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Effect of Processing on Flatus-Producing Factors in Legumes

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The effect of various treatments, viz., (1) soaking in plain water and sodium bicarbonate solution, (2) cooking of soaked seeds, (3) autoclaving of soaked seeds, (4) germination, and (5) frying of germinated seeds, was studied by measuring the oligosaccharide contents of five commonly grown legumes, viz., Rajmah (*Phaseolus vulgaris*), Bengal gram (*Cicer arietinium*), black gram (*Phaseolus mungo*), red gram (*Cajanus cajan*), and broad bean (*Vicia faba*). The contents of sucrose, raffinose, stachyose, and verbascose decreased under various treatments. Germination beyond 48 h resulted in complete disappearance of raffinose, stachyose, and verbascose. The 24-h germination is recommended as a reasonably good treatment for legumes for reduction of flatus production as considerable losses of raffinose, stachyose, and verbascose occur during this period.

Legumes consumed by humans in many forms are excellent sources of proteins (20–40%) and carbohydrates (50–60%) and fairly good sources of thiamin, niacin, calcium, and iron (Aykroyd and Doughty, 1977). Some legumes have specific nutrient deficiencies or certain undersirable flavors, flatus factors, and antimetabolites or other toxic substances (Rachie, 1973). Legumes are notorious inducers of flatulence owing to the presence of substantial amounts of flatus-producing oligosaccharides of the raffinose family of sugars (Salunkhe, 1982). Oligosaccharides of the raffinose family of sugars (verbascose, stachyose, and raffinose) are well-known to produce flatus in man and animals (Reddy et al., 1980). Owing to the absence of enzyme (α-galactosidase) capable of hydrolyzing the α1–6 galactosidic linkage, these oligosaccharides accumulate in the lower intestine and undergo anaerobic fermentation by bacteria (Salunkhe, 1982; Gitzelmann and Aurichhio, 1965). Therefore, to utilize legumes as a more acceptable source of inexpensive proteins, it is desirable to reduce the flatulence production. Very limited data are available on the oligosaccharide contents and effects of traditional methods of processing on the oligosaccharide profile of legumes (Iyengar and Kulkarni, 1977; Rao and Balavady, 1978; Reddy and Salunkhe, 1980). The present investigations were, therefore, undertaken (i) to investigate the effect of traditional methods of processing such as soaking, cooking, autoclaving, and germination on the oligosaccharide content of selected legumes and (ii) to evolve a suitable method of processing to decrease the oligosaccharide content of commonly consumed legumes.

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Chart I. Treatments

I	soaking in plain water, A, for 6 h, and then boiling for 60 min and boiling for 45 min soaking in plain water, B, for 12 h, and then autoclaving for 30 min at 15 psi
II	soaking in sodium bicarbonate solution, A, for 6 h, and then boiling for 45 min and boiling for 30 min soaking in sodium bicarbonate solution, B, for 12 h, and then autoclaving for 20 min at 15 psi
III	germination at 24, 48, 72, and 96 h
IV	frying of 24 h germinated seeds for 10 min

MATERIALS AND METHODS

Samples of five common legumes, viz., Rajmah (*Phaseolus vulgaris*), Bengal gram (*Cicer arietinum*), black gram (*Phaseolus mungo*), red gram (*Cajanus cajan*), and broad bean (*Vicia faba*) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hissar, India.

Processing. The traditional methods of cooking legumes as given in Chart I were followed in this investigation. The samples were soaked in plain water and sodium bicarbonate solution (0.03%) for 6- and 12-h periods at 25 °C. The samples thus soaked were cooked by boiling in 4 times water by weight and autoclaving at 15 psi in double the amount of water for the time specified in Chart I. The soak water was decanted before cooking. The samples to be germinated were surface sterilized with 1% sodium hypochlorite solution, washed thoroughly with distilled water, placed at 30 °C on a damp filter paper, and subjected to analysis at 24, 48, 72, and 96 h of germination.

