

Changes of α -galactoside content during soaking and cooking of peas

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SUMMARY. During soaking, the weight of six samples of Czech grain peas increased by 70–94 %, during combined soaking and cooking by 93–128 %. The content of α -galactosides decreased in the average by 17.15 % of the original amount during soaking, and by 31.2–40.7 % during combined soaking and cooking. The greatest losses were observed, when soaking was replaced by short cooking, followed by removal of water, and continuation of cooking in fresh water. Losses of oligosaccharides were in the order: sucrose > verbascose > stachyose > raffinose.

KEYWORDS: α -galactosides; oligosaccharides; peas; cooking

Peas, similarly to other grain legumes, contain undigestible oligosaccharides, mainly α -galactosides [1]. Their content is rather high in sown peas: 3–16 g.kg⁻¹ raffinose, 22–55 g.kg⁻¹ stachyose, 22 g.kg⁻¹ verbascose in the average, i. e. 47–113 g.kg⁻¹ total α -galactosides.

They are not cleaved by digestive enzymes in man and other mammals [2], but on the contrary, they are cleaved by enzymes of intestinal microflora with formation of lower fatty acids; gases, such as hydrogen, methane and carbon dioxide are formed as the by-products. These gases cause flatulence, which is the main reason, why the legume consumption declines in affluent countries. In a sociological search [3], the presence of flatulent factors was the objection against legumes in 32 % responses. However, other factors than α -galactosides are also present in legumes as the flatulence observed in rats was in no simple relation to the content of α -galactosides [4]. Hemicelluloses [5], resistant starch or other components [6] may contribute

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to it. Sathe [7] expressed some doubts on the importance of α -galactosides to the flatulence. Factors stimulating the intestinal microflora could have pronounced effect, too [8].

The annual consumption of legumes is low in Central Europe - about 2 kg of total legumes per capita, which is equivalent to 0.25–0.35 g of total α -galactosides daily, and such an amount would not cause digestive troubles. The problem is that legumes are not consumed daily in only small amounts, but only a few times a month in relatively large amounts (50–100 g portions, expressed as dry seeds), which already usually cause digestive troubles in most consumers.

The above (calculated) amount of α -galactosides does not, however, correspond with the total amount really consumed. Considerable losses may occur during food preparation, especially, if legumes are consumed fermented or germinated. In Central Europe, they are usually consumed after soaking and cooking. If the soaking water and water used for boiling legumes are not removed before the consumption, losses of α -galactosides are relatively low, for instance, in black gram [9]. On the contrary, about 70–80 % raffinose were removed after soaking for 18 h at 2 °C, and subsequent cooking for 90 min at 100 °C, if water had been removed [10].

About 72.2 % raffinose was lost during the preparation of lentils [11]. Reduction of α -galactoside content by 45–100 % was reported during soaking of lentils [12]. High losses occurred in the process of soaking chickpeas, kidney beans and lentils [13], while cooking reduced the content of sugars only in case of kidney beans; the cooking conditions play here obviously an important role.

In peas produced in Czechia, soaking losses alone were 36 %, and further 47 % were removed on cooking [14]. The water intakes during cooking were lower in peas [14] than in lentils [15]. Soaking in sodium bicarbonate solution produced higher losses of α -galactosides [16], but the alkaline medium enhanced destruction of vitamin B₁. Stachyose and verbascose were substantially removed from cowpeas during soaking and cooking [17]. The above data show some differences in observed changes, due to material studied, and methods of food preparation, but generally, losses were not negligible.

In our previous experiments on lentils [18], we studied the effect of soaking and cooking on water intake and on the texture of cooked lentils. In this paper, we used a similar method for sown peas, measuring the weight intake, and at the same time, we determined changes of α -galactosides.

Material and methods

Material

Sown peas produced in Czechia (the cultivars Lantra - green grains, and Komet - yellow grains) were collected from three different experiment stations. They belonged to common Czech cultivars [19] in 1997. Raffinose and stachyose were produced by Sigma-Aldrich Chemie (Prague, Czech Republic). The oligosaccharide contents in the experimental samples are given in the Tab. 1.

TABLE 1. Content of oligosaccharides in pea samples used in the experiments [g.kg⁻¹ of dry matter].

TABULKA 1. Obsah oligosacharidů ve vzorcích hrachů použitých v pokusech [g.kg⁻¹ sušiny].

Saccharides ¹	Verbascose ²	Stachyose ³	Raffinose ⁴	Sucrose ⁵
Maximum value ⁶	30.1	36.1	14.7	39.7
Minimum value ⁷	16.4	25.4	9.4	26.4
Mean value ⁸	24.7	28.4	12.1	30.9
Standard deviation ⁹	5.3	4.3	3.4	2.7

1 - sacharidy, 2 - verbaskóza, 3 - stachyóza, 4 - rafinóza, 5 - sacharóza, 6 - maximální hodnota, 7 - minimální hodnota, 8 - průměrná hodnota, 9 - směrodatná odchylka.

