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Nutritious novel snacks from some of cereals, legumes and skimmed milk powder

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Abstract

This study was aimed to prepare and evaluate six different snacks included control (Yellow corn, PC) and five formulas (P1, P2, P3, P4, and P5) based on local available ingredients snacks (cereals : yellow corn, wheat flour and broken rice and legumes: faba bean cotyledons and decorticated parched chickpea). Chemical composition, mineral elements, amino acid composition, in vitro protein digestibility (IVPD), C-PER and energy value in addition to sensory evaluation were determined of the snacks. Different extrudates were stored at RT up to 6 months since peroxide value was determined . Data revealed that protein content was increased of different products as: 14.9, 15.5, 12.7, 14.4 and 13.0 % in P1, P2, P3, P4, and P5, respectively compared to 6.89 % in the control product (PC). It was also shown that the total essential amino acids increased significantly and reached 46.87 g / 100 g protein (P4) compared to 40.24 in the control (PC). Denaturation of proteins during the extrusion processing increased the IVPD from 77.8% (PC) up to 89.3% (P4). Data also revealed that the complementing between cereal and legume and supplementing with dried skimmed milk improved all of minerals content, energy and C-PER in all snacks, Energy reached 381.16 compared to 345.65 kcal /100 g.(PC), while the C-PER reached 1.72 (P5) compared to 1.25 (PC). The sensory evaluation of the products was also conducted and it turned out that all of them were highly acceptable. The peroxide number also showed the high storage ability of the products under test up to 6 months at RT.

Keywords: Extruded Snacks, Cereals, Legumes, Skimmed Milk, Chemical Composition, Physical Properties, Sensory Evaluation,

INTRODUCTION

The effect of proper nutrition on thought and comprehension

Snacks are quick foods usually derived from one or more basic food items, and are eaten between meals. Snack foods have become a significant part of the diet of many individuals, particularly children, and can influence overall nutrition. There is a growing consumer interest in ready-to-eat snack foods mainly due to their convenience, wide availability, appearance, taste and texture. Population-based studies have shown increased food consumption related to the snacking habits (Shukla, 1994) [1]. In recent years, the food market has been fast adapting to diversified needs and requirements of a contemporary consumer. The proceeding economic, social and cultural changes have resulted in an increased demand of consumers for the so-called “convenient food”. The concept of convenient food encompasses food products obtained upon such processing of raw material that enables using them for fast, convenient and easy preparation of meals. The group of convenient foodstuffs includes, among others, prepared cereal-flour products, e.g. extruded snacks (Rytel et al., 2013) [2]. Cereal snacks are traditionally considered unhealthy because they contain high sugar or high fat levels and low essential nutrients. This has led the food industry to develop novel and healthier products like fortified snacks with functional ingredients for health conscious consumers. (Popkin, et al., 2010). Extrusion is a high temperature short-time process which involves simultaneous thermal and pressure treatment along with mechanical shearing, resulting in changes such as gelatinization of starch, denaturation of protein, and at

Times complete cooking of the extrudates to obtain ready-to-eat products. Many extruded products are mostly made from cereals such as corn, rice and wheat. These cereals are rich in carbohydrates and fibers but relatively low in protein content, thus they need to enhance the protein component in the extruded products [3-5]. Due to consumer demand for healthy extruded snack foods, many industries have increased focus in research and product development to produce products that are nutrient-dense [6]. Cereals and legumes, in general, play an important role in human nutrition. Recent studies have shown that cereals and beans contain constituents that have health benefits for humans, such as antioxidants and anti-disease factors [7]. Corn is the main cereal grain as measured by production but ranks third as a staple food, after wheat and rice. Corn grits are the main raw material for commercial production of extruded snacks. They have high porosity, crunchy texture, and are palatable [8]. Many formulated products are based on wheat flour (among other components) and its popularity is largely determined by the ability of the wheat flour to be processed into different products for example, a snack, which is mainly given by the unique properties of wheat-flour gluten proteins [9]. Extruded snack products are predominantly made from cereal flour or starches and tend to be low in protein and have a low biological value (i.e. low concentration of essential amino acids) (. Rice flour prepared from rice broken has become an ingredient of interest for many ready-to-eat breakfast cereals and snacks due to its bland taste, attractive white color, hypoallergenicity and easy of digestion [10]. Guha and reported that the glutinous rice was suitable material to produce the expanded extrudate rice product such as ready-to-eat snacks, breakfast cereal with low bulk density, high expansion and low shear stress. Chickpea *(Cicer arietinum L.)* is globally the third most important pulse crop after navy beans and dry beans. The subspecies arietinum is divided into two distinct types (i.e., Kabuli or Garbanzo type and Desi type). Kabuli chickpeas are of Mediterranean and Middle Eastern origin [11]. Chickpeas contain moderately high protein (17–22%), low fat (6.48%), high available carbohydrate (50%) and crude fiber contents of 3.82%.

