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Effect on Physicochemical Characteristics and Phytic Acid Content of Soybean During Soynut Processing

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Abstract. The nutritional benefits, and therapeutic value of soybean lures the technologists to develop viable technologies, for the production of ready-to-eat and health promoting snack foods with all nutrients intact. One, such technology for fried soybean (soynut) has been successfully developed, and evaluated for its nutritive quality, consumer acceptability and content of phytic acid (an anti-nutritive factor). Soynut contains 33.74% protein, 26.69% lipids, 4.40% minerals and 504 kcal energy/100g. The product was subjected to consumer evaluation with about 90% of the consumers accepted the product showing their preferences for colour, texture, taste and mouth feel. Various processing steps like boiling, subsequent soaking, and frying, significantly reduced the phytic acid content of soybean i.e. 11.31%, 21.64% and 35.12% respectively, as compared to raw soybean.

Keywords: soynut, physicochemical characteristics, phytic acid content, soybean

Introduction

Soybean is an excellent source of high quality protein, and recent research has indicated that soybean has several beneficial effects on health in addition to its nutritional benefits. It contains lecithin and essential fatty acid, i.e. oleic acid that helps to lower cholesterol in blood. It also contains high concentrations of isoflavonides which have anticarcinogenic activity (Jenkins *et al.*, 2002). Soybean reduces the blood cholesterol level (Meyer *et al.*, 2004). It helps to reduce the common menopausal symptoms (Potter *et al.*, 1993). Apart of these beneficial effects, soybean also contains trypsin inhibitor and phytic acid (Mebrahtu *et al.*, 1997). Phytic acid (myo-inositol-1,2,3,4,5,6-hexakisphosphate) is generally regarded as the primary storage form of both phosphate and inositol and widely spread in plants and grains and typically represents 1-2% of seed dry weight (Rasmussen and Hatzack, 1998; Irving, 1980). Cereal grains are among those foods of vegetable origin that possess the highest content of phytic acid (Hidvegi and Lasztity, 2002; Reddy and Salunkhe, 1981). As a polyanion at physiological pH, phytic acid acts as an effective chelator of positively charged cations. The antinutritional effects of phytic acid primarily relate to the strong chelating, associated with its six reactive phosphate groups. When consumed in foods, phytic acid will bind to nutritionally important mineral cations that it encounters in the intestinal tract, such as calcium, iron and zinc, and to proteins as well (Raboy, 2002), thus, decreasing their bioavailability (Hunt and Roughead, 2000; Tait, 1983). This phenomenon can contribute to human mineral deficiency, particularly with respect to iron and zinc (Etcheverry, *et al.*, 2006; Brown and Solomons, 1991). Soya foods have been a staple part of the Chinese diet for thousands of years, and are finding an increased market in western countries. Most common soy foods include tofu, temph, textured vegetable protein, soy sauce, soy oil, soymilk etc (Kano *et al.*, 2006). However this trend is not reflected in Pakistani markets.

In view of the nutritional importance and health benefits of soybean, it is important to develop a viable technology for the production of tasty and healthy snack, keeping all nutrients intact. Present study was undertaken to develop a ready-to-eat and health promoting snack food from soybean. This study also reveals the effect of processing on physicochemical characteristics and phytic acid content of soybean. The processed soynut was also subjected to sensory evaluation for determination of consumer preferences.

Materials and Methods

Soybean was purchased from local market, Karachi, Pakistan. In order to produce quality product, foreign substances, discoloured, shrunken and mouldy beans were removed. Cleaned and sorted beans were subjected to sieving to get uniform size, and rejecting the broken ones. All the sorting and sieving processes were done manually.

Soynut processing. Cleaned and sorted soybeans were graded to uniform size. These beans were washed thoroughly, then boiled for 3 min at 100 °C under atmospheric pressure in water where beans to water ratio was kept at 1:3. Thereafter, boiled

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beans were left for soaking in the same water for 2 h. Water drained off and the beans were dried by hot air blowing while, spreading on filter paper. Air dried beans were deep fried in sunflower oil using a temperature controlled deep fryer. Initial temperature of oil was maintained at 175 °C. Whereas frying temperature for soynut was adjusted to be 145 °C for 11 min. After frying excess oil was drained by centrifugal dryer. Soynut may be salted thoroughly. A schematic diagram of soynut process is shown in Fig. 1.

