# CHEMICAL COMPOSITION OF VARIOUS PEA AND BEAN VARIETIES GROWN IN LATVIA

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**Abstract.** The research evaluated the chemical composition of various locally grown pea and bean varieties and breeding lines. The amounts of crude protein (CP), soluble protein (SIP), undegradable intake protein (UIP) and acid detergent insoluble nitrogen (ADIN) were identified for pea and bean samples grown by Priekuli State Plant Breeding Institute as well as commercial soy bean samples. A comparison of the above mentioned quality parameters was done for evaluating the opportunity to replace commercial protein rich feedstuffs with locally grown peas and beans. The highest content of crude protein in dry matter was identified in soybean meal, compared with beans and peas. Among the pea varieties and breeding lines, the highest content of CP was identified in the varieties "Bruno" and "Vitra", while among beans the best performers were "Tolea" and "Priekuļu". Soybean meal, compared with beans and peas, had a considerably greater UIP fraction ($p < 0.05$). The SIP content in dry matter in all the varieties and breeding line of beans and peas analysed was higher ($p < 0.05$) than that in soybean meal. The ADIN content in dry matter in soybean meal was higher ($p < 0.05$) than that in all the varieties and breeding lines of beans and peas. The protein of the pea variety "Bruno" (ADIN – 0.17 %) was absorbed the best, compared with beans and soybean meal, as the absorption rate of it was higher. The digestibility of peas was the same or significantly better ($p < 0.05$) than that of soybean meal, while the digestibility of soybean meal, on average, was the same or slightly lower than that of beans.

**Keywords:** crude protein, soluble protein, undegradable intake protein, acid detergent insoluble nitrogen.

## Introduction

Soybean meal is the most common protein source included in concentrate feeds for dairy cows in Latvia and in other European countries as well. The need for alternative protein sources to soybean meal, partially or fully substituted in the diets of dairy cows, is an urgent problem nowadays in farming. The use of alternative plant proteins instead of the soybean meal protein in diets for producing animals aims to reduce the extra-EU soybean import and partially substitute genetically modified organisms in the food chain. Among possible alternatives, legume grains seem interesting for dairy cow diets, because of their rapid degradation in the rumen and readily available energy [1-3]. Pulses (pea, chickpea, and bean) are an important source of food and feed proteins. They contain high amounts of lysine, leucine, aspartic acid, glutamic acid and arginine and provide well balanced essential amino acid profiles.

The research studies indicate that some functional properties of pulse proteins may be comparable to those of other frequently used proteins such as soya and whey [4]. Protein is the source of amino acids and nitrogen in feeds. It is needed by livestock for growth and milk production. Protein is also needed by rumen bacteria, which digest much of the feed for ruminant animals like cattle, sheep and goats [5]. Protein consumed by ruminants is divided into three general categories: soluble or rumen degradable or degradable intake protein (SIP), undegradable intake protein (UIP) and indigestible or acid detergent insoluble protein (ADIN) [6; 7]. SIP is available for use by the rumen microbes to make microbial protein, but UIP escapes degradation in the rumen and flows to the abomasum, where the protein is hydrolyzed to amino acids, which then can be absorbed through the wall of the small intestine into the blood [8]. The microbial protein that is formed in the rumen is a very high quality protein in that it supplies those amino acids needed by the cow. Microbial protein can provide more than 60.0 % of the total protein reaching the small intestines of the cow. SIP is converted into ammonia in the rumen. UIP, also known as by-pass protein, is not converted into ammonia in the rumen. UIP does not dissolve in the liquid of the rumen, but it is completely available (digestible) in the next compartments of the digestive tract of the cow – the abomasum and the small intestine. The content of amino acids in UIP is very important and necessary, particularly in the diets of highly productive cows. The total amount of absorbed amino acids (from the protein of feed and microorganisms) in the small intestine provides the nutritional value of a feed ration for ruminants. The technical processing of protein (e.g. heating) considerably reduces the degradability of it, as it is observed for heated soybean meal protein; in the result, the UIP fraction increases at the expense of

the SIP fraction [9; 10]. The concentration of ADIN fraction in feeds affects ruminal digestibility. Feeds with a high content of ADIN have low effective crude protein (CP) digestibility [11].

