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Effect of Domestic Processing and Cooking on the Antinutrients of Black Gram

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ABSTRACT

*Domestic processing and cooking methods including soaking, ordinary and pressure cooking of soaked and unsoaked seeds, and sprouting significantly lowered phytic acid, saponin and polyphenol contents of black gram (*Vigna mungo*) seeds. Soaking for 18 h removed 28% of the phytic acid; extents of removal were higher with longer periods of soaking. Saponins and polyphenols were relatively less affected. Loss of the antinutrients was greater when soaked instead of unsoaked seeds were cooked. Pressure cooking had a greater effect than ordinary cooking. Antinutrient concentrations declined following sprouting; the longer the period of germination the greater was the reduction. Phytic acid was reduced to a greater extent than polyphenols or saponins.*

INTRODUCTION

Dry legumes constitute one of the richest and least expensive sources of protein in the human diet in many parts of the world. Black gram (*Vigna mungo*) is one of the most important food legumes produced and consumed in India. Biological utilisation of pulses is limited due to deficient sulphur-containing amino acids (Elias *et al.*, 1964) and the presence of antinutrients. The antinutrients include phytic acid, saponins, polyphenols, enzyme inhibitors, lectins, etc. (Salunkhe, 1982). Phytic acid, widely distributed in

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food grains (de Boland *et al*; 1975) lowers the bioavailability of minerals (Davies & Nightingale, 1975; Erdman, 1979) and inhibits proteases and amylases (Singh & Krikorian, 1982; Deshpande & Cheryan, 1984). Saponins, present in significant amounts in legume grains (Oakenful, 1981; Khokhar & Chauhan, 1986; Jood *et al*, 1986), impart a bitter taste to these plant foods and cause physiological disturbances and toxicity to the human system (George, 1965). Also, saponins have been reported to cause lowering of plasma cholesterol (Cheeke, 1976; Oakenful *et al.*, 1979). Polyphenols may lower digestibility of dietary protein (Elias *et al.*, 1979; Bressani & Elias, 1980) and starch (Thompson & Yoon, 1984). Removal of these antinutrients is, therefore, necessary for effective utilisation of food legumes for human nutrition.

In India, legume grains are processed and consumed in a variety of forms, depending on cultural and taste preferences. The most common methods of processing include soaking, ordinary and pressure cooking of soaked or unsoaked seeds, and sprouting. The present investigation was undertaken to determine the extent to which the antinutritional factors survive the domestic processing and cooking treatments and finally remain in the food.

MATERIALS AND METHODS

Materials

The seeds of black gram (*Vigna mungo*) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar, India.

Processing and cooking methods

Methods of processing and cooking included soaking in water for different intervals of time, ordinary and pressure cooking of soaked as well as unsoaked seeds and sprouting of seeds.

Soaking

Seeds freed from broken seeds, dust and other foreign materials were soaked in tap water for 6, 12 and 18 h at 37°C. A seed to water ratio of 1:5 (w/v) was used. The unimbibed water was discarded. The soaked seeds were washed twice with ordinary water followed by rinsing with distilled water and then dried in a hot air oven at 70°C for 36 h.

Cooking

Seeds, after soaking for 12 h, were rinsed in distilled water and put in round-mouthed tall beakers fitted with condensers. Having added distilled water

(three times the weight of dry seeds), the samples were boiled until cooked soft, as felt between the fingers. Cooked seeds along with cooking water were dried to a constant weight at 70°C for 36 h. Unsoaked seeds were also cooked in the same manner, using a seed to water ratio of 1:7 (w/v). For pressure cooking, the seeds were autoclaved at 1·05 kg/cm^2 pressure for 5, 10 and 15 min. For this, a dry seed to cooking ratio of 1:2 (w/v) was used. The cooked samples were mashed and then dried at 70°C.

Germination

The seeds soaked for 12 h were germinated in sterile Petri-dishes lined with wet filter paper for 24, 36, 48 and 60 h at 25°C, with frequent watering. The sprouts were then dried at 70°C.

The oven-dried unprocessed as well as processed samples were milled in a cyclone mill to pass through a 0·5 mm sieve and stored in plastic containers until required for further analysis.

Chemical analysis

Phytic acid was extracted in 0·5 M nitric acid and determined colorimetrically by the method as described by Davies & Reid (1979). The method of Gestetner *et al.* (1966) was employed for extraction and colorimetric determination of saponins. Total polyphenols were extracted by the method of Singh & Jambunathan (1981) and estimated as tannic acid equivalent according to the Folin-Denis procedure (Swain & Hills, 1959).