Analytical methods

Dry matter was determined by drying at 105 °C. Oligosaccharides were extracted from 2 g of finely ground seeds with 20 ml of 80 % aqueous ethanol. The suspension was refluxed for 1 h, the content transferred into a 200 ml volumetric flask, which was then filled to the volume with distilled water. The sample was filtered before the analysis.

Oligosaccharides were determined in the extract using high-performance liquid chromatography (HPLC) with use of a method proposed by Kvasnička et al. [14], with the following modifications: column 8 mm x 250 mm, packed with OSTION LGKS 0800 Na⁺ (Tessek Ltd., Prague, Czechia); liquid chromatograph HP 1050 (Hewlett-Packard, Waldbronn, Germany); micropump LCP 4000 (ECOM, Prague, Czechia); autosampler HP 1050 (Hewlett-Packard, Waldbronn, Germany); refractometer detector HP 1047A (Hewlett-Packard, Waldbronn, Germany); injected volume: 20 µl; inlet pressure 1.8 MPa; mobile phase: redistilled water; flow rate: 0.4 ml.min⁻¹;

column temperature: 80 °C; identification: retention times (10.2–18.9 min), compared with those of authentic reference compounds; calibration with external standards. The detection limits were 6.0–13.9 mg.l⁻¹.

Cooking Procedures

Procedure A - soaking. 100 g of air-dried peas were soaked in 300 ml of tap water for 12 h at room temperature (20–22 °C). The soaking liquid was discarded, swollen peas were drained off on a sieve for 30 s, and weighted immediately.

Procedure B - soaking and cooking with fresh water. The soaking operation was the same as in the Procedure A. The soaked peas were transferred into a stainless steel pot, 300 ml of fresh water were added, the pot covered, and the content gently boiled for 35 min. The cooking liquid was discarded, peas drained off on a sieve for 30 s, and weighted immediately.

Procedure C - soaking and cooking in the soaking liquid. The soaking operation was the same as in the Procedure B, peas were drained off, and 80 g of soaked grains were mixed with 240 ml of soaking liquid (i. e. the absolute amount was lower, as some peas and soaking water were used for the analysis, but the peas : liquid ratio was the same as in the Procedure B). The cooking proceeded in a covered pot for 35 min as in the Procedure B, the soaking (and cooking) liquid was discarded. Cooked peas were drained as under Procedure B, and weighted immediately.

Procedure D - modified cooking. 100 g of air-dried peas were mixed with 300 ml of tap water, the pot was covered, and the content warmed up, and boiled for 2 min. The covered sample was then left to cool for 1 h, the soaking liquid was discarded, soaked grains were drained off, and weighted; 100 g of soaked peas were boiled with 300 ml of fresh tap water for 50 min, the cooking liquid was discarded, peas left to drain off on a sieve for 30 s, and weighted immediately.

All samples were frozen, and kept at -15 °C till the analysis.

Results and discussion

Weight increase during soaking and cooking of peas

All samples were processed using the above four procedures in the duplicate. The average weight increase (Tab. 2) during soaking was 84 % of the original weight of air-dried seeds. The average repeatability of weight increase of the same sample was 2 % (average difference between the duplicates). Additional weight increase of 19–28 % was observed during the sub-

sequent cooking. Only small differences were observed between the cooking procedures of the same sample, the average differences between the duplicates being 4 %, 2 %, and 3 % in the Procedures B, C, and D, respectively. Pronounced differences were observed among individual samples.

Losses in dry weight of peas during soaking and cooking are due to extraction of water-soluble components into soaking and cooking waters. The losses (Tab. 3) were only small in all procedures. They were much higher during the soaking operation than during the subsequent cooking (1.4 % and 0.2–1.0 %, respectively).

TABLE 2. Weight increase during soaking and cooking of peas (expressed as % of the original weight).

TABULKA 2. Hmotnostní přírůstek během máčení a vaření hrachu (% původní hmotnosti).

Weight increase ¹ [%]	Procedure ² A	Procedure B	Procedure C	Procedure D
Maximum value ³	94	114	128	112
Minimum value ⁴	70	93	91	91
Mean value ⁵	84	104	112	103
Standard deviation ⁶	11.2	6.7	14.1	5.9

1 - hmotnostní přírůstek, 2 - postup, 3 - maximální hodnota, 4 - minimální hodnota, 5 - průměrná hodnota, 6 - směrodatná odchylka.

TABLE 3. Losses of dry weight during soaking and cooking of peas (expressed as % of the original value).

TABULKA 3. Ztráty sušiny hrachu během máčení a vaření (% původní hodnoty).