Given the fact that soybean meal is a widely used protein rich feed in the diets of dairy cows, the research aim is to compare the contents of crude protein and its fractions between various varieties of peas and beans grown for feed in Latvia and soybean meal.

## Materials and methods

The biochemical tests were done on 8 samples of locally grown average ($n = 5$) pea seeds, 11 samples of average ($n = 5$) faba bean seeds and samples of soybean meal ($n = 5$). Crude protein (LVS EN ISO 5983-2:2009), acid detergent insoluble nitrogen (Forage test method. 6:1993), soluble protein (BSN method), undegradable intake protein (calculation), digestibility (cellulase method) were identified in the present research. The average results were summarised and analysed in terms of the tests carried out in the years 2014 and 2015. Table 1 presents the varieties and breeding lines of peas and faba beans used for the biochemical tests.

Table 1

**Pea and faba bean varieties and breeding lines investigated**

| No | Pea varieties | Bean varieties | Fodder |
|---|---|---|---|
| 1 | "Bruno" | "Ada" | Soybean meal |
| 2 | "Vitra" | "Lielplatone" | - |
| 3 | "Zaiga" | "Jogevas" | - |
| 4 | "Lāsma" | "Fuego" | - |
| 5 | "Alma" | "Scirocco" | - |
| 6 | "Selga" | "Tolea" | - |
| 7 | Breeding line H-06-04-4 | "Priekuļu" | - |
| 8 | Breeding line H-86-19-3 | "Priekuļu 32" | - |
| 9 | - | "Bauskas" | - |
| 10 | - | "Valmieras" | - |
| 11 | - | Breeding line H-10-10-10 | - |

The obtained results were statistically processed and analysed. To identify the magnitude of difference among the indicators of faba beans, peas and soybean meal, the data were analysed employing a nonparametric method – the Mann-Whitney U-test [12]

$$U_i = n_1 * n_2 + \left(n_i(n_i + 1)/2\right) - \sum_{j=1}^{ni} R_{ij}\,, \tag{1}$$

where $i$ – 1, 2;
$n_1$, $n_2$ – size of the selection or the number of samples compared;
$R_{ij}$ – sum of ranks.

The smallest $U$-criteria value ($U_i$) was compared with the critical $U$-value, with a confidence interval of 95 % ($\alpha = 0.05$) [13]. The data processing was performed using the data processing program *SPSS 16.0*.

## Results and discussion

Data on the biochemical composition of varieties and breeding lines of peas and faba beans, compared with conventional dairy cows' feed, are presented in Tables 2 and 3. After processing the data, one can see that the content of crude protein (CP) among the varieties and breeding lines mostly shows significant differences ($p < 0.05$). The varieties and breeding lines, between which significant differences in the indicators are identified, are assigned the same number as presented in Table 1.

Overall, in the experiment, the highest CP content was identified in the pea variety "Bruno" (26.37 %), while the best digestibility (83.7 %) was specific to the pea breeding line H-06-04-4, compared with the other pea varieties. The highest CP content in faba beans was identified in the variety "Priekuļu" (31.36 %), while the faba bean variety "Jogevas" had the best digestibility

(81.50 %), compared with the other faba bean varieties and breeding line. The CP of soybean meal is higher than that of peas and faba beans (51.31 %), but the digestibility of it is lower (81.65 %) and shows no trend towards a significant difference, compared with the pea varieties and breeding lines. A comparison of digestibility between soybean meal and beans shows significant ($p < 0.05$) differences for a number of bean varieties and breeding line. The digestibility of soybean meal is much better.