Hence chickpea seeds can play an important role as a low-glycemic functional ingredient in a healthy diet [12]. The parched chickpea has an attractive golden – yellow color, a porous texture and a pleasant taste Wide cultivation and spread of faba bean *(Vicia faba L.)* in the temperate and the subtropical regions has ranked it the fourth most important legume crop in the world, next to dry beans, dry peas and chickpea [13]. *Vicia faba* is a sustainable protein source with a great potential in nutritional and functional properties [14, 15]. This study was carried out to prepare and evaluate six different snack samples characterized by high nutritional value based on local available ingredients cereals (yellow corn, wheat flour and broken rice), legumes (decorticated parched chickpea and faba bean cotyledons) and skimmed milk powder by extrusion technique. The chemical composition, minerals, physical properties, amino acids, C-PER, peroxide value and, sensory evaluation of snacks were determined [16].

MATERIALS AND METHODS

Materials

Wheat flour (Candy flour 72% extraction) was imported from USA by International Co. for Trading , Ibn El.Khatab, Cairo, Egypt [17]. Yellow corn *(Zea mays, L.)* variety Giza 162, faba bean *(Vicia faba, L.)* variety *Giza* 3 and Chickpea (*Cicer arietinum*, L) variety *Giza* 131 were obtained from Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Broken rice obtained from Rice Polishing Company, Damanhour, Behera Governorate, Egypt. Skimmed milk powder was imported from Ukraine. All chemicals used in the study were of analytical grade and were obtained from Sigma Aldrich (St. Louis, Mo, USA).

METHODS

Preparation of raw materials: Yellow corn and broken rice, chickpeas and faba beans were cleaned physically to eliminate dust particles, seeds of other crops and other physical contaminants. Decorticated parched chickpeas were prepared as outlined by [18-20]. The whole faba beans were mechanically decorticated with P.R.L " Mini" Dehuller , National Research Council, Canada. All samples except wheat flour were milled in the laboratory (Brabender Duisburg, Germany) and passed through 60 mesh screen and all were kept frozen in polyethylene bags at -20°C until use.

Preparation of formulas: Six formulas were prepared using the previous ingredients. These ingredients and its amounts are illustrated in Table 1.

Table 1: Ingredients of formulas.

Ingredients %	Formulas					
	FC	F1	F2	F3	F4	F5
Yellow corn	100	50	50	50	50	50
Wheat flour	---	15	15	---	---	7.5
Broken rice	---	---	---	15	15	7.5
Decorticated parched chickpea	---	25	---	25	---	12.5
Faba bean Cotyledons	---	---	25	---	25	12.5
Skimmed milk powder	---	10	10	10	10	10

Extrusion processing

Adjusting moisture content of formulas before extrusion, the amount of water was added as described by [21]. Extrusion cooking was carried out using a single screw extruder, Model-Do-Corder E 330, Brabender, Germany, to prepare the extruded product under the following conditions: L/D ratio 4 : 1, screw speed 150 rpm, feed rate 70 g/min; die d 3 mm, die length 20 mm, suppression 50%, barrel temperature 160 oC, moisture 18 %. These values were suggested by the previous study carried out in our laboratory according to the method of Sushma and Saxena.

Chemical analysis

Moisture, protein, lipids, ash and crude fiber were determined according to the methods of AOAC, (2005). N-free extract was calculated by difference. Mineral were determined by using Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer according to AOAC, (2005). Total calories of snacks was calculated from the following equation as reported by [22-25]. Energy value=4 (g protein+g carbohydrates)+9 (g fat). Amino acids of products were determined according to by using The Beckman 7300 High Performance Amino Acid Analyzer. The tryptophan was determined by using Perkin Elmer (Model 3000, Ltd, UK) Fluor meter according to Pirjo and Pekka, (1996). The chemical score of the protein was calculated by expressing the amount of each essential amino acid of the sample as percentage of the content of the same individual amino acid in reference protein of FAO/WHO/UNU pattern, (1985). In vitro digestibility of protein was determined by successive pepsin - trypsin enzyme system according to method of Chavan et al., (2001). C-PER of each sample was calculated using the amino acid profile and data obtained from the in vitro protein digestibility procedure (enzyme method). The calculation was based on the equations described by AOAC (2005) and through the nine steps of [27].

Physical properties of snacks

Bulk density was measured by the method of [28]. True Density was estimated according to method of [29, 30]. Expansion index was determined as described by [31]. The water absorption index and water solubility index was determined according to [32]. The colour measurement was done using HunterLab ColorFlex (A60-1010- 615 Model Colorimeter, Hunter Lab, Reston VA). The extrudate was milled to pass through a 425-mesh sieve with a laboratory mill. The color of extrudates was expressed as the average of three L*, a*, and b* readings, where L* stands for brightness, +a* redness, –a* greenness, +b* yellowness, and –b* blueness. A white calibration plate (L=−91.09, a=−1.12, b=1.51). was used to standardize the equipment prior to color measurements. The total colour difference (ΔE) of extrudates was calculated as outlined by using Eq. as follows:

$$\Delta E = [(Ls - L^*)2 + (as - a^*)\ 2 + (bs - b^*\ )\ 2\ ]1/2.$$

Shelf life of snacks

The snacks products were packed in PE pags and stored at room temperature (25 ± 2.0°C) and relative humidity (67 ± 2.5%). Samples were analyzed at zero time, after two month, after four month and after six month for peroxide value according to method recommended by AOAC, (2005).

