also, determined. The sensory properties of yellow corn and its formulae were evaluated.

The results showed an increase in protein, fiber and total carbohydrates, resultant due to chickpea, wheat germ, hull-less barley and milk power in extruded formulae. The physical properties showed that the color was affected when the raw mixture materials increased up to 65% and the formula mad from 35% raw mixture materials had no affected color. Moreover, these products also showed that the expansion ratio in formulae (F_1 and F_2) were decreased by increasing protein whereas, bulk density were increased due to the high proportion of protein and high in water absorption index. Where as, the sensory evaluation of snacks and its extruded formulae showed that the formulae made from 35% raw mixture materials had the highest score followed by 65% in over all acceptability.

Generally, snacks extruded formulae made from 35 and 50% from raw mixture materials had the highest scores taste panelists.

INTRODUCTION

Extrusion processing has become one of the major processes for producing convenience foods. Extruded foods range from breakfast cereals to snack foods containing modified starches and flour Harper (1981). Snack foods have become an integral part of the daily food intake of the majority of the world’s population. Basically, they are prepared from natural ingredients or components according to predesigned plans to produce products with specified quality.

Extrusion-cooking is accompanied by the process of starch gelatinization, involving the cleavage of intermolecular hydrogen bonds. It causes a significant increase in water absorption index, including the breakage of starch granules. Gelatinized starch increases the dough viscosity, and high protein content in the processed material facilitates higher flexibility and dough aeration. After leaving the die hot material rapidly expands as a result of immediate vaporization and takes on a porous structure. In the extruded dough protein membranes cover the pores, creating cell-like spaces, and starch, owing to dehydration, loses its plasticity and fixes the porous nature of the material. Rapid cooling causes the stiffening of the mass, which is typical for carbohydrate complexes embedded in a protein matrix and totally enclosed by the membrane of hydrated protein Cheftel (1986).

Extrusion cooking technology, high temperature-short time processing being used increasingly in the food industries for the development of new products such as cereal-based snacks including dietary fiber, baby foods, breakfast cereals and modified starch from cereals Sebio and Chang (2000).The thermal energy generated by viscous dissipation during extrusion with combination of shearing effect cooks quickly the raw mixture so that the properties of the materials are modified by physico-chemical changes of the biopolymers Thymi *et al.* (2005).

The nutritional properties are important for the consumer acceptability of the snacks depends mainly on the physical and organoleptic properties of the snacks measured as expansion ratio, density, texture, appearance and their flavor. These parameters are related to the proportion and type of the available starch which affects the number and size of air cells developed during extrusion Allan *et al.* (2010).

Andlauer and Furst (1997) showed that according to epidemiological reports cereal and cereal products may exert beneficial effects by reducing cancer risk. Cereals are rich in antioxidant, such as vitamin E and carotenoids which are found mainly in the fat-rich germ. These inhibit the generations free radicals and thereby may diminish induced carcinogenesis. An adequate intake of antioxidant containing food is recommended for cancer presentation. Therefore, for optimum health benefits, the intake of whole grain products is recommended.

The objective of this research was to investigate the possibility of using twin –screw extrusion technology to produce puff snack foods made from grains and legumes with high nutrition value and quality and with sensory attributes that are acceptable to the children.

MATERIALS AND METHODS

Raw materials:

Hull-less barley (Hordeum vulgare) variety Giza130, broken rice (Oryza sativa) variety *Saka 1* ,yellow corn (Zea mays , L.) variety Giza 162, chickpea (Cicer arietinum, L) variety Giza 1 were obtained from Field Crops Research Institute, Agricultural Research Center, Giza , Egypt. Wheat germ was obtained from North Cairo Flour Mills Company. Milk powder was obtained from local supermarket.

Wheat germ , broken rice, hull-less barley and yellow corn were milled by using Attenzione Mill, HZ50 H:I , Volt 220 Italy , chickpea seed was milled by using Barbender Duisburg Mill, Type 279002 Germany.