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Table I. Mean ± SE of Sucrose Content (Percent) of Different Legumes[a]

treatments	legumes				
	Rajmah (red bean)	Bengal gram (chickpea)	red gram (pigeon pea)	black gram	broad bean (horsebean)
raw	1.58 ± 0.09	1.30 ± 0.06	1.25 ± 0.21	1.40 ± 0.10	1.20 ± 0.20
soaking					
6-h soaking in plain water	1.48 ± 0.5 (−7%)	1.02 ± 0.06 (−23%)	1.16 ± 0.06 (−7%)	1.10 ± 0.09 (−22%)	0.99 ± 0.20 (−18%)
6-h soaking in $NaHCO_3$ solution	1.37 ± 0.05 (−14%)	1.00 ± 0.05 (−23%)	1.11 ± 0.03 (−11%)	0.92 ± 0.02 (−34%)	0.96 ± 0.05 (−20%)
12-h soaking in plain water	1.23 ± 0.06 (−22%)	0.73 ± 0.07 (−50%)	1.00 ± 0.05 (−20%)	0.54 ± 0.09 (−61%)	0.53 ± 0.01 (−56%)
12-h soaking in $NaHCO_3$ solution	1.19 ± 0.07 (−25%)	0.70 ± 0.06 (−51%)	0.80 ± 0.03 (−36%)	0.40 ± 0.02 (−69%)	0.48 ± 0.03 (−60%)
soaking and cooking					
6-h soaking in plain water and cooking for 60 min	0.75 ± 0.06 (−53%)	0.48 ± 0.02 (−69%)	0.40 ± 0.00 (−68%)	0.35 ± 0.01 (−75%)	0.45 ± 0.04 (−63%)
6-h soaking in $NaHCO_3$ solution and cooking for 45 min	0.73 ± 0.08 (−54%)	0.40 ± 0.01 (−79%)	0.36 ● 0.01 (−71%)	0.28 ± 0.02 (−80%)	0.36 ± 0.01 (−70%)
12-h soaking in plain water and coong for 45 min	0.67 ± 0.00 (−58%)	0.35 ± 0.00 (−73%)	0.30 ± 0.10 (−76%)	0.25 ± 0.00 (−82%)	0.30 ± 0.00 (−75%)
12-h soaking in $NaHCO_3$ solution and cooking for 30 min	0.59 ± 0.03 (−63%)	0.28 ± 0.00 (−78%)	0.23 ± 0.01 (−80%)	0.20 ± 0.00 (−85%)	0.19 ± 0.00 (−83%)
soaking and autoclaving					
12-h soaking in plain water and autoclaving at 15 psi for 30 min	0.46 ± 0.02 (−71%)	0.25 ± 0.00 (−81%)	0.20 ± 0.00 (84%)	0.17 ± 0.01 (−88%)	0.14 ± 0.00 (−89%)
12-h soaking in $NaHCO_3$ solution and autoclaving at 15 psi for 20 min	0.30 ± 0.00 (−81%)	0.20 ± 0.01 (−84%)	0.16 ± 0.01 (−87%)	0.14 ± 0.00 (−90%)	0.10 ± 0.00 (−91%)
germination					
24-h germination	1.57 ± 0.06 (−1%)	1.29 ± 0.05 (−1%)	1.25 ± 0.15 (−0%)	1.39 ± 0.10 (−1%)	1.20 ± 0.25 (−0%)
48-h germination	1.60 ± 0.05 (+1%)	1.32 ± 0.00 (+2%)	1.29 ± 0.02 (+3%)	1.44 ± 0.09 (+3%)	1.29 ± 0.19 (+8%)
72-h germination	1.70 ± 0.04 (+8%)	1.54 ± 0.06 (+19%)	1.31 ± 0.04 (+5%)	1.54 ± 0.02 (+10%)	1.46 ± 0.08 (+22%)
96-h germination	1.89 ± 0.00 (+20%)	1.64 ± 0.00 (+26%)	1.56 ± 0.06 (+25%)	1.84 ± 0.04 (+32%)	1.79 ± 0.00 (+49%)
24-h germination and 10-min frying	1.22 ± 0.06 (−24%)	0.99 ± 0.02 (−30%)	1.00 ± 0.01 (−20%)	0.94 ± 0.02 (−33%)	0.99 ± 0.01 (−24%)

[a] CD at 5%; pulses = 0.0338; treatments = 0.0609. Values in parenthesis indicate the percent loss or gain under different treatments. Values given in the table are the mean values of quadruplicate analyses.