Sorting/ Sieving of raw soybeans
↓
Washing
↓
Boiling for 3 min
↓
Soaking in water for 2 h
↓
Draining water
↓
Hot air drying
↓
Deep frying at 145°C for 11 min
↓
Centrifugation
↓
Salting
↓
Packing

Fig. 1. Soynut processing flow chart.

Physical analysis: ***Seed weight, volume and density.*** Seed weight was determined by taking one hundred randomly selected soybean seeds, weighed and recorded as 100 seed weight (Rehman and Shah, 2000). Seed volume was determined as described by Phirke *et al.* (1982). Hundred weighed seeds were immersed in a cylinder containing water and the amount of water displaced was recorded as volume of seeds. Apparent bulk density was calculated from the values already obtained for weight and volume.

Water absorption capacity. Water absorption capacity of soybean at different soaking times was determined through the method described by Safa-Dadeh and Stanley (1979). After boiling, 10 g seed samples were soaked, in distilled water at 28-32 °C. Seed to water ratio was maintained at 1:5. After predetermined soaking time intervals, the seeds were removed from water, drained, surface dried by spreading on the filter paper and weighed. Weight gain was taken as the quantity of water absorbed and expressed as the percentage of the initial dry weight of the seeds.

Swelling capacity. Swelling capacity of soybean was determined by the method described by Akinyele *et al.* (1986). Weighed seeds were cooked in boiling water for 20 min. The seeds were drained and re-weighed. The final weight plus the leached solids were taken as the cooked weight. The swelling capacity was obtained by dividing the cooked weight by the raw seed weight per 100 g seeds.

Chemical analysis. Chemical analysis of raw and processed soybean was conducted according to methods described by Delwiche (2005) i.e. Ash (32.1.05; 923.03), moisture (32.1.03; 925.10), fat (32.2.01F; 945.38) protein (32.1.22; 920.87). Calories were calculated, taking fat as 9 kcal/g, protein 4 kcal/g and carbohydrates 4 kcal/g.

Phytic acid. Phytate content was estimated by combining two methods i.e extraction and precipitation of phytate, performed according to method developed by Thompson and Erdman (1982). Phosphorous was determined after extraction of sample with 3%TCA and 10%Na_2SO_4, the precipitates of ferric phytate were digested and dissolved in 15 ml of 3N HCl. The solution was made upto 100 ml. Phosphorous was determined by spectronic 21, spectrophotometer, according to procedure described by Hart and Fisher (1981). Phytic acid was then calculated assuming 28.20% phosphorous in the phytate molecules (Reddy and Salunkhe, 1981).

Sensory analysis. The soynut was subjected to sensory evaluation by 50 untrained judges for its quality attributes i.e. taste, colour, mouth feel and texture. They ranked the product into five levels of acceptance ranging from poor to excellent as per method described by Land and Shepherd (1988).

Statistical analysis. To assess consumer acceptability towards soynut, the chi square-test was applied to observed frequencies of consumer data. Whereas, Dunkan's Multiple Range test was applied to certain parameters to determine the level of significance among the data as described by Steel *et al.* (1997).

Results and Discussion

A number of processing steps were incorporated to produce a product with better nutritional and sensory characteristics. Among these the control on boiling and soaking times are significantly important to get quality product. The boiling step is vital because, during 3 min boiling, the enzymatic activity was arrested, resulting in the improved colour product whereas, water absorption was also facilitated hence reducing the soaking time. Bulk density and water absorption capacity was determined at every half an hour as shown in Table 1, in order to determine correct soaking time. The collected data depicted that water absorption and seed volume kept increasing for the first 2 h of

Table 1. Effect of boiling and subsequent soaking time on seed density and water absorption

