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Effect of Domestic Processing Techniques on the Mineral Content in Soybean

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Food legumes are widely consumed all over the world as these are good sources of dietary proteins, carbohydrates and minerals. Common domestic processing techniques like soaking, germination and cooking are employed so as to enhance the digestibility and nutritive value. The effects of soaking, germination (5 day period) and cooking (microwave, pressure and ordinary cooking) were studied on the mineral content of soybean. Germination (2nd day) leads to significant increases in the Ca, Cu and Zn content. Microwave cooking resulted in greater retention of minerals as compared to pressure cooking and ordinary cooking. Based on these results germination (day 2) for soybean should be popularized as a simple process for naturally fortifying food with essential minerals. While amongst cooking treatments microwave cooking could be suggested for soybean preparation.

Key Words: Processing, Nutrients, Germination, Cooking, Minerals.

INTRODUCTION

Food legumes are an important part of the human diet[1], as these are good and inexpensive sources of proteins, carbohydrates and dietary fibers. These are also rich in B-group vitamins (thiamin, riboflavin, niacin) and minerals like K, Ca, Mg, Cu, Fe and Zn. The most commonly grown legumes world over include soybean, peanut, beans, peas, chickpeas and lentils. On account of their high nutritive value they are the main sources for human and animal nutrition especially in the developing countries. While in the developed countries, legumes are increasingly being used in dietetic formulations in the treatment and prevention of diabetes, cardiovascular diseases and cancer of colon[2,3].

Some simple and inexpensive processing techniques, such as soaking, germination and cooking are commonly used for legume preparation[3]. Processing techniques cause important changes in the biochemical, nutritional and sensory characteristics in legumes. These are known to enhance the nutritional value of legumes, by increasing essential amino acids, protein digestibility, amino acid availability and certain B-vitamins[4].

Soaking is an integral part of a number of treatments, such as germination, cooking and fermentation. It consists of hydration of the seeds in water for a few hours. Several studies indicate that soaking can reduce the levels of minerals, phytic acid and proteolytic enzyme inhibitors[3,5], which can be partly or totally solubilized and eliminated with the discarded soaking solution.

In many parts of the world, legumes are often consumed after soaking and germination during which the nutritional value is enhanced[6]. During germination of food grains, it has been reported[7,8] that certain minerals, were increased whereas phytic acid and trypsin inhibitor[9] were decreased.

Cooking is probably the oldest treatment for making legumes edible. Usually, it includes pre-soaking of the seeds and subsequent cooking in boiling water until they become tender. Soaking and/or cooking can cause considerable losses in some essential nutrients, such as water soluble minerals due to their leaching into the cooking medium[9].

Considerable research work has been carried out on the effect of soaking and germination on the mineral content of chickpea (kabuli), mungbean, lentils, faba beans, black gram and soybean. But the effect of the common types of cooking on the mineral content of soybean has not been attempted. Here, we provide a detailed study on the effects of soaking, germination and cooking (ordinary cooking, pressure cooking and microwave cooking) on the variation of 8 important minerals in soybean. An attempt has also been made to suggest the optimum period of germination, one which has the greatest mineral content.

Therefore, this study attempts to provide a clear picture of the effects of various processing techniques on the minerals K, Ca, Mg, P, Fe, Cu, Mn and Zn and hence allows for the selection of the best conditions for improving the mineral quality of soybean when they have to be processed for human nutrition.

EXPERIMENTAL

Soybean (*Glycine max*) seeds were purchased from nearby local market in New Delhi (India). The seeds were cleaned from broken seeds, dust and other foreign materials.

Soaking: The seeds were washed twice in water to remove any external matter sticking to the seed coats. Then the seeds were soaked in distilled water (1:5, w/v) for 12 h at room temperature[10,11].

Germination: The soaked seeds were germinated in sterile Petri dishes lined with damp filter papers at 25 ºC. Seeds were germinated for 24, 48, 72, 96 and 120 h, respectively. The sprouts were dried at 55 ºC.

Ordinary cooking: The soaked seeds, after rinsing in water, were put in round bottom flasks and after addition of water (1 g:5 mL), the samples were cooked on a hot plate for 2 h until the tenderness of seeds was achieved[10,11].

Pressure cooking: Presoaked seeds were placed in beakers containing water (1 g:5 mL). The tops of the beakers were covered with aluminum foil and then cooked in an autoclave at 1.05 kg/cm^2 (15 lbs/inch^2) for 15 min until the tenderness of seeds was achieved[10].

Microwave cooking: Presoaked seeds were placed in beakers containing water (1 g:5 mL) and then cooked in a domestic Samsung bioceramic microwave oven (model CE283DN-850 W cooking power) for 15 min until the tenderness of seeds was achieved[10].