Dry weight ¹ [%]	Procedure ² A	Procedure B	Procedure C	Procedure D
Maximum value ³	1.8	1.8	2.6	1.8
Minimum value ⁴	1.1	1.3	2.2	1.4
Mean value ⁵	1.4	1.6	2.4	1.6
Standard deviation ⁶	0.4	0.4	0.2	0.2

1 - sušina, 2 - postup, 3 - maximální hodnota, 4 - minimální hodnota, 5 - průměrná hodnota, 6 - směrodatná odchylka.

Losses of total α -galactosides during soaking and cooking of peas

The contents of total α -galactosides are shown in the Tab. 1 for original seeds, and in the Tab. 4 for processed peas. The loss during cooking slightly exceeded losses during soaking (Tab. 5). The average differences between

duplicates were 2.5 g, 2.6 g, 2.8 g, and 1.2 g for the Procedures A, B, C, and D, respectively. Substantial differences were observed among individual samples, as evident from the standard deviations. The losses of α -galactosides were of the same order as the losses of dry weight (1.8 % and 2.0 %, respectively).

TABLE 4. Content of total α -galactosides during soaking and cooking of peas
[g.kg⁻¹ of dry weight].

TABULKA 4. Obsah celkových α -galaktosidů během máčení a vaření hrachu [g.kg⁻¹ sušiny].

Galactosides ¹	Procedure ² A	Procedure B	Procedure C	Procedure D
Maximum value ³	62.8	50.4	57.8	48.6
Minimum value ⁴	46.6	32.6	37.5	34.3
Mean value ⁵	55.0	40.8	42.8	36.9
Standard deviation ⁶	5.5	5.7	6.7	4.9

1 - galaktosidy, 2 - postup, 3 - maximální hodnota, 4 - minimální hodnota, 5 - průměrná hodnota, 6 - směrodatná odchylka.

TABLE 5. Losses of α -galactosides during soaking and cooking of peas
[% of the original value].

TABULKA 5. Průměrné ztráty α -galaktosidů během máčení a vaření hrachu
[% původní hodnoty].

Galactosides ¹	Procedure ² A	Procedure B	Procedure C	Procedure D
Maximum value ³	19.9	37.2	31.2	40.5
Minimum value ⁴	14.3	37.1	31.2	40.4
Mean value ⁵	17.2	37.2	31.2	40.5
Standard deviation ⁶	3.0	0.1	0.02	0.02

1 - galaktosidy, 2 - postup, 3 - maximální hodnota, 4 - minimální hodnota, 5 - průměrná hodnota, 6 - směrodatná odchylka.

Changes of individual α -galactosides during soaking and cooking

Average losses of individual polysaccharides are shown in the Tab. 6. Losses of the most important α -galactosides were similar during soaking (about 28 % of the original contents), while the loss of sucrose was smaller (only 17.1 %). On the contrary, during combined soaking and boiling, the losses decreased in the following order:

sucrose > verbascose > stachyose > raffinose.

TABLE 6. Average losses of individual oligosaccharides during soaking and cooking of peas [% of the original amount].

TABULKA 6. Průměrné ztráty jednotlivých oligosacharidů během máčení a vaření hrachu [% původních hodnot].

Procedure ¹	Verbascose ²	Stachyose ³	Raffinose ⁴	Sucrose ⁵
A	27.8	28.8	27.9	17.1
B	40.7	35.9	27.9	53.9
C	32.1	31.4	26.9	40.5
D	44.7	39.4	29.8	52.3

1 - postup, 2 - verbaskóza, 3 - stachyóza, 4 - rafinóza, 5 - sacharóza.

Conclusions

The results show that soaking and cooking can substantially reduce the content of the flatulent α -galactosides in peas.

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References

1. DESHPANDE, U. S. - DESHPANDE, S. S.: Legumes in foods of plant origin. In: Salunkhe, D. K. - Deshpande, S. S.: Foods of plant origin. New York : AVI, 1991, p. 137-300.
2. RACKIS, J. J.: Oligosaccharides of food legumes: Alpha-galactosides activity and flatus problem. In: Jeans, A. - Hodge, J.: Physiological effects of food carbohydrates. Washington, D.C. : American Chemical Society, 1975, p. 207-222.
3. DOSTÁLOVÁ, J. - POKORNÝ, J.: The legumes - the importance in human nutrition and possibilities to increase their consumption. In: Proceedings of the 11th IGWT Symposium "Commodity science and sustainable development". Vol. 2. Vienna : IGWT, 1997, p. 105-106.
4. PHILLIPS, R. D. - ABBEY, B. W.: Composition and flatulence-producing potential of commonly eaten Nigerian and American legumes. Food Chemistry, 33, 1989, p. 271-280.
5. TADDESE, K. - EASTWOOD, M. A.: Metabolism of dietary fiber component in man, assessed by breath hydrogen. British Journal of Nutrition, 40, 1978, p. 393-396.
6. STEGGERDA, F. R. - RICHARDS, E. R. - RACKIS, J. J.: Effects of various soybean products on flatulence in the adult man. Proceedings of the Society of Experimental Biology and Medicine, 121, 1996, p. 1235-1239.
7. SATHE, S. K.: The nutritional value of selected Asian pulses: chickpea, black gram, mungbean and pigeon pea. In: Nwokolo, E. - Smardt, J.: Food and feed from legumes and oilseeds. London : Chapman and Hall, 1996, p. 12-32.