Table II. Mean ± SE of Raffinose Content (Percent) of Different Legumes[a]

treatments	legumes				
	Rajmah (red bean)	Bengal gram (chickpea)	red gram (pigeon pea)	black gram	broad bean (horse bean)
raw	0.89 ± 0.05	1.09 ± 0.05	1.00 ± 0.00	0.78 ± 0.00	0.96 ± 0.05
soaking					
6-soaking in plain water	0.80 ± 0.01 (−10%)	0.92 ± 0.09 (−16%)	0.80 ± 0.08 (−20%)	0.76 ± 0.05 (−4%)	0.83 ± 0.05 (−11%)
6-h soaking in $NaHCO_3$ solution	0.76 ± 0.02 (−14%)	0.84 ± 0.10 (−21%)	0.65 ± 0.02 (−35%)	0.66 ± 0.05 (−15%)	0.81 ± 0.02 (−12%)
12-h soaking in plain water	0.56 ± 0.02 (−37%)	0.80 ± 0.08 (−23%)	0.60 ± 0.01 (−40%)	0.58 ± 0.00 (−26%)	0.70 ± 0.00 (−25%)
12-h soaking in $NaHCO_3$ solution	0.55 ± 0.00 (−38%)	0.75 ± 0.06 (−30%)	0.58 ± 0.00 (−42%)	0.50 ± 0.00 (−36%)	0.65 ± 0.00 (−30%)
soaking and cooking					
6-h soaking in plain water and cooking for 60 min	0.54 ± 0.03 (−40%)	0.60 ± 0.01 (−45%)	0.50 ± 0.01 (−50%)	0.40 ± 0.01 (−49%)	0.50 ± 0.02 (−46%)
6-h soaking in $NaHCO_3$ solution and cooking for 45 min	0.49 ± 0.00 (−45%)	0.52 ± 0.01 (−52%)	0.45 ± 0.00 (−55%)	0.39 ± 0.00 (−50%)	0.44 ± 0.01 (−52%)
12-h soaking in plain water and cooking for 45 min	0.45 ± 0.00 (−50%)	0.40 ± 0.01 (−63%)	0.36 ± 0.00 (−64%)	0.20 ± 0.04 (−74%)	0.33 ± 0.02 (−63%)
12-h soaking in $NaHCO_3$ solution and cooking for 30 min	0.39 ± 0.00 (−56%)	0.29 ± 0.00 (−72%)	0.28 ± 0.01 (−72%)	0.16 ± 0.01 (−79%)	0.28 ± 0.00 (−70%)
soaking and autoclaving					
12-h soaking in plain water and autoclaving at 15 psi for 30 min	0.33 ± 0.01 (−63%)	0.20 ± 0.00 (−81%)	0.20 ± 0.01 (−81%)	0.10 ± 0.00 (−87%)	0.15 ± 0.01 (−84%)
12-h soaking in $NaHCO_3$ solution and autoclaving at 15 psi for 20 min	0.20 ± 0.02 (−77%)	0.14 ± 0.01 (−86%)	0.12 ± 0.01 (−88%)	0.08 ± 0.01 (−89%)	0.09 ± 0.00 (−89%)
germination					
24-h germination	0.79 ± 0.02 (−17%)	0.95 ± 0.06 (−13%)	0.59 ± 0.03 (−41%)	0.35 ± 0.03 (−55%)	0.28 ± 0.00 (−70%)
48-h germination	0.50 ± 0.01 (−44%)	0.65 ± 0.05 (−40%)	0.49 ± 0.01 (−51%)	0.30 ± 0.01 (−62%)	0.22 ± 0.01 (−76%)
72-h germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
96-h germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
24-h germination and 10-min frying	0.62 ± 0.03 (−30%)	0.79 ± 0.08 (−28%)	0.48 ± 0.04 (−52%)	0.30 ± 0.04 (−62%)	0.21 ± 0.01 (−78%)

[a] CD at 5%; pulses = 0.0174; treatments = 0.0291. Values in parentheses indicate the percent loss under different treatments. Values given in the table are mean values of quadruplicate analyses.