Statistical analysis

The data were processed for the analysis of variance according to standard methods of statistical analysis (Snedecor & Cochran, 1962).

RESULTS AND DISCUSSION

Soaking

Soaking in plain water lowered phytic acid, saponin and polyphenol contents of black gram seeds significantly (Table 1). The extent of the loss increased with increase in the period of soaking. After 18 h soaking, the phytic acid, saponin and polyphenol contents of the seeds were less by 28%, 17% and 10%, respectively. Raising the time of soaking from 12 to 18 h did not affect the phytic acid content of the seed to a significant extent whereas saponins and polyphenols were further significantly reduced.

TABLE 1
Effect of Soaking on Phytic Acid, Saponin and Polyphenol Contents of Black Gram (mg/100 g, on dry weight basis)[a]

Soaking period (h)	*Phytic acid*	*Saponin*	*Polyphenols*
0	645 ± 12	3335 ± 256	866 ± 5
6	622 ± 5 (−4)	2968 ± 67 (−11)	831 ± 4 (−4)
12	438 ± 9 (−25)	2835 ± 67 (−15)	814 ± 4 (−6)
18	467 ± 26 (−28)	2768 ± 92 (−17)	780 ± 4 (−10)
CD[b] ($P < 0.05$)	16	76	10

[a] Values are means ± SD of four independent determinations. Figures in parentheses indicate per cent decrease (−) of control values.
[b] Critical difference. Differences of two means between the treatments exceeding this value are significant.

The decreases in phytate, saponin and polyphenol contents of the legume seeds during soaking may be attributed to leaching out of these antinutrients into soaking water under the influence of the concentration gradient. Similar losses of phytic acid (Ologhobo & Fetuga, 1984; Khokhar & Chauhan, 1986), saponins (Khokhar & Chauhan, 1986; Jood *et al.*, 1986) and polyphenols (Deshpande & Cheryan, 1983; Sathe & Salunkhe, 1981) during soaking have been reported earlier for different legume seeds.

Soaking, an integral part of traditional methods of processing, saving energy costs by shortening cooking time, offers an additional advantage of rendering the grains nutritionally superior by removing certain anti-nutritional factors like phytic acid, saponin and polyphenols.

Cooking

Cooking lowered phytic acid, saponin and polyphenol contents of the seeds significantly (Table 2). Pressure cooking for 15 min had a greater reducing effect for all the antinutrients. Cooking, after soaking, seemed to be more advantageous than cooking of unsoaked seeds. Phytic acid was reduced by 33% when soaked seeds were pressure-cooked whereas pressure cooking of unsoaked seeds could lower phytic acid by 8% only.

Levels of all the antinutrients decreased further when the period of pressure cooking was raised from 5 to 15 min. Of the antinutrients, phytic acid was more drastically reduced during pressure cooking than saponin or polyphenols. After 15 min of pressure cooking, the losses of saponins and polyphenols were 22% and 23%, respectively. When unsoaked seeds were pressure cooked for the same time, the loss of these antinutrients was

TABLE 2
Effect of Cooking on Phytic Acid, Saponin and Polyphenol Contents of Black Gram (mg/100 g, on dry weight basis)[a]

Cooking method	*Phytic acid*	*Saponin*	*Polyphenols*
Ordinary cooking of soaked seeds	458 ± 8 (−29)	2792 ± 193 (−18)	745 ± 10 (−14)
Ordinary cooking of unsoaked seeds	613 ± 7 (−5)	2868 ± 71 (−14)	780 ± 11 (−10)
Pressure cooking of soaked seeds			
5 min	468 ± 2 (−27)	2801 ± 73 (−16)	727 ± 8 (−16)
10 min	457 ± 11 (−29)	2701 ± 116 (−19)	701 ± 8 (−19)
15 min	435 ± 4 (−33)	2601 ± 45 (−22)	675 ± 9 (−22)
Pressure cooking of unsoaked seeds			
15 min	593 ± 18 (−8)	3001 ± 35 (−10)	753 ± 12 (−13)
CD[b] ($P < 0.05$)	16	76	10

[a] Values are means ± SD of four independent determinations. Figures in parentheses indicate per cent decrease (−) of control values.
[b] Critical difference: Differences of two means between treatments exceeding this value are significant.

relatively less. When soaked seeds were normally cooked, phytic acid was reduced by 29%, saponin by 18% and polyphenols by 14%. Pressure cooking of seeds was therefore more effective than ordinary cooking.