Methods:

Adjusting moisture content before extrusion:

The amount of water was added to bring 1000 grams of sample to the desire moisture level extrusion and it was calculated according to the following equation:

$$\text{Water added} = \frac{\text{Moisture desired \%} - \text{Moisture samples} \times 10^3}{100 - \text{Moisture desired \%}}$$

Water was added gradually to the samples and mixed for 5 minutes by mechanical mixer. The samples were placed in plastic bags and kept for 24 hrs at 4 ºC to equilibrate the moisture according to EL-Dash (1985).

Extrusion conditions

A Model BC21co-rotating Clextral twin screw extruder with intermeshing screws (Clextral, Firminy Cedex, France) and 3 mm diameter circular die was used. The unit was operated at flow rate of 12 kg h-1 and 400 rpm screw speed. Temperature profile in the four barrel sections from the feed end were set at 150ºC for in experiment was preformed according to Supat *et al.* (2008).

Preparation of mixture raw material:

A mixture raw material was prepared from the raw materials as the following.

Mixture	**Raw Materials**					**Total**
	Rice	**Chickpea**	**Wheat germ**	**Barley**	**Milk Powder**	
	40%	25%	20%	10%	5%	100

Two formulae were prepared from mixture raw material as following:

Formula	**Corn yellow %**	**Raw materials mixture %**	**Total**
Control	100	-	100
F_1	65	35	100
F_2	50	50	100

F_1 : Yellow corn 65%+raw materials mixture 35%.

F_2 : Yellow corn 50%+ raw materials mixture 50%.

Determination the chemical composition of raw materials and formulae:

Proximate analysis including moisture, crude protein, crude lipids, ash, crude fibers and total carbohydrates were estimated of raw materials. Yellow corn and different snack formulae were determined the chemical compositions according to the methods of A.O.A.C. (2000).

Measurement of the physical properties extrusion snack formulae:

Determination of Expansion Ratio (E.R.).

Expansion index of the extrusion was determined by the method described by Gujska and Khan (1990) by dividing the extrusion diameter by the extruder die .Each value was an average of five determinations.

Determination of bulk density (B.D.).

Graduate cylinder (250 ml) was tarred and gently filled with a quantity of the extrusion. The bottom of the cylinder was repeatedly tapped gently on a laboratory bench until there was no further reduction of sample volumes and weights were recorded and it was used to calculate (BD) as the method described by Park *et al.* (1993).

Determination of water solubility index (WSI) and water absorption index (WAI):

The water absorption index (WAI) is the weight of gel obtained per gram of dry ground sample. The WAI of extrusion was determined according to the A.A.C.C. (1995). The water solubility index (WSI) is the percentage of dry matter recovered after the supernatant is evaporated from the water absorption determination. The supernatant was dried in a vacuum oven at 84.4ºC and 20–24 mmHg gauge pressure for 24 h and weighed. The WSI was the weight of dry solids in the supernatant expressed as a percentage of the original weight of sample on dry basis according to the A.A.C.C. (1995).

Sensory evaluation of extrusion snack products:

The sensory evaluation of the extrusion snacks were performed to access for color, porosity texture, porosity distribution, hardness, crispness, brittleness and overall acceptability according to Bhattacharya and Parkash (1994). The overall acceptability of the samples was evaluated according to the following:

Quality description	Excellent	Good	Fair	Poor
Total score	86-100	76-85	61-75	50-60

Statistical analysis:

Data from the sensory characteristics were subjected to mean values of data were obtained from triplicate determination. Values expressed are mean ±SD significance of differences between control and treated samples were evaluated using Duncan 's multiple range tests at 5% level according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Chemical composition of raw materials:

Yellow corn, broken rice, chickpea, wheat germ, hull-less barley and milk were determined and the results are reported in Table (1). The parameters in Table (1) pointed out that broken rice, hull-less barley and yellow corn had the highest content of total carbohydrates (78.5, 69.6 and 67.0% respectively), and the lowest content of ash (1.57, 2.9 and 1.8%, respectively).