Table III. Mean ± SE of Stachyose Content (Percent) of Different Legumes[a]

treatments	legumes				
	Rajmah (red bean)	Bengal gram (chickpea)	red gram (pigeon pea)	black gram	broad bean (horsebean)
raw	1.62 ± 0.04	1.18 ± 0.09	2.45 ± 0.02	0.80 ± 0.03	0.75 ± 0.05
soaking					
6-h soaking in plain water	1.50 ± 0.03 (−8%)	1.10 ± 0.03 (−7%)	2.26 ± 0.05 (−9%)	0.75 ± 0.02 (−6%)	0.69 ± 0.04 (−8%)
6-h soaking in $NaHCO_3$ solution	1.39 ± 0.02 (−14%)	1.00 ± 0.04 (−9%)	2.12 ± 0.03 (−14%)	0.73 ± 0.01 (−9%)	0.68 ± 0.02 (−9%)
12-h soaking in plain water	0.87 ± 0.00 (−46%)	0.82 ± 0.02 (−31%)	1.90 ± 0.04 (−23%)	0.53 ± 0.01 (−34%)	0.48 ± 0.03 (−36%)
12-h soaking in $NaHCO_3$ solution	0.80 ± 0.04 (−50%)	0.74 ± 0.07 (−37%)	1.87 ± 0.06 (−24%)	0.45 ± 0.02 (−43%)	0.46 ± 0.01 (−39%)
soaking and cooking					
6-h soaking in plain water and cooking for 60 min	0.72 ± 0.05 (−56%)	0.60 ± 0.00 (−49%)	0.59 ± 0.03 (−75%)	0.35 ± 0.03 (−56%)	0.25 ± 0.00 (−67%)
6-h soaking in $NaHCO_3$ solution and cooking for 45 min	0.69 ± 0.06 (−58%)	0.58 ± 0.04 (−50%)	0.55 ± 0.04 (−77%)	0.30 ± 0.00 (−63%)	0.23 ± 0.06 (−69%)
12-h soaking in plain water and cooking for 45 min	0.61 ± 0.00 (−63%)	0.50 ± 0.02 (−57%)	0.42 ± 0.02 (−83%)	0.25 ± 0.01 (−69%)	0.19 ± 0.01 (−75%)
12-h soaking in $NaHCO_3$ solution and cooking for 30 min	0.58 ± 0.01 (−64%)	0.45 ± 0.00 (−59%)	0.40 ± 0.01 (−84%)	0.24 ± 0.02 (−70%)	0.16 ± 0.00 (−78%)
soaking and autoclaving					
12-h soaking in plain water and autoclaving at 15 psi for 30 min	0.40 ± 0.00 (−75%)	0.25 ± 0.01 (−78%)	0.30 ± 0.02 (−88%)	0.14 ± 0.00 (−83%)	0.09 ± 0.00 (−87%)
12-h soaking in $NAHCO_3$ solution and autoclaving at 15 psi for 20 min	0.35 ± 0.04 (−77%)	0.20 ± 0.00 (−83%)	0.28 ± 0.01 (−89%)	0.08 ± 0.00 (−89%)	0.08 ± 0.00 (−88%)
germination					
24-h germination	0.48 ± 0.03 (−70%)	0.56 ± 0.01 (−53%)	0.61 ± 0.04 (−75%)	0.22 ± 0.02 (−73%)	0.49 ± 0.00 (−35%)
48-germination	0.17 ± 0.00 (−89%)	0.35 ± 0.03 (−70%)	0.47 ± 0.00 (−81%)	0.18 ± 0.02 (−78%)	0.15 ± 0.02 (−80%)
72-h germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
96-germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
24-h germination and 10 min frying	0.40 ± 0.05 (−75%)	0.48 ± 0.06 (−59%)	0.57 ± 0.05 (−77%)	0.21 ± 0.00 (−74%)	0.36 ± 0.02 (−52%)

[a] CD at 5%; pulses = 0.0170; treatment = 0.0285. Values in parentheses indicate the percent loss under different treatments. Values given in the table are the mean vaues of quadruplicate analyses.