After each type of processing, excess water was drained and the seeds were dried. The samples were then ground in a domestic electric grinder to pass through a 100 mesh sieve and then stored in resealable plastic bags at room temperature until further analysis[10,11].

Mineral estimation: A portion of legume sample was digested with nitric acid[12,13] at 100-120 ºC for 3 h. Minerals were then determined by inductively coupled plasma-atomic emission spectroscopy (VISTA- MPX, Varian, Australia).

Statistical analysis: Mean and standard deviations were calculated from the results of the analyses performed. The data were subjected to analysis of variance (ANOVA). Means were compared using Duncan's multiple range test. Significance was defined as $p < 0.05$.

RESULTS AND DISCUSSION

Soaking: From Tables 1 and 2, it is evident that soaking resulted in decrease of 9 % in K, 4 % in Ca, 5 % in Mg, 7 % in P, 3 % in Fe. The decrease in content of minerals on soaking is the result of leaching into the soak water[14,15].

TABLE-1
EFFECT OF PROCESSING ON MINERALS IN SOYBEAN

Processing	K	Ca	Mg	P
Dry	952.56 ± 18.42h	353.86 ± 3.35bc	305.72 ± 3.46e	499.38 ± 18.38f
Soaking	870.74 ± 28.64g	341.41 ± 6.76ab	289.71 ± 10.37d	464.39 ± 14.29e
Germination day-1	852.41 ± 5.99f	361.88 ± 7.61cde	292.16 ± 4.98d	436.30 ± 4.57cd
Germination day-2	817.83 ± 7.16e	371.56 ± 3.46e	312.91 ± 9.25e	445.99 ± 7.88cd
Germination day-3	793.20 ± 8.06d	348.60 ± 5.75bc	279.16 ± 0.48c	415.28 ± 7.71bc
Germination day-4	778.82 ± 9.33d	367.41 ± 11.27de	286.90 ± 2.67cd	444.88 ± 35.49cd
Germination day-5	773.56 ± 7.09d	331.17 ± 9.43a	290.78 ± 1.73d	423.72 ± 21.17bc
Ordinary cooking	410.57 ± 8.87a	370.46 ± 8.88e	252.32 ± 9.43b	380.69 ± 21.15a
Microwave cooking	514.60 ± 1.66c	363.26 ± 5.53cde	256.47 ± 3.62b	399.78 ± 5.00ab
Pressure cooking	435.75 ± 8.98b	357.18 ± 12.49cde	241.81 ± 3.35a	377.09 ± 10.14a

Results are means of triplicate ± standard deviation, expressed on dry matter basis. Different letters in the same column means significant differences ($p < 0.05$).

Germination: High declines were observed in amount of potassium which increased progressively with germination over the period of 5 days. The decline in amount varied from around 11 % on day 1, 16 % on day 3-19 % on day 5, respectively. Germination leads to increase in calcium concentration which was 2.3 % on day 1 and became 5 % on day 2 and 4 % on day 4. After an initial decrease in magnesium content there was a marginal gain on day 2 further the amount declined (losses in range of 5-9 %). As a consequence of germination the phosphorus content showed decreases that varied from 10-16 %. Copper content showed the maximum increase during germination in soybean which was continuous. After an initial decrease of 6 % in iron content on day 1 there was an increase in amount on day 2 which was followed by a regular decrease in content as the process progressed. An increasing trend was observed in manganese content. During germination the zinc content showed increase of 7 % on day 2 and 10.5 % on day 4.

TABLE-2
EFFECT OF PROCESSING ON MINERAL CONTENT

Processing	Cu	Fe	Mn	Zn
Dry	1.61 ± 0.05a	8.96 ± 0.41c	2.23 ± 0.12a	3.52 ± 0.36abc
Soaking	3.02 ± 0.05b	8.69 ± 1.10c	2.59 ± 0.13bc	4.14 ± 0.29d
Germination day-1	3.27 ± 0.02b	8.41 ± 0.22c	2.39 ± 0.09ab	3.42 ± 0.20abc
Germination day-2	3.01 ± 0.04b	8.94 ± 3.20c	2.28 ± 0.24a	3.77 ± 0.49bc
Germination day-3	4.15 ± 1.42c	4.75 ± 0.43a	2.24 ± 0.03a	3.30 ± 0.06ab
Germination day-4	8.48 ± 0.28d	5.35 ± 0.02ab	2.49 ± 0.19ab	3.89 ± 0.57cd
Germination day-5	4.47 ± 0.10c	4.95 ± 0.17ab	2.29 ± 0.09a	3.52 ± 0.09abc
Ordinary cooking	1.58 ± 0.06a	7.14 ± 1.85bc	2.79 ± 0.18c	3.18 ± 0.27a
Microwave cooking	3.15 ± 0.56b	6.99 ± 0.37abc	2.71 ± 0.02c	3.09 ± 0.08a
Pressure cooking	1.80 ± 0.09a	6.77 ± 0.38abc	2.81 ± 0.32c	3.14 ± 0.12a

Results are means of triplicate ± standard deviation, expressed on dry matter basis. Different letters in the same column means significant differences ($p < 0.05$).