Results in the same table indicated that the wheat germ, milk powder and chickpea presented the highest protein content (29.3, 26.6 and 20.3%), they are considered a good protein source. Elsewhere, the chickpea belongs to legumes which are rich in protein ranged from 22.0% to 24.0% investigated by Sabanis *et al*. (2006). Moreover, according to Nelson (1985) wheat germ usually contains about 30% protein, 10% fat, 7.8% total dietary fiber and 45% carbohydrate, and is rich in minerals, trace element and vitamins.

Malnutrition is common among neonates and infants in developing countries. There is a need to develop new food products with high protein quality and a high caloric value, high acceptability and low costs for low income families Rodriguez-Miranda *et al*. (2011and 2012).

The other cereals and milk powder had a relatively high fat content at 28.5%. This makes them an important energy source for vegans and those without regular access to meat and dairy products confirmed by Biomed (2006). The crude fat content in wheat germ was 8.6% higher than those reported in other seeds and legumes. Moreover, milk powder manufacture is a simple process now carried out on a large scale. It involves the gentle removal of water at the lowest possible cost under stringent hygiene conditions while retaining all the desirable natural properties of the milk; color, flavor, solubility and nutritional value. The milk powder contains lactose (38%), protein (26%), fat (26%) and ash (6%) in the same proportions as fluid milk Eckles (2001).

The hull-less barley and chickpea flours showed a crude fiber content of 6.5% and 5.3%, values that were higher than those reported in other cultivars. Moreover, milk powder had no detected in crude fiber. Barley grains are generally rich in *β*-glucan that provides an excellent source of soluble dietary fiber for attenuating blood glucose, and reducing low-density lipoprotein cholesterols (LDL). Barley grains also contain *β*-glucan which has beneficial health effects on coronary heart disease prevention by the reduction of serum cholesterol and postprandial serum glucose levels Inglett *et al*. (2013).

Table (1): Chemical composition of raw materials (g/100g).

Samples / Properties	Yellow Corn	Broken rice	Chickpea	Wheat germ	Naked barley	Milk Powder
Moisture	10.1	10.6	8.60	7.40	8.80	2.50
Crude protein	12.7	7.30	20.3	29.3	10.7	26.6
Total lipids	5.50	0.94	4.20	8.60	1.50	28.5
Crude fibers	2.90	0.84	5.30	3.80	6.50	000
Total ash	1.80	1.57	3.30	4.80	2.90	5.60
T. carbohydrates	67.0	78.5	58.3	46.1	69.6	36.6

Chemical composition of yellow corn and formulae:

Chemical composition of yellow corn and formulae were prepared from 35 and 50% raw materials mixture and the results are reported in Table (2). From the results it could be noticed that the yellow corn had contained crude protein, total fat, crude fiber, ash and total carbohydrates (12.7, 2.2, 3.21, 2.44 and 70.7%, respectively). Meanwhile, formulae 1 and 2 were (10.8, 4.34, 3.0, 2.0 and 69.9%) and (11.7, 3.9, 3.1, 2.1 and 69.7%) respectively.

Cereals and legumes, in general, play an important role in human nutrition. Recent studies have shown that cereals and legumes contain constituents that have health benefits for humans, such as antioxidants and anti-disease factors Ragaee *et al.* (2006). Studies have also demonstrated that foods with high carbohydrate and dietary fiber content, such as resistant starch derived from cereals, allowed Withdrawal of oral hypoglycemic agents or a reduction in the insulin dose for diabetic subjects Pathak *et al.* (2000) and Kutos *et al.* (2003).

Table (2) : Chemical composition of yellow corn and formulae (g/100g).