Table 2

**Biochemical composition of pea varieties and breeding lines**

| No | Varieties and breeding lines | CP, crude protein, % in DM | ADIN, acid detergent insoluble nitrogen, % in DM | SIP, soluble protein, % in DM | UIP, undegradable intake protein, % of CP | Digestibility, % |
|---|---|---|---|---|---|---|
| 1 | "Bruno" | 26.37±0.055 $^{2,3,4,5,6,7,8}$ | 0.17±0.009 $^{2,3,4,5,6,7,8}$ | 13.93±0.045 $^{2,3,4,5,7,8}$ | 45.58±0.007 $^{2,3,4,5,6,7,8}$ | 82.00±0.141 $^{2,3,4,5,6,7,8}$ |
| 2 | "Vitra" | 25.06±0.120 $^{1,3,4,5,6,7,8}$ | 0.23±0.021 $^{1,4,5,6,7,8}$ | 12.18±0.016 $^{1,3,4,5,6,7,8}$ | 50.05±0.045 $^{1,3,4,5,6,7,8}$ | 82.5±0.071 $^{1,3,4,5,6,7,8}$ |
| 3 | "Zaiga" | 21.93±0.040 $^{1,2,4,5,6,7,8}$ | 0.28±0.021 $^{1,5,7}$ | 11.89±0.071 $^{1,2,4,5,6,7,8}$ | 43.47±0.044 $^{1,2,4,5,6,7,8}$ | 83.2±0.141 $^{1,2,4,5,6,7,8}$ |
| 4 | "Lāsma" | 20.11±0.083 $^{1,2,3,5,6,7,8}$ | 0.30±0.007 $^{1,2,5,7,8}$ | 11.32±0.007 $^{1,2,3,5,6,7,8}$ | 40.73±0.035 $^{1,2,3,5,6,7,8}$ | 83.4±0.071 $^{1,2,3,5,6,7,8}$ |
| 5 | "Alma" | 22.67±0.066 $^{1,2,3,4,6,7,8}$ | 0.37±0.007 $^{1,2,3,4,6,7,8}$ | 12.76±0.007 $^{1,2,3,4,6,7,8}$ | 40.46±0.007 $^{1,2,3,4,6,7,8}$ | 81.4±0.071 $^{1,2,3,4,6,7,8}$ |
| 6 | H-06-04-4 | 22.37±0.221 $^{1,2,3,4,5,7,8}$ | 0.28±0.028 $^{1,2,5,7}$ | 13.46±0.062 $^{2,3,4,5}$ | 38.34±0.043 $^{1,2,3,4,5,7,8}$ | 83.7±0.100 $^{1,2,3,4,5,7,8}$ |
| 7 | H-86-19-3 | 23.21±0.160 $^{1,2,3,4,5,6,7}$ | 0.35±0.007 $^{1,2,3,4,5,6}$ | 14.17±0.041 $^{1,2,3,4,5}$ | 36.7±0.007 $^{1,2,3,4,5,6,8}$ | 82.9±0.072 $^{1,2,3,4,5,6,8}$ |
| 8 | "Selga" | 18.59±0.144 $^{1,2,3,4,5,6,7,}$ | 0.27±0.007 $^{1,2,4,5,7}$ | 10.53±0.051 $^{1,2,3,4,5,6,7,8}$ | 40.93±0.022 $^{1,2,3,4,5,6,7}$ | 82.5±0.069 $^{1,2,3,4,5,6,7}$ |
| 9 | Soybean meal | 50.42±2.94 $^{1,2,3,4,5,6,7,8}$ | 2.34±0.301 $^{1,2,3,4,5,6,7,8}$ | 4.75±0.165 $^{1,2,3,4,5,6,7,8}$ | 73.1±2.560 $^{1,2,3,4,5,6,7,8}$ | 81.65±0.774 $^{2,3,4,6,7,8}$ |

Data are presented as means ± *SD* ($n = 5$ in each group).
Means with different superscript numbers ($^{1,2,3,4,5,6,7,8,9,10,11}$) are significantly different between groups ($p < 0.05$). Data were analysed by the Mann-Whitney U-test, at significance level $\alpha = 0.05$.

As shown in Tables 2 and 3, the content of protein in the bean and pea varieties and breeding lines can differ within a wide range.

The content of CP in the dry matter of soybean meal (50.42 %) is considerably ($p < 0.05$) higher than that in the dry matter of all the cultivars of beans ands peas. Among the pea varieties and breeding lines, the highest CP content was indentified in "Bruno" (26.37 %) and "Vitra" (25.06 %), while among the bean varieties in "Tolea" (31.68 %) and "Priekuļu" (31.36 %).