Acceptance test of snacks

Sensory analysis of the snacks was performed to evaluate the attributes of taste (20), odor (10), color (10), hardness (10), crispness (10), bitterness (10), porous texture (15) and porous distribution (15). The sensory panel consisted of 35 untrained, randomly recruited testers. The overall acceptability of samples was evaluated according to the following: Excellent (86-100), Good (76-85), Fair (61-75) and Poor (50-60) as described by Bhattacharya and Parkash, (1994).

Statistical analysis

All experimental data were measured by three replicates. Data were analyzed by a one-way ANOVA and Duncan's test (SPSS Inc., Chicago, IL, U.S.A.) was performed by SPSS 20.0 statistical software. A p-value <0.05 was considered to be statistically significant throughout the study [28].

RESULTS AND DISCUSSION

Chemical analysis of raw materials

Food composition was carried out to identify and determine the chemical nature of the principles in foods that affect human health. Chemical analysis of raw materials used in preparing formulas for snacks are shown in Table 2. The results are significantly difference; skimmed milk powder contains high percentage of protein (35.1%) while the lowest protein content is found in broken rice 6.56%. It could be noticed that the highest value of moisture content is found in faba bean cotyledons (10.9%), while the lowest moisture content is recorded in skimmed milk powder (4.22%) [33-35]. The highest content of fat is found in decorticated parched chickpea (4.88%), but the lowest content is recorded for broken rice (0.42%). The highest value of ash content is noticed in skimmed milk powder (6.39%), while the lowest ash is found in broken rice (0.35%). The highest content of crude fiber is observed in wheat flour (2.24%), meanwhile skimmed milk powder is free of crude fiber. The highest content of N-free extract is found in broken rice (81.87%), but the lowest content is observed for skimmed milk powder (52.5%). These results were similar with that published by [36].

Data concerning mineral contents of raw materials are illustrated in Table 2. Data are significantly different, and the results showed that potassium, magnesium and calcium are the main minerals in all raw materials. Potassium recorded the predominant mineral especially in skimmed milk powder (1209 mg/100g) followed by faba bean cotyledons (879.2 mg/100g). It is clear that legumes and cereals under test except broken rice are rich in iron in contrary with skimmed milk powders which considered a poor source of iron (0.54 mg/100g). Decorticated parched chickpea and faba bean cotyledons are rich sources of iron 4.55 and 4.37 mg/100g, respectively. The point of interest is that all the proposed sources for producing different extruders with high nutritional value were actually higher in all mineral elements under test compared to maize (i.e., Ca, Fe, Mg., K, Na and Zn). These results were in agreement with [37-40]].

Chemical analysis of formulas

Formulas were analyzed for determining proximate composition and the data are presented in Table 3. The results were significantly different. Data revealed that all formulas had considerable amounts of protein compared with control formula, where control formula contained a considerable amount of N- free extract compared with all other formulas. Generally, moisture in all formulas ranged between 9.8 to 10.8%, and it was evident that the protein content of all formulas had almost two folds that of the control formula. Also, the ash rose significantly in all formulas compared to the control, and the percentages of increase ranged between 60% (F3) and 76% (F1 & F2). In contrast, the fat content of all formulas decrese significantly compared to the control. Moreover, the crude fiber contents of all formulas were significantly decreased compared to the control (FC) . Samah, (2004) reported that admix cereal and legumes increase the protein content and improve the protein quality of cereal based complementary foods. The in vitro digestibility of protein was significantly increased in the different formulas as a result of complementary mixing cereals and legumes, as well as, as a result of adding skimmed milk powder. The in vitro protein digestibility ranged from 74.1% (F1) to 78.4% (F4) compared to the control (FC) sample (69.2%) [41].

Table 2: Chemical analysis of raw materials.