Table IV. Mean ± SE of Verbascose Content (Percent) of Different Legumes[a]

treatments	legumes				
	Rajmah (red bean)	Bengal gram (chickpea)	red gram (pigeon pea)	black gram	broad bean (horse bean)
raw	3.26 ± 0.19	3.41 ± 0.21	2.96 ± 0.09	3.36 ± 0.04	2.60 ± 0.04
soaking					
6-h soaking in plain water	2.92 ± 0.16 (−11%)	3.08 ± 0.29 (−10%)	2.80 ± 0.08 (−6%)	3.00 ± 0.05 (−11%)	2.15 ± 0.05 (−17%)
6-h soaking in $NaHCO_3$ solution	2.72 ± 0.08 (−17%)	2.95 ± 0.10 (−14%)	2.70 ± 0.09 (−9%)	2.86 ± 0.06 (−15%)	1.97 ± 0.06 (−24%)
12-h soaking in plain water	2.62 ± 0.09 (−20%)	2.45 ± 0.20 (−28%)	2.00 ± 0.08 (−33%)	2.75 ± 0.01 (−18%)	1.60 ± 0.00 (−39%)
12-h soaking in $NaHCO_3$ solution	2.50 ± 0.06 (−23%)	2.20 ± 0.15 (−36%)	1.85 ± 0.10 (−38%)	2.50 ± 0.05 (−26%)	1.50 ± 0.03 (−42%)
soaking and cooking					
6-h soaking in plain water and cooking for 60 min	2.00 ± 0.00 (−39%)	0.85 ± 0.00 (−75%)	1.13 ± 0.00 (−62%)	1.70 ± 0.00 (−50%)	0.62 ± 0.02 (−76%)
6-h soaking in $NaHCO_3$ solution and cooking for 45 min	1.80 ± 0.05 (−42%)	0.69 ± 0.02 (−79%)	1.00 ± 0.01 (−66%)	1.60 ± 0.00 (−53%)	0.55 ± 0.01 (−79%)
12-h soaking in plain water and cooking for 45 min	1.08 ± 0.00 (−69%)	0.28 ± 0.02 (−92%)	0.52 ± 0.01 (−82%)	0.13 ± 0.00 (−66%)	0.45 ± 0.01 (83%)
12-h soaking in $NaHCO_3$ solution and cooking for 30 min	0.90 ± 0.03 (−72%)	0.25 ± 0.01 (−93%)	0.52 ± 0.03 (−82%)	0.98 ± 0.01 (−70%)	0.39 ± 0.00 (−85%)
soaking and autoclaving					
12-h soaking in plain water and autoclaving at 15 psi for 30 min	0.59 ± 0.01 (−82%)	0.19 ± 0.01 (−95%)	0.28 ± 0.01 (−91%)	0.68 ± 0.02 (−80%)	0.25 ± 0.01 (−90%)
12-h soaking in $NaHCO_3$ solution and autoclaving at 15 psi for 20 min	0.55 ± 0.02 (−83%)	0.17 ± 0.00 (−96%)	0.24 ± 0.02 (−92%)	0.58 ± 0.03 (−83%)	0.23 ± 0.00 (−91%)
germination					
24-germination	0.39 ± 0.02 (−88%)	0.87 ± 0.01 (−75%)	0.96 ± 0.03 (−68%)	0.30 ± 0.02 (−91%)	0.88 ± 0.04 (66%)
48-germination	0.25 ± 0.04 (−92%)	0.29 ± 0.02 (−91%)	0.17 ± 0.02 (−94%)	0.23 ± 0.02 (−93%)	0.16 ± 0.00 (−94%)
72-h germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
96-germination	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)	0.00 (−100%)
24-h germination and 10-min frying	0.28 ± 0.04 (−98%)	0.50 ± 0.01 (−85%)	0.80 ± 0.02 (−73%)	0.30 ± 0.00 (−78%)	0.56 ± 0.02 (−78%)

[a] CD at 5%; pulses = 0.0107; treatments = 0.0064. Values in parentheses indicate the percent loss under different treatments. Values given in the table are mean values of quaruplicate analyses.