The content of ADIN-related protein in dry matter in "Bruno" and "Vitra" was the lowest, 0.17 and 0.23 %, respectively. Among the bean varieties, the lowest ADIN content was specific to breeding line H-10-10-10 (0.77 %) and variety "Tolea" (0.92 %). Soybean meal, compared with beans and peas, had the highest ADIN content, at 2.34 %. According to the data on ADIN contents, it means that feeding soybean meal to dairy cows results in greater protein losses in dry matter than feeding beans and peas. Soybean meal is produced by thermally processing soybeans; therefore, according to research studies by Osītis [10], one can conclude that it contributes to the formation of ADIN in feedstuffs.

The highest UIP content among the pea varieties and breeding lines was identified in "Vitra" (50.05 %) and "Bruno" (45.58 %). Among the bean varieties and breeding line, the highest UIP content was specific to "Tolea" (49.95 %) and "Valmieras" (48.29 %). Soybean meal, compared with beans and peas, had a considerably ($p < 0.05$) higher UIP content (73.01 %). This might confirm a finding of Osītis [1; 10] that the processing of soybean meal leads to a higher UIP content and a lower SIP content.

Table 3

**Biochemical composition of faba bean varieties and breeding line**

| No | Cultivar | CP, crude protein, % in DM | ADIN, acid detergent insoluble nitrogen, % in DM | SIP, soluble protein, % in DM | UIP, undegradable intake protei, % of CP | Digesti-bility % |
|---|---|---|---|---|---|---|
| 1 | "Ada" | 30.75±0.106 [2,3,4,5,6,7,8,10,11] | 1.18±0.021 [2,3,4,6,7,8,9,10,11] | 17.2± 0.074 [2,3,4,5,6,7,8,9,10,11] | 38.63±0.025 [2,3,4,5,6,7,8,9,10,11] | 79.5±0.071 [2,3,4,6,7,8,9,10,11] |
| 2 | "Lielplatones" | 29.41±0.444 [1,3,4,5,6,7] | 1.01±0.023 [1,3,4,5,6,7,10,11] | 15.62±0.032 [1,3,4,5,6,7,8,9,10,11] | 42.14±0.032 [1,3,4,5,6,7,8,9,10,11] | 79.2±0.068 [1,3,4,5,6,7,8,10,11] |
| 3 | "Jogevas" | 29.68±0.014 [1,2,4,5,6,7,8,10,11] | 1.12±0.014 [1,2,4,5,6,7,8,9,10,11] | 16.78±0.009 [1,2,4,5,6,7,8,9,10,11] | 38.35±0.016 [1,2,4,5,6,7,8,9,10,11] | 81.5±0.100 [1,2,4,6,7,9,10,11] |
| 4 | "Fuego" | 26.66± 0.379 [1,2,3,5,6,7,8,9,10,11] | 1.06±0.021 [1,2,3,5,6,9,11] | 13.45±0.036 [1,2,3,5,6,7,8,9,10,11] | 44.7±0.016 [1,2,3,5,6,7,8,9,10,11] | 77.5 ±0.076 [1,2,3,5,6,7,8,9,10,11] |
| 5 | "Scirocco" | 28.42±0.015 [1,2,3,4,6,7,8,9,10,11] | 1.21±0.028 [2,3,4,6,7,8,9,10,11] | 13.79±0.016 [1,2,3,4,6,7,8,9,10] | 45.75±0.025 [1,2,3,4,6,7,8,9,10,11] | 79.1±0.505 [2,4,6,9] |
| 6 | "Tolea" | 31.68±0.92 [1,2,3,4,5,8,9,10,11] | 0.92±0.038 [1,2,3,4,5,7,10,11] | 14.63±0.038 [1,2,3,4,5,7,8,9,10,11] | 46.95±0.029 [1,2,3,4,5,7,8,9,10,11] | 80.1±0.070 [1,2,3,4,5,7,8,9,10,11] |
| 7 | "Priekuļu" | 31.36±0.485 [1,2,3,4,5,8,9,10,11] | 1.05±0.029 [1,2,3,5,6,9,11] | 16.01±0.033 [1,2,3,4,5,6,8,9,10,11] | 43.8±0.016 [1,2,3,4,5,6,8,9,10,11] | 78.9±0.071 [1,2,3,4,6,8,9,10,11] |
| 8 | "Piekuļu 32" | 28.78±0.072 [1,3,4,5,6,7,9,11] | 0.99±0.070 [1,3,5,11] | 15.26±0.047 [1,2,3,4,5,6,7,9,10,11] | 42.53±0.008 [1,2,3,4,5,6,7,9,10,11] | 79.1±0.105 [1,2,4,6,7,9,10,11] |
| 9 | "Bauskas" | 30.20±0.704 [4,5,6,7,8,] | 0.94±0.022 [1,2,3,4,5,7,10,11] | 14.71±0.016 [1,2,3,4,5,6,7,8,10,11] | 47.24 ±0.032 [1,2,3,4,5,6,7,8,10,11] | 78.6±0.08 [1,3,4,5,6,7,8,10,11] |
| 10 | "Valmieras" | 29.18±0.416 [1,3,4,5,6,7,11] | 1.03±0.029 [1,3,5,6,9,11] | 13.52±0.025 [1,2,3,4,5,6,7,8,9,11] | 48.29±0.036 [1,2,3,4,5,6,7,8,9,11] | 79.8±0.09 [1,2,3,4,6,7,8,9,11] |
| 11 | H-10-10-10 | 29.35±0.212 [1,3,4,5,6,7,8,10] | 0.77±0.028 [1,2,3,4,5,6,7,8,9,10] | 13.70±0.071 [1,2,3,4,6,7,8,9,10] | 47.61±0.016 [1,2,3,4,5,6,7,8,9,10] | 79.8±0.149 [1,2,3,4,6,7,8,9,10] |
| 12 | Soybean meal | 50.42±2.940 [1,2,3,4,5,6,7,8,9,10,11] | 2.34±0.301 [1,2,3,4,5,6,7,8,9,10,11] | 4.75±0.165 [1,2,3,4,5,6,7,8,9,10,11] | 73.1±2.560 [1,2,3,4,5,6,7,8,9,10,11] | 81.65±0.774 [1,2,4,5,6,7,8,9,10,11] |