Parameters	**Yellow corn**	**Wheat flour**	**Broken rice**	**Faba bean cotyle-dons**	**Decorticated parched chickpea**	**Skimmed milk powder**
Chemical composition (g/100g)						
Moisture	10.55^{ab}	8.77^{c}	10.30^{b}	10.90^{a}	7.83^{d}	4.22^{e}
Protein	6.92^{e}	11.90^{d}	6.56^{e}	28.30^{b}	23.50^{c}	35.10^{a}
Fat	4.61^{b}	1.48^{d}	0.42^{f}	1.06^{e}	4.88^{a}	1.79^{c}
Ash	1.05^{d}	0.71^{e}	0.35^{f}	3.04^{b}	2.83^{c}	6.39^{a}
Crude fiber	2.07^{b}	2.24^{a}	0.50^{e}	1.75^{d}	1.85^{c}	0.00^{f}
N-free extract	74.80	74.90	81.87	54.95	59.11	52.50
Minerals (mg/100g)						
Calcium	14.9^{e}	30.9^{d}	31.1^{d}	185.6^{b}	169.9^{c}	1040^{a}
Iron	3.19^{c}	3.33^{c}	1.66^{d}	4.37^{b}	4.55^{a}	0.54^{e}
Magnesium	53.4^{e}	65.6^{d}	55.5^{e}	159.5^{b}	168.3^{a}	111.9^{c}
Potassium	131.3^{f}	297.9^{d}	178.1^{e}	879.2^{b}	768.9^{c}	1209^{a}
Sodium	14.5^{f}	16.8^{e}	26.5^{d}	74.4^{b}	58.6^{c}	469.0^{a}
Zinc	1.67^{e}	2.39^{d}	1.44^{f}	3.42^{c}	4.91^{a}	4.22^{b}

Table 3: Chemical analysis of raw formulas.

Parameters	**Formulas**					
	FC	**F1**	**F2**	**F3**	**F4**	**F5**
Chemical composition (g/100g)						
Moisture	10.8^{a}	9.8^{b}	10.1^{b}	9.9^{b}	10.2^{b}	9.9^{b}
Protein	6.90^{f}	14.6^{a}	15.7^{b}	12.4^{e}	14.6^{c}	12.9^{d}
Fat	4.56^{a}	3.71^{b}	2.89^{d}	3.70^{b}	2.74^{e}	3.18^{c}
Ash	1.09^{c}	1.92^{a}	1.92^{a}	1.74^{b}	1.85^{a}	1.78^{b}
Crude fiber	1.99^{a}	1.84^{b}	1.70^{c}	1.56^{d}	1.71^{c}	1.69^{c}
N-free extract	74.66	68.13	67.69	70.70	68.90	71.45
Protein digestibility (%)	69.2^{d}	74.1^{c}	76.8^{b}	77.0^{b}	78.4^{a}	78.1^{a}
Minerals (mg/100g)						
Calcium	23.99^{d}	158.9^{c}	163.8^{ab}	157.5^{c}	165.8^{a}	160.1^{bc}
Iron	2.961^{d}	3.231^{a}	3.257^{a}	3.040^{c}	3.069^{c}	3.171^{b}
Magnesium	48.13^{c}	87.17^{a}	84.43^{b}	87.11^{a}	85.41^{b}	87.89^{a}
Potassium	129.4^{e}	404.6^{d}	562.7^{a}	491.7^{b}	494.1^{b}	427.8^{c}
Sodium	14.22^{d}	68.96^{c}	76.74^{a}	73.83^{ab}	72.78^{b}	74.39^{ab}
Zinc	1.644^{e}	2.780^{a}	2.405^{d}	2.704^{b}	2.675^{bc}	2.627^{c}

The macro elements Na, Mg, K and Ca as well as microelements Fe and Zn of raw formulas used in preparing different samples of extrudates are illustrated in Table 3. Data were significantly different. It could be noticed that potassium and calcium were the main elements in all raw formulas followed by magnesium and sodium [42]. The different formula under the test caused a significant increase in the content of mineral elements compared to the control, where the results showed that the Ca content increased by between 6.6 fold (F3) and 6.9 fold (F5), K content increased by between 3.1 fold (F1) and 4.3 fold (F2), Na content increased by between 4.8 fold (F1) and 5.4 fold (F2), Mg content increased by more or less 1.8 fold (F1 - F5), Fe content increased by between 1.01 fold (F3) and 1.1 fold (F2), and Zn content increased by between 1.5 fold (F2) and 1.7 fold (F1), compared to that corresponding present in the control (FC) . Veena et al., (2011) stated that the fortified cereal-legume snacks may act as a novel vehicle for increasing calcium bioavailability intake in children [45].

Chemical analysis of snacks products:

The chemical composition of the different extrusion products is presented in the Table 3. It was clear that there was a significant decrease in the moisture content as a direct result of the extrusion process, especially the heat and pressure factors generated inside the extruder. The moisture content has decreased from 9.8% (F1) – 10.8% (FC) in the raw formulas to 6.79% (P3) – 7.43% (PC) in the extrudates. On the other hand, we find that the extrusion process did not significantly affect the approximate chemical composition and mineral elements content. But the significant difference is still clear in the products compared to the control, especially the high content of protein in the formulas proposed in this study. It was evident that the In vitro digestibility of protein was significantly increased in all samples as a direct result of the extrusion process, and the percentage increase reached 10.9% (P4) and that there was no significant difference between P4 and P5, while the value of that control sample was markedly less. These results agreement with Kitabatake and Doi, (1992) who reported that the denaturation of proteins during the extrusion processing caused increased of protein digestibility. In terms of energy resulting from consuming 100 grams of the products under study, we find that all formulas were significantly greater (371.16 – 377.32 kcal/100 gm) compared to the control (345.65 kcal/ 100 gm).However, the energy values were more or less the same for all formula except the control. It was evident that the percentage of energy resulting from the NFE relative to the total energy generated was significantly reduced in all samples compared to the control, which confirms the improvement in the nutritional value of the different formulas (P1 – P5) compared to the control (PC) [46]. In other words, the contribution of carbohydrates to energy decreased from 90% (PC) in the control to a value ranging between 75% (P1) and 78% (P5). The higher energy comes from carbohydrates may be due to the higher content of cereal that used in the products. On the other hand, the contribution of protein in the total energy has increased significantly in all samples under study compared to the control. The percentage of energy produced by protein was represented within a range from 13.5% (P3) to 16.7% (P2) compared to 8% in the control (PC) [47-50]. The recommended dietary allowance of proteins and calories is 14 g and 650 Kcal/day for infants. In our study products, 100 g covered about 58% of recommended dietary allowance for energy. In other words , About 172 grams of samples under test (P1 - P5) are nearly enough to meet the infant's daily energy requirement [51]. The point of interest is that 100 grams of these snacks (P1 – P5) is sufficient to provide the infant with his daily need of protein, but when taking into account the in vitro protein digestibility in these products, it becomes clear that we need 115-118 grams of such products. These results agreed with Walker (1990) who reported that protein to energy ratio for human milk to be 7% and desirable ratio for cereal based weaning foods to be 10-13%. It was also reported that the nutritional value was increased in the protein due to mild extrusion processing conditions.

Table 4: Chemical analysis of snacks product

Parameters	Products					
	PC	P1	P2	P3	P4	P5
Chemical composition (g/100g)						
Moisture	7.43^{a}	7.21^{ab}	7.07^{bc}	6.79^{c}	7.31^{ab}	6.88^{c}
Protein	6.89^{e}	14.9^{b}	15.5^{a}	12.7^{c}	14.4^{b}	13.0^{c}
Fat	4.61^{a}	3.78^{b}	2.99^{c}	3.64^{b}	2.90^{c}	3.11^{c}
Ash	1.05^{c}	1.88^{a}	1.90^{a}	1.81^{b}	1.77^{b}	1.79^{b}
Crude fiber	1.87^{a}	1.79^{b}	1.74^{bc}	1.62^{d}	1.75^{bc}	1.72^{c}
N-free extract	78.15	70.44	70.8	73.44	71.87	73.5
Energy (Kcal./100g)	345.65	375.38	372.11	377.32	381.16	373.99
Protein digestibility (%)	77.8^{d}	83.8^{c}	86.3^{b}	85.9^{bc}	89.3^{a}	88.6 ^{a}
Minerals (mg/100g)						
Calcium	22.54^{d}	173.3^{b}	180.1^{a}	167.3^{c}	176.8^{ab}	165.9^{c}
Iron	2.832^{d}	3.252^{a}	3.148^{c}	3.053^{a}	3.180^{bc}	3.222^{ab}
Magnesium	45.31^{c}	79.98^{b}	86.67^{a}	87.93^{a}	87.66^{a}	86.93^{a}
Potassium	143.8^{e}	392.4^{d}	542.5^{a}	504.8^{b}	491.5^{b}	434.9^{c}
Sodium	13.47^{d}	68.04^{c}	72.71^{b}	78.51^{a}	76.29^{a}	73.73^{b}
Zinc	1.587^{d}	2.823^{a}	2.605^{c}	2.690^{b}	2.605^{c}	2.666^{b}

*Means in a row not sharing the same superscript are significantly different at $p \le 0.05$

Amino acid and chemical score of formulas and snacks product:

Materials used in food manufacture. The adequate intake of protein is essential amino acids for normal

The amino acids analysis of food products is an important index of its protein quality and can produce useful information on the nutritional quality and authenticity of food products and the sources of raw

growth. The essential amino acids are necessary for tissue maintenance and also required for the growth of child. Daily protein required for infancy from 1.6 to 2.5

gm. /kg body weight/day. About 40% of total protein intake should come from essential amino acids (FAO,1991) [52]. The results of the amino acids composition for the six formulas were presented in the Table 5. It turned out that the total essential amino acids were high in all the studied formulas (i.e. , P1 – P5) compared to the control (PC) and ranged between 46.36 (P2) and 46.87 (P4) compared to the control (PC) 40.24 gm / 100 gm protein. It was evident that all the essential amino acids were higher than the FAO/WHO/UNU pattern (1985) except for the amino acid lysine [53]. Although cereals and legumes were low in their content of sulfur amino acids, the integration between them, as well as the addition of dry skimmed milk, led to the fact that the formulas P1 and P5 was equal or slightly higher than the requirements of FAO/WHO/UNU (1985), while the rest of the products, namely P2, P3, P4, came very close to the daily requirements, according to FAO/WHO/UNU pattern. In general, the control sample markedly the lowest in both lysine and sulfur amino acids (Table 5).