Samples / Properties	Yellow corn	F_1	F_2
Moisture	8.63	9.52	9.30
Crude protein	12.7	10.8	11.7
Total lipids	2.20	4.34	3.90
Crude fibers	3.21	3.00	3.10
Total ash	2.44	2.00	2.10
T. carbohydrates	70.7	69.9	69.7

Chemical composition of snack products:

The results in Table (3) showed that the snacks made from yellow and formulae (F1 and F2) prepared from raw materials mixture. From the results the formulae (F1 and F2) had contained the highest of protein (11.6 and 12.4%) total carbohydrates (68.5 and 70.5%) compared with yellow corn (11.2 and 67.1). Whereas, the yellow corn had contained the highest percentage of lipid, crude fiber and ash were 4.53, 3.1 and2.2%, respectively. Extrusion is a rapid processing method involving high temperature and pressure and short time and is used to prepare a variety of processed foods like baby foods, snack foods, ready-to-eat breakfast cereals. The consumer preference of extruded foods is mainly due to convenience, attractive appearance and texture and utilizing barley in extruded foods would increase consumer acceptance as it contains bioactive functional components. The effects of extrusion cooking on the polyphenol content and antioxidant activity in rye bran has been reported by Gumul and Korus (2006) and in a snack bar composed of chickpea, corn, oat, carrot and hazelnut by Ozer *et al*. (2006).

Table (3) : Chemical composition of snacks products (g/100g).

Samples / Properties	Yellow corn	F_1	F_2
Moisture	12.6	11.2	9.17
Total protein	11.2	11.6	12.4
Crude lipids	4.53	3.42	2.93
Crude fibers	3.10	2.84	2.61
Total ash	2.20	2.00	2.10
T. carbohydrates	67.1	68.5	70.5

The properties measurements of snack products:

Data in Table (4) showed that the expansion ratio in blend and formulae (F_1 and F_2) were decreased by increasing the protein and it was decreased the oil as follows (16.2, 15.75 and 13.61). The bulk density was increased due to the high proportion of protein as follows (0.028, 0.032 and 0.072). These results are similar with those reported by Altan *et al.* (2008).

Water absorption index (WAI) was used to assess this quality factor. Extrusion snacks (all formulae) had significantly higher WAI than yellow corn control. This may be attributed in part to the high proportion of gelatinized starch found in the extrusion snack. Debbouz (1992) found a high correlation between WAI and starch gelatinization. Water soluble index (WSI) expresses the percentage of dry matter recovered after the supernatant is evaporated from the water absorption determination.

Table (4) : The properties measurements of snacks products.

Samples / Properties	Control	F_1	F_2
Expansion ratio (ER)	16.20	15.75	13.61
Bulk density (B.D) (gm/cm^3)	0.028	0.032	0.072
Water solubility index (WSI)	22.00	20.50	15.00
Water absorption index (WAI)	5.128	5.840	5.870

Sensory evaluation of snack products.

Sensory evaluation score (taste, odor, color, hardness, crispness, bitterness, porous texture, porous distribution and overall acceptability) were evaluated by the panelists after extrusion processing. The results are shown in Table (5). From the table (5) the results showed that the formula (F_1) gave the highest total score 89.2%, followed by yellow corn control 84.4%. Meanwhile, formula (F_2) gave the lowest total score 77.1% due to the raw materials mixture were 65% and effected on the all parameter, these results are accordance with those reported by Aylin *et al.* (2009).

From the obvious results, it could be recommended that the best fortified level 35% from blends (broken rice 40%, chickpea 25%, wheat germ 20%, barley 10% and milk powder 5%) improvement the nutritional value and sensory qualities of children food produced thermal extrusion. Moreover, the sensory evaluation showed that the formulae 2 (the lowest in color) may be due to the increasing concentration of raw materials. Extruded snack formula 1 made from 35% raw materials and 65% yellow corn was the most like by the taste panelists.

Table (5) : Sensory evaluation of snacks product.