Data are presented as means ± *SD* ($n = 5$ in each group).
Means with different superscript numbers ($^{1,2,3,4,5,6,7,8,9,10,11}$) are significantly different between groups ($p < 0.05$). Data were analysed by the Mann-Whitney U-test, at significance level $\alpha = 0.05$.

Soybean meal, compared with beans and peas, had a considerably ($p < 0.05$) lower content of SIP – degradable intake protein (4.75 %). The highest degradable intake protein content was identified in the pea variety "Bruno" (13.93 %) and breeding line H-06-04-4 (13.46 %), while among the bean varieties and breeding line the best performers were "Ada" (17.20 %) and "Jogevas" (16.78 %). In the cow organism, SIP protein is responsible for the performance of microorganisms in the rumen and, in its turn, the supply of most energy to the cow [1; 10], which points to its role in a feed ration.

The indicator of feed digestibility is as important as the composition of feed. A high feed digestion rate increases the amount of nutrients in an animal's organism, thus providing a high overall productivity level. The digestibility of the pea breeding line H-06-04-4 (83.70 %) was considerably ($p < 0.05$) better than that of the pea variety "Lāsma" (83.40 %) and soybean meal (81.65 %). The bean varieties and breeding line, compared with soybean meal, on average, had the same or slightly worse digestibility.

The obtained results show that the varieties and breeding lines of beans and peas grown in Latvia contain the proteins necessary in feed and may be used in cow diets, replacing an equivalent amount of soybean protein.