As a result of calculating the chemical score, from which the first and second limiting amino acids were determined, it was clear that the first limiting amino acid in all treatments was lysine except for treatment P2, in which the first limiting amino acid was the sulfur amino acids (SAA). Also, the second limiting amino acid was the sulfur amino acids in all treatments except for the P2 treatment, in which the exchange took place so that lysine became the second limiting amino acid after SAA (Table 5). With regard to talking about the non-essential amino acids, they showed a marked decrease in the products of all treatments, as a result of increasing the content of the essential amino acids resulting from complementing grains and legumes and supplementation them with dry skimmed milk, compared to the control (PC). However, the total non-essential amino acids ranged between 53.30 g/100g protein (P3) and 53.88 g/100g protein (P1) compared to the control (PC) which contained 58.82 g/100g protein [54,55].

The data (Table 5) regarding the calculated C-PER values clearly confirm that the process of complementing grains and legumes, as well as supplementation with skimmed milk powder, which has a high nutritional value for its proteins, in addition to the extrusion process itself led to a significant improvement in the calculated protein efficiency ratio (C-PER). In other words, the C-PER value increased in a range between 1.54 (P3) to 1.72 (P5) compared to the control (PC) with C-PER = 1.25. The process of high temperature short time extrusion bring gelatinization of starch, denaturation of protein, modification of lipid and inactivation of enzymes, microbes and many antinutritional factors [56].

Table 5: Amino acids composition of different formulas snack products.

A.A	**PC**	**P1**	**P2**	**P3**	**P4**	**P5**	**FAO/WHO/UNU ***
Histidine	2.76	3.61	3.53	3.42	3.33	3.50	1.8
Isoleucine	2.91	4.88	4.76	5.01	5.08	4.99	2.8
Leucine	12.80	10.32	10.21	10.93	10.72	10.80	6.6
Lysine	2.75	5.10	5.83	5.05	5.12	5.21	5.8
Meth + ½ Cys	2.22	2.54	2.30	2.39	2.43	2.50	2.5
Phenl + Tyr	7.97	9.32	9.28	9.40	9.56	9.42	6.3
Threonine	3.52	3.81	3.73	3.88	3.91	3.68	3.4
Tryptophan	1.35	1.26	1.30	1.28	1.32	1.29	1.1
Valine	3.96	5.82	5.42	5.33	5.40	5.41	3.5
TEAA**	40.24	46.66	46.36	46.69	46.87	46.80	
Alanine	6.57	5.52	5.65	5.72	5.77	5.88	
Arginine	4.99	6.90	6.17	6.35	6.51	6.47	
Aspartic	7.46	7.46	7.66	7.93	7.88	7.78	
Glycine	5.36	3.48	3.62	3.55	3.76	3.67	
Glutamic	22.81	18.74	18.95	18.64	18.73	18.80	
Proline	5.65	7.65	7.62	6.88	6.94	6.83	
Serine	5.98	4.13	4.02	4.23	4.18	4.29	
TNEAA***	58.82	53.88	53.69	53.30	53.77	53.72	
1^{st} LAA	Lysine	Lysine	S.A.A	Lysine	Lysine	Lysine	
2^{nd} LAA	S.A.A	S.A.A	Lysine	S.A.A	S.A.A	S.A.A	
C PER	1.25	1.55	1.61	1.54	1.71	1.72	

Physical properties of snacks:

Physical analysis is an important for manufactory food process because it measures many parameters such as density, water solubility Index, water absorption Index and expansion ratio. Data in Table 6 showed that significant difference of functional properties of snakes. The results showed that the complementary of cereals and legumes, as well as the supplementing with dry skimmed milk, which were processed for the purpose of improving the nutritional value, led to a significant increase in the values of each of bulk density, true density and expansion ratio. Bulk density (g/cm3) of different snacks ranged between 0.032 (P1) and 0.045 (P3), true density (g/cm3) varied from 0.051 (P5) to 0.065 (P3) and expansion ratio ranged between 14.5 (P3) and 15.3 (P4) compared to 0.028 , 0.044 and 14.3 , respectively in the control (PC). The highest true density may correlated with crude fiber content in the composite flour sample.(Qing et al., 2005) . They reported that true density increased with cereals starch in extrudates. Deshpande and Poshadri, (2011) reported that the crude fiber has effect on the bulk density. Singh et al., (1996) reported that the decrease in expansion ratio could be because of high level of dietary fiber, while protein affects expansion through their ability to effect water distribution in the matrix and through their macro molecular structure and confirmation [57-60]. Bhattacharya and Prakash (1994) studied the extrusion of blends of rice and chickpea flours, containing 20% moisture through single screw extruder. It was observed that incorporation of chickpea into rice flour decreased torque and product expansion, but increased bulk density and shear strength. Water absorption index quantifies the amount of water absorbed by starch and can be used as an indicator of gelatinisation. It is an estimate of damaged starch along with protein denaturation and new macromolecular composite formations. Extrusion temperature and feed moisture content had a strong impact on gelatinisation during extrusion, thereby influencing the water absorption index (Kaushal , et al., 2019). Data presented in Table 6 revealed that Water absorption index (%) and Water solubility index (%) are significantly different between different snack samples under study. Water absorption index (%) varied from 383.7 (P3) to 413.2 (P4) , while Water solubility index (%) ranged between 5.37 (P4) and 6.10 (P1) as a result of adding legume sources and also due to the difference in the type of each of the added legumes and grains. It well Known that During extrusion, protein structures are disrupted and altered under high shear, pressure, and temperature. Protein solubility decreases and cross-linking reactions occur possibly due to some covalent bonds formed at high temperature, as well as protein denaturation and formation of complexes between starch and lipids and between protein and lipids. Water solubility index measures the degree of starch dextrinisation and degradation of molecular compounds during extrusion. The variation in water absorption index of extrudates may be due to several factors like protein denaturation and starch gelatinisation that occurred during extrusion. This effect was attributed to the relative decrease in starch content with the addition of legumes which may influence the extent of starch gelatinisation in the barrel, thereby resulting in reduced water absorption.