Sensory attributes		Control	F_1	F_2	LSD
Taste	10	8.4 ±0.70 a	8.8 ±0.42 a	7.2 ±0.63 b	0.54715
Odor	10	8.3 ± 0.48 a	8.6 ± 0.51 a	7.6 ± 0.52 b	0.46387
Color	10	8.5 ± 0.53 a	8.5 ± 0.53 a	7.0 ± 0.47 b	0.46722
Hardness	10	7.7 ± 0.48 a	8.3 ± 0.48 a	8.7 ± 0.67 b	0.50876
Crispness	10	9.0 ± 0.00 a	8.8 ± 0.42 a	6.8 ± 0.63 b	0.40269
Bitterness	10	8.3 ± 0.67 a	8.3 ± 0.48 a	8.0 ± 0.82 a	0.61681
Porous texture	10	8.6 ± 0.52 a	8.6 ± 0.52 a	7.2 ± 0.42 b	0.44675
Porous distribution	10	8.8 ± 0.42 a	8.8 ± 0.42 a	7.6 ± 0.52 b	0.41789
Overall acceptability	20	16.8 ± 0.79 a	18.5 ± 0.71 b	15.2 ± 0.79 c	0.69972
Total score	100	84.4 ± 5.01	89.2 ± 4.49	77.1 ± 5.47	-

CONCLUSION

Children foods producing has been high protein by adding chickpeas and wheat germ as a source of protein and added milk powder as a source of animal protein ratio. This mixture was added at 35% and the mixture consisted of (broken rice 40% and chickpeas 25% and wheat germ 20%, naked barley 10%, skim milk powder 5%) is which gave to the best qualities of chemical and technological and sensory properties**.**

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إنتاج أغذية خفيفة عالية القيمة الغذائية للأطفال من الحبوب والبقول

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فى هذا البحث تم دراسة امكانية إنتاج أغذية أطفال عالية القيمة الغذائية. حيث تم عمل خلطة مكونة من ٤٠ % كسر الأرز و٢٥% الحمص و٢٠% جنين القمح و١٠% الشعير و٥% لبن البودرة على التوالي. تم تصنيع ثلاث منتجات في جهاز البثق الحراري ، المنتج الأول عبارة عن ذرة صفراء ١٠٠% بدون أي إضافات والمنتج الثاني تم إضافة الخلطة بنسبة ٣٥ % والذرة الصفراء بنسبة ٦٥% والمنتج الثالث تم أضافة الخلطة بنسبة ٥٠% والذرة الصفراء بنسبة ٥٠%. تم تقدير التركيب الكيميائي والخواص الفيزيائية مثل نسبه الانتفاخ و الكثافة الظاهرية و نسبة التشرب و درجة الذوبان وأيضا تم تقدير الصفات الحسية.

أظهرت النتائج زيادة في نسب كلا من البروتين والألياف والكربوهيدرات الكلية وهذا يرجع إلى ارتفاع في محتواهم الحمص وجنين القمح والشعير واللبن المضاف للخلطات. وأظهرت الخصائص الفيزيائية أن الخلطة التي تحتوى ٣٥، ٦٥% مواد خام لم يتأثر لونها ، بالرغم من ذلك ظهر أن نسبه الانتفاخ انخفضت في خلطات (F_1 ، F_2) وذلك يرجع إلى زيادة البروتين وزادت الكثافة الظاهرية ونسبة الامتصاص وذلك يرجع إلى نسبة البروتين العالية. أظهر التقييم الحسي أن الوجبات الخفيفة المصنعة من ٣٥ ، ٥٠% من المواد الخام كانت الأكثر قبولا. وبصفه عامة الوجبات الخفيفة الناتجة عن البثق الحراري المصنوعة من ٣٥ ، ٥٠% من المواد الخام حصلت على أعلى الدرجات في التقييم الحسي.

ام بتحكيم البحث

أ.د / مسعد عبد العزيز ابو ريه	**كلية الزراعة – جامعة المنصورة**
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