The apparent decrease, observed in phytic acid content of the legume seeds during cooking, may be attributed to the formation of insoluble complexes between phytate and other components (Kumar *et al.*, 1978). A reduction in phytate content after cooking of dry beans (Iyer *et al.*, 1980), moth beans (Khokhar & Chauhan, 1986), and horse gram (Borade *et al.*, 1984) has been reported earlier.

Possibly the thermolabile nature of saponins and formation of a poorly-extractable complex may account for the loss of saponin during cooking (Jood *et al.*, 1986). Reductions in saponin levels during cooking of moth bean (Khokhar & Chauhan, 1986), chickpea and black gram (Jood *et al.*, 1986) have been observed earlier.

A decreased amount of polyphenols in cooked seeds could result from their reduced extractability or change in chemical reactivity (Satwadhar *et al.*, 1981). Autoclaving and ordinary cooking, involving moist heating, may destroy polyphenols. Cooking has been reported to decrease the polyphenol contents of mung bean (Barroga *et al.*, 1985), pigeon pea and cowpea (Ekpenyong, 1985). The loss during cooking might be due to the fact that

phenols react with proteins forming poorly extractable protein phenolic complexes. The smaller loss on cooking of unsoaked seeds may be due to the fact that soaking of seeds had already removed a significant amount of antinutrients and relatively smaller amounts were left when the seeds were cooked.

Germination

Of all the processing methods, germination had the most pronounced decreasing effect on phytic acid, saponin and polyphenol contents of the legume grains. Germination of soaked seeds for 24 h reduced phytic acid, saponin and polyphenols significantly. As the germination period was raised, the concentration of these antinutrients declined further (Table 3). Phytic acid suffered a decrease of 32% after 24 h which increased up to 54% following 60 h germination. Similarly, the losses in the concentrations of saponin and polyphenols increased from 17% to 23% and 11% to 26%, respectively, when germination was prolonged from 24 to 60 h.

Loss of phytic acid during germination may be attributed to phytase activity in the germinating legume seeds as reported in faba bean (Michael Eskin & Wiebe, 1983). A decrease in phytic acid content of cowpea, soyabean and limabean (Ologhobo & Fetuga, 1984), horse gram and moth bean (Borade *et al.*, 1984; Khokhar & Chauhan, 1986) during germination has been reported.

Enzymic degradation could be a possible explanation of the saponin loss during germination, which is far from established. Loss of saponin from

TABLE 3

Effect of Germination on Phytic Acid, Saponin and Polyphenol Contents of Black Gram (mg/100 g, on dry weight basis)[a]

Germination period (h)	*Phytic acid*	*Saponin*	*Polyphenols*
0 (After 12 h soaking)	483 ± 9 (−25)	2835 ± 67 (−15)	812 ± 4 (−6)
24	439 ± 4 (−32)	2768 ± 52 (−17)	771 ± 20 (−11)
36	336 ± 7 (−48)	2668 ± 53 (−20)	727 ± 7 (−16)
48	310 ± 8 (−52)	2601 ± 28 (−22)	684 ± 40 (−21)
60	297 ± 11 (−54)	2568 ± 65 (−23)	641 ± 3 (−26)
CD[b] ($P < 0.05$)	16	76	10

[a] Values are means ± SD of four independent determinations. Figures in parentheses indicate per cent decrease (−) of control values.

[b] Critical difference: Differences of two means between treatments exceeding this value are significant.

moth bean (Khokhar & Chauhan, 1986) and chickpea (Jood *et al.*, 1986) during germination has been observed. The presence of polyphenolic oxidase may account for the loss of polyphenols during germination of food legumes (Rao & Deosthale, 1982). Germination has been shown to decrease the polyphenol contents of pigeon pea, chick pea and green gram (Rao & Deosthale, 1982; Barroga *et al.*, 1986).

Phytic acid, saponin and polyphenols, present in significant amounts in black gram and many other food legumes, are significantly reduced during domestic processing and cooking. This infers better nutritional use and more effective utilisation during human consumption of processed and cooked food legumes. Germination of legume grains seemed to be the most effective method of removing these antinutrients.

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