Table 6: Physical properties of different snack products.

Parameters	Products					
	PC	P1	P2	P3	P4	P5
Bulk density (g/cm^3)	0.028^c	0.032^{bc}	0.035^b	0.045^a	0.041^a	0.036^b
True density (g/cm^3)	0.044^d	0.055^{bc}	0.058^b	0.065^a	0.060^{ab}	0.051^c
Expansion ratio (ER)	14.3^d	15.0^{ab}	15.2^a	14.5^{cd}	15.3^a	14.7^{bc}
Water absorption index (%)	394.3^b	395.2^b	405.3^a	383.7^c	413.2^a	392.2^b
Water solubility index (%)	5.88^b	6.10^a	5.67^c	5.41^d	5.37^d	5.59^c

The color of food products is one of the basic parameters affecting consumer acceptance. In order to have consumer acceptance, the appearance of extrudates is important. Color is one of the most important appearance attributes because consumers buy products based on expected color from previous experience. The color of sample is denoted by the three dimensions L, a and b. The L value gives a measure of the lightness of the product color. The redness and yellowness are denoted by the a and b values, respectively (Bakalov, et al., 2016). The measured values of the color parameters of extruded blends varied in the range from 69.15 (P1) –72.04 (PC) for lightness (L), 5.75 (PC) – 6.12 (P4) for redness (a), and 36.63 (P5) – 37.05 (P5) for yellowness (b).

From the results of determining the color of the different products, it is clear that there is a slight significant decrease in the lightness value of the color and the degree of yellowness compared to the control (PC), in contrast to the degree of redness of the color, which increased slightly but significantly in all treatments (P1 – P5) compared to the control (PC). By calculating the amount of change in each parameter, we find that the decrease in the lightness ranged between 1% (P3) and 4% (P1), while there was an increase in the redness by 1% (P5) to 6% (P4), also we find that the yellowness of the color decreased by between 1% (P3) and 3% (P2) , respectively compared to the corresponding parameter in the control (PC). The total color difference (ΔE) of extrudates also confirmed the aforementioned observation since % of total color difference (ΔE) varied from 0.071 (P3) to 2.93 (P1). In other words, it can be said that the production of extrusions by adding sources of grains and legumes in addition to yellow corn flour and supplementation with dry skimmed milk led to all the products, despite their markedly different color parameter values, but all the products retained the lightness color and the degree of yellowness with a slight increase in the value of the redness color that required in such snacks. A color difference value (ΔE) above 2 can be noticed by an inexperienced observer (Mokrzycki and Tatol, 2011). It is clear from the results that the color difference value (ΔE) was less than the value 2.0 in three samples, namely P3, P4 and P5, while the values of the remaining two samples (i.e., P1 and P2) were also less than 3.0 (Table 7).

Table 7: Color of different snack products.

Samples	L*	a*	b*	EΔ
PC	72.04^{a}	5.75^{c}	37.05^{a}	-
P1	69.15^{c}	6.07^{a}	35.90^{b}	2.98
P2	69.45^{c}	6.02^{ab}	35.73^{b}	2.71
P3	71.35^{ab}	5.90^{abc}	36.95^{a}	0.71
P4	70.57^{b}	6.12^{a}	36.86^{ab}	1.87
P5	70.19^{bc}	5.82^{c}	36.63^{ab}	1.90

Sensory evaluation of snack products:

Table No. 8 shows the results of the sensory evaluation tests for the different samples under test. The sensory evaluation of the snacks products were performed to access for taste (20), odor (10), color (10), hardness (10), crispness (10), bitterness (10), porous texture (15) and porous distribution (15). Despite the presence of significant differences among the samples within each sensory characteristic, all samples were sensory acceptable, and three samples obtained an excellent rating, namely PC, P3 and P5, while the remaining three samples obtained a good rating which are P1, P2 and P4.

