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Antinutrients and Protein Digestibility (*in vitro*) of Mungbean as Affected by Domestic Processing and Cooking

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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 polyphenols of mungbean (*Vigna radiata *L.) seeds. Soaking for 18 h removed 30% phytic acid and extent of removal was still higher when the period of soaking was raised. 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 more disparaging effect than ordinary cooking. An increase in the period of pressure cooking was more effective in reducing saponins and polyphenols than phytic acid. Antinutrient concentration declined and protein digestibility improved following sprouting; the longer the period of germination the greater was the reduction or the improvement. Phytic acid was reduced to a greater extent than polyphenols or saponins. Processing and cooking improved protein digestibility (*in vitro*); treatments including heat processing had the most marked effect. The greater the period of pressure cooking, the higher was the protein digestibility.*

INTRODUCTION

Food legumes are good sources of protein and continue to contribute significantly towards the protein content of the diets of people in India and other developing countries. Mungbean is one of the most important food

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legumes grown and consumed in India. The utilisation of food legumes for human nutrition is constrained due to the inherent antinutritional factors like phytate, polyphenols, saponins, protease and amylase inhibitors, lectins, etc. (Salunkhe, 1982).

For human consumption the legume grains are processed by various methods including soaking, boiling, sprouting, pressure cooking and fermentation, depending upon tradition and taste preferences. Domestic processing and cooking have been known to reduce the level of the stress factors like phytic acid (Ologhobo & Fetuga, 1984; Khokhar & Chauhan, 1986*a*; Kataria *et al.*, 1988), polyphenols (Sathe & Salunkhe, 1981; Deshpande & Cheryan, 1983; Jood *et al.*, 1987), saponins (Khokhar & Chauhan, 1986*a*; Jood *et al.*, 1986) as well as to increase protein digestibility (Satwadhar *et al.*, 1981; El Faki *et al.*, 1984; Khokhar & Chauhan, 1986*b*) of the legume grains. This paper reports the effect of common methods of domestic processing and cooking on the levels of phytic acid, polyphenols, saponins and *in vitro* protein digestibility of mungbean grains.

MATERIALS AND METHODS

Materials

The seeds of mungbean (*Vigna radiata*) 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 the seeds.

Soaking

Seeds freed from broken seeds, dust and other foreign materials were soaked in 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 to a constant weight.

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 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, dry seeds to water ratios of 1:2 (w/v) were 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 0·3M nitric acid and determined colorimetrically by the method 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 equivalents according to the Folin–Denis procedure (Swain & Hills, 1959).

Protein digestibility (*in vitro*) was assessed by employing pepsin and pancreatin (Akeson & Stahmann, 1964). The nitrogen contents of the sample and the undigested residue were determined by the micro-Kjeldahl method (AOAC, 1980). The digested protein of the sample was calculated by subtracting residual protein from total protein of the sample.

$$\text{Protein digestibility (\%)} = \frac{\text{Digested protein}}{\text{Total protein}} \times 100$$

Statistical analysis

The data were processed for the analysis of variance according to the standard method of statistical analysis (Snedecor & Cochran, 1967).

RESULTS AND DISCUSSION

Soaking

Soaking of seeds in plain water lowered phytic acid, saponin and polyphenol of mungbean significantly (Table 1). The loss of these antinutrients increased

TABLE 1
Effect of Soaking on the Antinutrients (mg/100 g) and *in vitro* Protein Digestibility (%) of Mungbean (on dry matter basis)[a]

Soaking period (h)	*Phytic acid*	*Polyphenols*	*Saponins*	*Protein digestibility*
0	741 ± 4	808 ± 4	2848 ± 93	56·0 ± 1·4
6	644 ± 6 (−13)	784 ± 4 (−3)	2840 ± 30 (−0·3)	58·0 ± 3·3 (+4)
12	616 ± 5 (−17)	759 ± 5 (−6)	2706 ± 62 (−5)	64·2 ± 2·6 (+15)
18	519 ± 9 (−30)	721 ± 4 (−11)	2649 ± 32 (−7)	67·8 ± 1·3 (+21)
CD ($P < 0·05$)	15·6	10·0	76·2	2·4

[a] Values are means ± SD of four independent determinations.
Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

with increase in the period of soaking. Soaking for 18 h reduced phytic acid, saponin and polyphenol contents of the seeds by 30, 11 and 7%, respectively. Raising the time of soaking from 12 to 18 h did not influence saponin content of the seed to a significant extent whereas phytic acid and polyphenols were further significantly reduced.