The 24 h germinated samples were shallow fried for 10 min in hydrogenated vegetable oil on a naked flame. The samples thus processed were dried at 80 °C in a hot air oven until of constant weight (48 h) and ground in an electric grinder to pass through a 100-mesh sieve and stored in air tight polyethylene bottles at room temperature (25 °C) until further analysis. The oligosaccharides of the raffinose family and sucrose were estimated in the samples. The various analytical procedures used were as follows. Oligosaccharides were extracted from powdered whole legumes according to the method of Cerning and Guilbot (1973). Quantitative determination of oligosaccharides, viz., sucrose, raffinose, verbascose, and stachyose, was carried out by partition paper chromatography. Oligosaccharides were separated on Whatman No. 1 chromatographic paper by descending chromatography using propanol–ethanol–water in the ratio of 70:10:20 (Tharanathan et al., 1975). A standard sugar mixture containing sucrose, raffinose, stachyose, and verbascose was run simultaneously. The sugars were located by the end strip method and their concentrations estimated by the phenol–sulfuric acid method (Dubois et al., 1956).

RESULTS AND DISCUSSION

Observations in Table I indicate that soaking of seeds in both the mediums resulted in a decreased concentration of sucrose in each case. The extent of losses increased as the time of soaking was increased to 12 h. The present findings are similar to those reported by Silva and Braga (1982), who also observed losses in the content of oligosaccharides on soaking. On cooking of the 6 h plain water soaked and sodium bicarbonate solution soaked seeds, there was a reduction in sucrose content that was further reduced when the soaking time was increased to 12 h. The differences in the reduction of sucrose levels of 6- and 12-h soaking and cooking were significant ($P < 0.05$). After the seeds were autoclaved, the losses of sucrose content were significantly higher than those of other treatments.

In subsequent stages of germination, the increase in sucrose content was proportional to the stage of germination. After 48 h of germination, none of the oligosaccharides could be identified, which indicates that the sucrose content increased at the expense not only of starch but also of oligosaccharides of the raffinose family. During germination, the oligosaccharides of the raffinose family disappear. It may be due to the action of α-galactosidase, which cleaves selectively galactose from raffinose, stachyose, and verbascose and leaves behind sucrose. Similar results were obtained by Gupta and Wagle (1980). After the seeds were fried, the sucrose content decreased significantly ($P < 0.05$) as compared to that of the control (raw legumes), probably because of decomposition in the frying medium.

The raffinose, stachyose, and verbascose contents of the legumes are given in Tables II, III, and IV, respectively. After being soaked, the raffinose, stachyose, and verbascose content of pulses decreased proportionately with the time of soaking, the reduction being significantly ($P < 0.05$) higher in sodium bicarbonate solution soaked seeds as compared to the plain water soaked seeds, both at 6- and 12-h soaking. Significantly ($P < 0.05$) higher losses of raffinose and stachyose were found when the soaked seeds were cooked. These were further reduced significantly ($P < 0.05$) on autoclaving. On germination, raffinose, stachyose, and verbascose could only be detected up to 48 h of germination; in subsequent stages these three sugars completely disappeared. On frying of 24 h germinated seeds, the decrease in the content of these three sugars were significantly ($P < 0.05$) more as compared to that of 24 h germinated seeds. These results are in agreement with those of Reddy and Salunkhe (1980) but contradictory to the results of Rao and Balavady (1978), who observed complete disappearance of two sugars, stachyose and raffinose, after 72 h. The germinated seeds of black gram were found to produce low flatulence when fed to rats (Reddy et al., 1980). The low flatus produced is thus attributed to about 90% reduction in stachyose and verbascose contents. One interesting observation was that during the first 24 h of germination, maximum reduction was observed in the levels of verbascose followed by stachyose and raffinose. This may be due to the reason that galactosidase during germination first attacks verbascose followed by stachyose and raffinose.

Thus, it may be concluded that soaking for 12 h in plain water or sodium bicarbonate solution followed by autoclaving causes the losses of raffinose, stachyose, and verbascose to the extent of 60–90%, 75–90%, and 80–96%, respectively. Soaking in plain water may be preferable to that in sodium bicarbonate solution because of susceptibility of some vitamins of the B complex group to alkali, particularly thiamin and riboflavin, which are known to be destroyed slowly in alkaline medium at room temperature (Swaminathan, 1974). Sprouting for 24 h also causes considerable losses of these three oligosaccharides. In addition, it also results in better digestibility and increased ascorbic acid, niacin, and available iron contents as reported by Barnerjee and Banerjee (1950).

Registry No. Sucrose, 57-50-1; raffinose, 512-69-6; stachyose, 470-55-3; verbascose, 546-62-3.

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