In general, the best two samples in terms of taste are PC and P5, and in terms of odor, the best two samples are P4 and P5, while all samples were close in terms of color values, above especially P4 and P5. On the other hand, the best two samples in each of the Hardness and Crispness were PC and P3, and all samples were excellent and equal in terms of Bitterness. In terms of Porous Texture, the best two samples were PC and P5. While the samples PC, P3 and P5 obtained an excellent evaluation in terms of overall acceptability. The results of the color completely agree and fall within the range that published by Yagci and Gogus (2009) for Expanded Extrudates from the blends of hazelnut flour-durum clear flour-rice

Table 8: Sensory evaluation of the snacks product.

Properties	**Products**					
	P.C	P1	P2	P3	P4	P5
Taste	17.9^{a}	17.2^{bc}	16.9^{c}	16.9^{c}	17.2^{bc}	17.6^{ab}
Odor	8.75^{ab}	8.48^{b}	8.42^{b}	8.78^{ab}	9.13^{a}	9.12^{a}
Color	9.45^{a}	8.72^{b}	8.61^{b}	9.43^{a}	9.34^{a}	9.53^{a}
Hardness	9.42^{a}	7.61^{bc}	6.92^{d}	9.42^{a}	7.25^{c}	8.24^{b}
Crispness	9.41^{a}	7.13^{c}	6.32^{d}	9.40^{a}	7.21^{c}	7.61^{b}
Bitterness	9.72^{a}	9.78^{a}	9.81^{a}	9.72^{a}	9.82^{a}	9.82^{a}
Porous texture	12.5^{a}	11.2^{d}	12.0^{c}	11.5^{d}	12.1^{bc}	12.4^{ab}
Porous distribution	12.7^{a}	11.3^{c}	12.2^{b}	12.5^{ab}	12.3^{b}	12.2^{b}
Overall acceptability	89.85 (excellent)	81.42 (good)	81.18 (good)	87.65 (excellent)	84.35 (good)	86.52 (excellent)

Table 9: Peroxide value of snacks product during storage period.

Storage periods	**PC**	**P1**	**P2**	**P3**	**P4**	**P5**
Zero time	^{d}0.35^{ab}	^{d}0.33^{ab}	^{d}0.32^{b}	^{d}0.36^{a}	^{d}0.33^{ab}	^{d}0.32^{b}
2 months	^{c}0.62^{a}	^{c}0.59^{b}	^{c}0.52^{c}	^{c}0.58^{b}	^{c}0.52^{c}	^{c}0.54^{c}
4 months	^{b}0.92^{a}	^{b}0.75^{b}	^{b}0.69^{c}	^{b}0.73^{b}	^{b}0.67^{c}	^{b}0.70^{c}
6 months	^{a}1.55^{a}	^{a}0.99^{b}	^{a}0.79^{d}	^{a}0.82^{d}	^{a}0.78^{d}	^{a}0.94^{c}

Storage stability of snack products

Peroxide value as one of an important of oil constant to attribute shelf life of snacks was performed. Effect of storage on peroxide value of snack products at zero time, after two months, after four months and after six months are presented in Table 9. Data revealed that there were significant difference between samples concerning the changes in Peroxide Value (P.V) of fats extracted from different snack products during storage at temperature (25°C). The increase in peroxide value was significant ($p>0.05$) among the products for all the samples when compared within the same period and during a storage period up to 6 months. It could be noted that peroxide value of fats extracted from all snake products increased with storage time at 25°C . It could be noticed that the peroxide value increased significantly in the control (PC) during storage at temperature 25°C and changed from 0.35 to 1.55 meq O2/kg of oil during 6 month of storage at RT. On the other hand, the peroxide value in the P2 and P4 had the lowest peroxide value during storage at temperature 25°C since they changed from 0.32 and 0.33 at zero time to 0.79 and 0.78 meq O2/kg of oil, respectively at the end of the storage period. In general, the results of the experiment of storage stability of the snack products find the preference for all the formulas used compared to the control, where the values of the peroxide number were multiplied with significantly low values compared to the control. The values were 3.0, 2.5, 2.3, 2.4 and 2.9 folds in P1, P2, P3, P4 and P5, respectively compared to the figure 4.4 for the control snack sample (PC).The results were in agreement with Uma et al., (2011).

CONCLUSION

Extruded snack products prepared from complementing some cereals (i.e. yellow corn, wheat flour and broken rice) and legumes (faba bean cotyledons and decorticated parched chickpea) with supplementing with skimmed milk powder are considered a valuable addition for children foods. These formulas understudy improved both the approximate chemical composition, especially the protein, essential amino acid composition and mineral content, as well as raising the nutritional value represented in in vitro protein digestibility and CPER. These products were also distinguished by a high storage ability value.

CONFLICT OF INTEREST

The authors declare that this study has no conflict of interest.

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