Boiling/ soaking time	Seed weight (g)	Gain in weight (g)	Seed volume (ml)	Apparent bulk density	Water absorption (%)
Boiling for 3 min	10	5.8 ± 0.08[d]	14.0 ± 0.41[d]	0.71 ± 0.07[a]	58 ± 0.58[e]
Soaking for ½ h	10	8.8 ± 0.12[c]	17.0 ± 0.41[c]	0.59 ± 0.10[b]	88 ± 0.69[d]
Soaking for 1 hr	10	10.3 ± 0.16[bc]	18.5 ± 0.82[bc]	0.54 ± 0.13[c]	103 ± 1.10[c]
Soaking for 1 ½ h	10	10.6 ± 0.14[ab]	19.0 ± 0.41[ab]	0.53 ± 0.03[cd]	106 ± 1.10[b]
Soaking 2 hrs.	10	11.3 ± 0.16[a]	19.5 ± 0.41[a]	0.51 ± 0.08[d]	113 ± 0.90[a]
Soaking for 2 ½ h	10	11.4 ± 0.08[a]	19.5 ± 0.18[a]	0.51 ± 0.01[d]	114 ± 0.87[a]
Soaking for 3 h	10	11.6 ± 0.16[a]	19.6 ± 0.32[a]	0.51 ± 0.01[d]	116 ± 1.21[a]
Soaking for 3 ½ h	10	11.6 ± 0.16[a]	19.5 ± 0.22[a]	0.51 ± 0.13[d]	116 ± 0.87[a]
Soaking for 4 h	10	11.6 ± 0.04[a]	19.6 ± 0.36[a]	0.51 ± 0.07[d]	116 ± 0.97[a]

soaking, after that seed volume remained almost constant with non-significant change in these indicators. The seeds reached maximum bulk density of 0.51 with no change in this parameter thereafter. Rupturing of bean coat was also noted when soaking exceeds than 2 h, therefore, this soaking period was found appropriate for soynut processing. Physical characteristics of unprocessed soybean are depicted in Table 2. The soybean seeds are having seed density 1.17.

Table 2. Physical characteristics of unprocessed soybean

Physical characteristics	Unprocessed soybean
100 seed weight	14 g
100 seed volume	12 ml
Seed density	1.17
Swelling capacity	1.23

Nutritive values of unprocessed soybean compared with laboratory developed soynut are shown in Table 3. Newly developed soynut contain 3.02% moisture, have a protein value of 33.74%, lipid 26.69% and an average energy value 504 kcal/100 g. These values represent soynut as a healthy snack. Unprocessed soybean contained 6.3% moisture while moisture content of soynut is low i.e. 3.02%, but no shrinkage of the nuts was noticed. This may be attributed to the replacement of moisture by frying oil during frying. At the same time high calories content of soynut is mainly due to this oil absorption during frying. On the other hand loss in protein and ash contents was observed. These losses were 7.85% for protein and 0.77% for ash. It is likely that nitrogenous matter and minerals leached out during pre-boiling. Soynut is an excellent source of protein providing approximately 75% of recommended daily allowance (RDA). Fried nuts provide 504 kcal/ 100 g which is 21% of RDA for calories need.

There are several methods of decreasing the inhibitory effect of phytic acid on mineral absorption i.e. cooking, germination, fermentation, soaking and autolysis. Changes in phytate content during boiling, soaking and frying is presented in Table 4. Throughout the processing steps of soynut, decrease in phytate content was noted. After boiling for 3 min and soaking for 2 h, the decrease in phytic acid content was 11.31% and 21.64%, respectively. The fried nuts contained 7.97mg/g phytic acid, depicting

Table 3. Physicochemical characteristics of unprocessed soybean and soynut

Parameters	Soybean (%)	Soynut (%)	RDA (g)	%RDA	%RDA
Moisture	6.30	3.02	-	-	-
Ash	5.17	4.40	-	-	-
Protein	41.60	33.74	45.0	74.97	74.97
Fat	20.21	26.69	75.0	35.59	35.59
Carbohydrates	26.72	32.15	360.0	08.93	08.93
Food energy	455 kcal	504 kcal	2400	20.99	20.99