Fordham *et al.*[16] reported soybean contained more Ca and Fe (3180 and 90 µg/g, respectively) than a number of common pea and bean species. While Osborn[17], observed that defatted soybean contained 20 µg/g Cu and 3100 µg/g Mg. According to Bau and Debry[18], soybean germination was associated with an increase in calcium content. However, the phosphorus content decreased regularly as germination progressed, the decrease reached 15.93 % after 3 days of germination. As approximately 70 % of the total phosphorus in soybean occurs in the form of phytate inositol hexaphosphate this decrease could be attributed to the increase of phytase activity during germination, resulting in partially water-soluble free phosphorus derived from the phytate.

Lee and Karunanithy[14], reported high losses in potassium, moderate losses in magnesium and smaller losses in iron in soybean. However, there was increase in calcium content in *Glycine max* and *Glycine hispida* on account of germination. They explained that the losses of divalent metals were low during germination due to their binding to protein and the formation of phytate-cation-protein complexes.

Sangronis and Machado[7], reported germination increased the content of calcium by 5 % in black beans. A significant loss in magnesium content (23.7 % in white casing *P. vulgaris* L) due to germination was observed by Sangronis and Machado[7], who attributed it to lixiviation during germination. An increase of 37.7 % in zinc content was also seen in germinated pigeon beans. But a decrease in iron content was observed on account of germination. The black beans showed a decrease of 42.6 % as compared to the iron content of ungerminated grains. Augustin and Klein[19], reported that the content of P, K, Zn and Cu increased significantly in various legumes.

Cooking: The cooking treatments lead to a significantly high decrease in potassium ranging from 46 % (microwave cooking) to 57 % (ordinary cooking). While in case of calcium there were small increases upon cooking that ranged from 1 % (pressure cooking) to 4 % (ordinary cooking). Cooking lead to decrease in magnesium content that varied from 16 % (microwave cooking) to 20 % (pressure cooking). High losses (20-24 %) in phosphorus content were observed during cooking. In contrast the copper content showed increases upon cooking (96 % microwave cooking-12 % pressure cooking) while a small loss of 2 % on ordinary cooking. Iron content declined (20-24 %) during cooking. Increases of around 25 % were seen in manganese content of soybean due to cooking. For zinc content the losses ranged from 10-12 % during cooking.

Boiling of presoaked chickpeas (12 h) in water for 1 h resulted in a significant loss in the mineral content. The losses amounted[20] to 38 % P, 49 % K and 54 % Na. Haytowitz and Matthews[21], reported that cooking in boiling water caused losses in potassium and iron. Longe[22], observed losses of 22 % in magnesium content from mature cowpeas on pressure cooking.

Sharma[8] reported that in mung beans, cowpea, chickpea and lentils there was an increase in contents of Mn, Zn and Fe upon ordinary and pressure cooking.

Wang *et al.*[23], concluded that cooking lentils in boiling water resulted in a significant increase in Ca (14 %), Cu (10 %) and Mn (8 %).

Conclusion

Since time immemorial, legume seeds have made a significant contribution to the human diet. These are a good and inexpensive source of dietary proteins, carbohydrates, vitamins and minerals. Domestic processing like soaking, germination, cooking are used so as to enhance digestibility and nutritive value of legumes. The effects of soaking, germination (5 day period) and cooking (microwave, pressure and ordinary cooking) were studied on the minerals in soybean.

Soaking lead to significant declines in K, Ca, Mg, P and Fe content on account of their leaching into soak water. Losses during soaking are unavoidable as it is a preliminary step common to almost all methods of preparing legumes. However, soaking for a smaller duration may reduce the losses.

Germination leads to significant increases in calcium and zinc contents. Upon comparison it is observed that overall 2nd day germination is the best as the increase in calcium and zinc are high on day 2 with marginal increases in magnesium and iron and the losses in potassium and phosphorus are low on day 2.

Cooking treatments decreased the mineral content significantly the losses being highest in case of potassium and phosphorus. Microwave cooking resulted in greater retention of minerals compared to pressure cooking and ordinary cooking.

Based on these results since germination (day 2) resulted in greatest retention of all minerals as compared to cooking treatments it should be popularized as a simple process for naturally fortifying food with essential minerals. While amongst cooking treatments micro wave cooking could be suggested for soybean preparation.

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