The decrease in the level of these antinutrients of the legume seeds during soaking may be attributed to leaching out into soaking water under the concentration gradient. Similar losses of phytic acid (Ologhobo & Fetuga, 1984; Khokhar & Chauhan, 1986*a*), saponin (Khokhar & Chauhan, 1986*a*; Jood *et al.*, 1986) and polyphenols (Deshpande & Cheryan, 1983; Sathe & Salunkhe, 1981; Jood *et al.*, 1987) during soaking have been reported earlier for different legume seeds.

Soaking of the seeds in water brought about an improvement in protein digestibility which increased continuously following an increase in the period of soaking. Soaking of seeds for 18 h improved *in vitro* protein digestibility by 21% (Table 1).

The decrease in the level of the antinutrients including phytic acid and polyphenols during soaking could account for improvement of protein digestibility of the mungbeans as reported for other food legumes earlier (Boralkar & Reddy, 1985; Khokhar & Chauhan, 1986*b*).

Soaking, an integral part of traditional methods of processing and saving energy costs by shortening cooking time, thus offers an additional advantage of rendering the grains nutritionally superior by removing the anti-

nutritional factors and by improving the digestibility of proteins of the legume seeds.

Cooking

Cooking lowered phytic acid, saponin and polyphenols in the seeds significantly (Table 2). A loss of 20, 15 and 8% in phytic acid, polyphenols and saponin, respectively, was observed when the soaked mungbean seeds were ordinarily cooked. The loss of phytic acid and polyphenols was significantly ($P < 0.05$) less when unsoaked instead of soaked seeds were cooked. Seeds ordinarily cooked after soaking or without soaking did not have significantly different levels of saponin. The reducing effect on the antinutrients was relatively higher when the seeds were pressure cooked (15 min). Phytic acid, polyphenols and saponins were reduced by 25, 23 and

TABLE 2
Effect of Cooking on the Antinutrients (mg/100 g) and *in vitro* Protein Digestibility (%) of Mungbean (on dry matter basis)[a]

Cooking method	*Phytic acid*	*Polyphenols*	*Saponins*	*Protein digestibility*
Ordinary cooking of soaked seeds	592 ± 6 (−20)	689 ± 7 (−15)	2 620 ± 57 (−8)	70·2 ± 0·9 (+25)
Ordinary cooking of unsoaked seeds	629 ± 7 (−15)	737 ± 4 (−9)	2 677 ± 81 (−6)	63·0 ± 2·8 (+12)
Pressure cooking of soaked seeds				
5 min	571 ± 27 (−23)	670 ± 8 (−17)	2 478 ± 53 (−13)	72·3 ± 1·6 (+29)
10 min	563 ± 4 (−24)	646 ± 4 (−20)	2 364 ± 33 (−17)	77·8 ± 2·8 (+39)
15 min	556 ± 9 (−25)	622 ± 7 (−23)	2 278 ± 67 (−20)	83·0 ± 4·2 (+48)
Pressure cooking of unsoaked seeds				
15 min	608 ± 12 (−18)	720 ± 10 (−11)	2 620 ± 92 (−8)	71·2 ± 8·8 (+27)
Control	741 ± 4	808 ± 4	2 848 ± 93	56·0 ± 1·4
CD ($P < 0.05$)	15·6	10·0	76·2	2·4

[a] Values are means ± SD of four independent determinations.
Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

20%, respectively, when the soaked seeds were pressure cooked, whereas pressure cooking of unsoaked seeds could lower these antinutrients by 15, 9 and 6% only.

Levels of all the antinutrients except phytic acid decreased further when the period of pressure cooking was raised from 5 to 15 min. When unsoaked seeds were pressure cooked for the same time the loss of these antinutrients was relatively less. The apparent decrease in phytic acid content of the legume seeds during cooking may be partly attributed to the formation of insoluble complexes between phytate and other components (Kumar *et al.*, 1978). Possibly the thermolabile nature of saponin and formation of a poorly extractable complex (Jood *et al.*, 1986) may account for the loss of saponin during cooking. A decreased amount of polyphenols in cooked seeds could result from reduced extractability due to their changed chemical reactivity (Satwadhar *et al.*, 1981). Autoclaving and ordinary cooking involving moist heating may also destroy polyphenols. Less antinutrient lowering effect of cooking of unsoaked seeds may be due to the fact that soaking of seeds had already removed a significant amount of antinutrients from the grains and relatively smaller amounts were left when the soaked seeds were cooked.