8. NOWAK J. - SZCZEBIETKO, K.: Effect of homogenates and aqueous extracts from pea and soybean on gas formation by and growth of *Clostridium perfringens* of intestinal origin. *Bromatologia, Chemia i Toksykologia*, 25, 1992, p. 203-208.
9. REDDY, N. R. - BALAKRISHNA, C. V. - SALUNKHE, D. K.: Phytate phosphorus and minerals changes during germination and cooking of black gram (*Phaseolus mungo*) seeds. *Journal of Food Science*, 43, 1978, p. 540-543.
10. IYER, V. - SALUNKHE, D. K. - SATHA, S. K. - ROCKLAND, L. B.: Quick cooking beans (*Phaseolus vulgaris*). II. Phytates, oligosaccharides and antienzymes. *Qualitas Plantarum and Plant Foods in Human Nutrition*, 30, 1980, p. 45-52.
11. IYENGAR, A. K. - KULKARNI, P. R.: Oligosaccharides levels of processed legumes. *Journal of Foods Science and Technology (India)*, 14, 1997, p. 222-223.
12. VIDAL-VALVERDE, C. - FRÍAS, J. - VALVERDE, S.: Effect of processing on the soluble carbohydrate content of lentils. *Journal of Food Protection*, 55, 1992, p. 301-304, 306.
13. VIDAL-VALVERDE, C. - FRÍAS, J. - VALVERDE, S.: Changes in the carbohydrate composition of legumes after soaking and cooking. *Journal of American Dietetical Association*, 93, 1993, p. 547-550.
14. KVASNIČKA, F. - VAVROUŠOVÁ, R. - VOLDOICH, M. - KADLEC, P. - MRŠKOŠ, M. - DOLEŽAL, V.: Antinutritivní sacharidy hrachu II. Výživa a potraviny, 50, 1995, p. 3-4.
15. DOSTÁLOVÁ, J. - DIVIŠOVÁ, J. - POKORNÝ, J. - VALENTOVÁ, H. - HOUŠKA, M.: Quality assessment of cooked lentils. In: *Proceedings of the Fifth International Commodity Sciences Conference in Poznan*. Poznan : Akademia Ekonomiczna, 1996, p. 372-375.
16. ABDEL-GAWAD, A. S.: Effect of domestic processing on oligosaccharide content of some dry legume seeds. *Food Chemistry*, 46, 1993, p. 25-31.
17. AKINYELE, I. O. - AKINLOSOTU, A.: Effect of soaking, dehulling and fermentation on the oligosaccharide and nutrient content of cowpeas (*Vigna unguolata*). *Food Chemistry*, 41, 1991, p. 45-53.
18. DOSTÁLOVÁ, J. - DIVIŠOVÁ, J. - POKORNÝ, J.: Effect of soaking and cooking on water holding and sensory characteristics of cooked lentils. *Polish Journal of Food and Nutritional Sciences*, 7, 1998, p. 455-464.
19. HÁJEK, D. - MRŠKOŠ, M. - SCHWARZBACH, E.: The impact of breeding on the yield of peas (*Pisum sativum* L.) and faba beans (*Vicia faba* L.) in Czechoslovakia in the years of 1971-1990. *Rostlinná výroba*, 38, 1992, p. 185-194.

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Změny obsahu α -galaktosidů během máčení a vaření hrachu

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SOUHRN. Během máčení stoupla hmotnost u šesti vzorků českého hrachu o 70–94 %, během kombinovaného máčení a vaření o 93 % až 128 %. Obsah α -galaktosidů klesl v průměru o 17,15 % původního množství v průběhu máčení a o 31,2 % až 40,7 % při použití kombinace máčení s následným vařením. Největší úbytek oligosacharidů nastal, jestliže bylo máčení nahrazeno krátkým povařením, voda byla odstraněna a pak následovalo vaření v čerstvé vodě. Ztráty oligosacharidů klesaly v pořadí: sacharóza > verbaskóza > stachyóza > rafinóza.

Klíčová slova: α -galaktosidy; oligosacharidy; hrách; vaření