Table 4. Effect of processing on phytic acid contents of soybean

Processing conditions	Phosphorous (mg/100g)	Phytic acid (mg/100 g)	Decrease (%)
Unprocessed soybean	346.50	1228.72	-
Boiled at 100 °C for 3 min	307.31	1089.75	11.31
Soaked for 2 h	271.53	962.87	21.64
Drained and fried at 145 °C for 11 min	224.80	797.16	35.12

rated the texture as excellent. Whereas colour and mouth feel of the product lured the 78% evaluators each, which ranked the soynut as excellent to good in these sensory parameters. However taste needs to be further improved as the significant number of consumers i.e. 22% ranked the taste below average. Here the application of continental chilly flavours replacing the applied plain salt may improve the taste profile of the snack. The statistical evaluation of sensory data shows that calculated value for χ^2 is 21.58. This value being greater than tabulated value, helps to conclude that soynut is acceptable to consumers by statistical point of view.

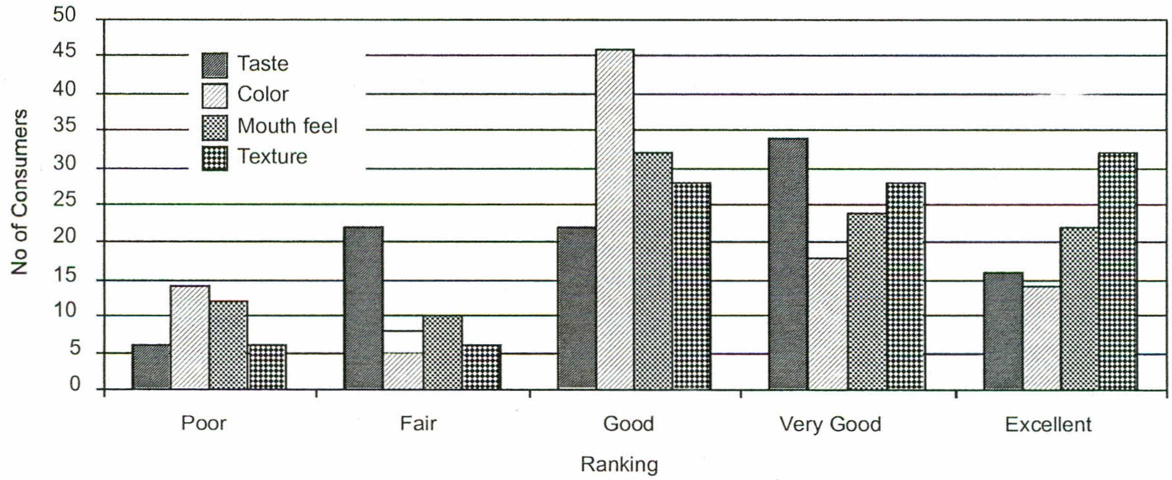

Fig. 2. Percent consumer grading of sensory attributes for soynut.

35.12% reduction in comparison to unprocessed soybean. Several investigators observed similar decrease in phytic acid content during soaking and heat processing the legumes. A sharp decrease in phytic acid during soaking and germination of different legumes was observed (Riaz *et al.,* 1981). Mebrahtu *et al.* (1997) reported accumulation of phytic acid in soybean, which was eliminated by heating process such as blanching. Similarly autoclaving and roasting were found to be more effective in reducing phytic acid in chickpea, mungbean and soybean (Chitra *et al.,* 1996). Our results of phytic acid reduction during processing are in close agreement with the work of Khan *et al.* (1988) who reported the 12.5% loss of phytate contents during boiling in black gram (*Cicer arietinum*), in a combination of soaking with subsequent boiling, loss rose upto 25.0% and when these grams were fried, the amount of phytate decreased to 37.5%.

Acceptability of soynut is dependent on taste, colour, mouth feel and texture. Consumer grading on these attributes is presented in Fig. 2. Texture was most acceptable among these sensory attributes as highest number of evaluators i.e. 16

Conclusion

Presently peanuts, popcorn, and potato chips are widely used as snacks. Soynut high in nutritive value as well as beneficial for health would be a good breakthrough for snack lovers. It is anticipated that the physicochemical data of this research study would be helpful for the business concerns of Pakistan interested in the development of production process for fried soya snack foods.

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