Ordinarily cooked seeds of mungbean had better protein digestibility than unsoaked and soaked seeds. As is evident from Table 2 the protein digestibility was higher when soaked instead of unsoaked seeds were cooked. The protein digestibility improved considerably when the soaked seeds were pressure-cooked for 5 min. The digestibility of protein increased continuously following an increase in the period of pressure cooking. The values of protein digestibility of ordinarily cooked seeds, of soaked seeds pressure-cooked for 5 min and of unsoaked seeds pressure-cooked for 15 min were almost similar. The increase in the protein digestibility of legumes on cooking and autoclaving may be due to the destruction of trypsin inhibitor and through denaturation.

Germination

Germination of soaked seeds for 24 h reduced phytic acid, saponin and polyphenols, significantly ($P < 0{\cdot}05$). As the period of germination was raised, the concentration of these antinutrients declined further (Table 3). Phytic acid witnessed a decrease of 27% after 24 h which moved up to 38% following 60 h germination. Similarly, the loss in the concentration of saponin and polyphenols rose from 4 to 20% and 13 to 19%, respectively, when the germination was prolonged from 24 to 60 h. Loss of phytic acid during germination may be attributed to phytase activity in germinating mungbean seeds (Mandal *et al.*, 1972). A decrease in phytic acid content of

TABLE 3
Effect of Germination on the Antinutrients (mg/100 g) and *in vitro* Protein Digestibility (%) of Mungbean (on dry matter basis)[a]

Germination period (h)	*Phytic acid*	*Polyphenols*	*Saponins*	*Protein digestibility*
24	541 ± 21 (−27)	702 ± 50 (−13)	2734 ± 53 (−4)	70·2 ± 1·4 (+25)
36	503 ± 18 (−32)	695 ± 20 (−14)	2649 ± 32 (−7)	75·5 ± 2·7 (+35)
48	489 ± 6 (−34)	686 ± 10 (−15)	2534 ± 55 (−11)	78·8 ± 1·3 (+41)
60	459 ± 6 (−38)	656 ± 11 (−19)	2278 ± 104 (−20)	80·7 ± 2·0 (+44)
Control	741 ± 4	808 ± 4	2848 ± 93	56·0 ± 1·4
CD ($P < 0·05$)	15·6	10	76·2	2·4

[a] Values are means ± SD of four independent determinations.
Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

mungbean (Abdullah *et al.*, 1984), cowpea, limabean (Ologhobo & Fetuga, 1984), horse gram and moth bean (Borade *et al.*, 1984; Khokhar & Chauhan, 1986*a*) during germination has been reported earlier.

Enzymic degradation could be a possible explanation of the saponin loss during germination which is far from established. Loss of saponin from moth bean (Khokhar & Chauhan, 1986*a*) and chickpea (Jood *et al.*, 1986) during germination has earlier been reported from this laboratory. 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 polyphenol contents of pigeon pea, chickpea and green gram (Rao & Deosthale, 1982; Jood *et al.*, 1987).

The *in vitro* digestibility of protein of mungbean increased following germination (Table 3). There was an increase in the digestibility as the period of germination increased. The values for protein digestibility after 60 h germination were significantly higher ($P < 0·05$) than those after 24 h or 36 h germination. Germination beyond 48 h could not produce significant improvement in protein digestibility. Improvement in protein digestibility of mungbean during germination may be attributed to the modification and degradation of storage proteins. Germination has been reported to increase *in vitro* protein digestibility of soybean (Boralkar & Reddy, 1985), chickpea,

cowpea and horse gram (El Faki *et al.*, 1984) and moth bean (Subbulakshmi *et al.*, 1976; Satwadhar *et al.*, 1981; Khokhar & Chauhan, 1986*b*).

Phytic acid, saponin and polyphenols present in significant amounts in mungbean, like many other food legumes, are significantly reduced during domestic processing and cooking. This infers better nutritional value and more effective utilization of processed and cooked food legumes. Germination of legume grains seemed to be the most effective method of getting rid of these antinutrients. Germination and pressure-cooking methods produced most pronounced improvement in protein digestibility. Other methods were less effective.

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