## Conclusions

1. Soybean meal, compared with beans and peas, had the highest content of crude protein (CP). Among the pea varieties and breeding lines, the highest CP content was identified in "Bruno" and "Vitra", while among the bean varieties and breeding line in "Tolea" and "Priekuļu".
2. The fraction of ADIN protein in dry matter was significantly higher ($p < 0.05$) in soybean meal than that in beans and peas, which indicates greater losses of protein excreted from an animal's organism as unused protein. The protein of the pea variety "Bruno" (ADIN 0.17 %) is better absorbed by cows than that of peas and soybean meal.
3. Soybean meal, compared with beans and peas, had a considerably ($p < 0.05$) higher UIP fraction.
4. All the varieties and breeding lines of beans and peas, compared with soybean meal, had a considerably ($p < 0.05$) higher SIP fraction in dry matter.
5. The digestibility of most varieties and breeding lines of peas was considerably ($p < 0.05$) higher than that of soybean meal, while the digestibility of the varieties and breeding line of beans and of soybean meal was the same.

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## References

1. Osītis U. Barības līdzekļu novērtēšana atgremotāju ēdināšanā. Latvijas Lauksaimniecības konsultāciju un izglītības centrs, Latvijas Lauksaimniecības Universitāte (Evaluation of Feedstuffs in Ruminant Diets. Latvian Agricultural Advisory and Training Centre, Latvia University of Agriculture) Jelgava, 1998, pp. 48-66. (in Latvian)
2. Wilkins R.J., Jones R. Alternative Home-grown Protein Sources for Ruminants in the United Kingdom. Animal Feed Science and Technology, vol. 85, issue 1-2, 2000, pp. 23-32.
3. Volpelli L.A., Comellini M., Gozzi M., Masoero F., Moschini M. Pea (Pisum sativum) and Faba Beans (Vicia faba) in Dairy Cow Diet: Effect on Milk Production and Quality. Italian Journal of Animal Science, vol. 11, issue 2, 2012, pp. 217-222. [online] [18.02.2016]. Available at http://www.tandfonline.com/doi/full/10.4081/ijas.2012.e40.
4. Boye J., Zare F., Pletch A. Pulse Proteins: Processing, Characterization, Functional Properties and Applications in Food and Feed. Food Research International, vol. 43, issue 2, 2010, pp. 414-431.
5. Rayburn E.B. Forage Quality – Protein. 1996. [online] [07.01.2016]. Available at: http://www.wvu.edu/~agexten/pubnwsltr/TRIM/5010.html.
6. Bohnert D.W., Schauer C.S., DelCurto T. Influence of Rumen Protein Degradability and Supplementation Frequency on Performance and Nitrogen Use in Ruminants Consuming Low-quality Forage: Cow Performance and Efficiency of Nitrogen Use in Wethers. Proceedings, Western Section, American Society of Animal Science, 2001, vol. 52, pp. 305-310.
7. Block E. Rumen Microbial Protein Production: Are We Missing an Opportunity to Improve Dietary and Economic Efficiencies in Protein Nutrition of the High Producing Dairy Cow? Industry Presentation. Proceedings of High Plains Dairy Conference, 2006, pp.33-46.
8. Hopkins B.A., Whitlow L.W. Effective Use of Protein in Early Lactations Diets. 2009. [online] [11.01.2016]. Available at: https://www.cals.ncsu.edu/an_sci/extension/dairy/204D.pdf.
9. Clark J.H. Editor on board. Protein and Amino Acids. In: Nutrient Requirements of Dairy Cattle. Seventh Revised Edition. Washington, D.C: National Academy press, 2001, pp. 43-104.
10. Osītis U. Dzīvnieku ēdināšana kompleksā skatījumā. Latvijas Lauku un Konsultāciju centrs. (Animal Diets from a Complex Perspective. Latvian Rural and Advisory Centre) Jelgava, 2005, pp. 71-75. (in Latvian)

11. Chrenkova M., Čerešnakova Z., Weisbjerg M.R., Formelova Z., Polačikova M., Vondrakova M. Characterization of Proteins in Feeds according to the CNCPS and Comparison to *in situ* Parameters. Czech Journal of Animal Science, vol. 59, 2014 (6), pp. 288-295.
12. Krastiņš O. Ekonometrija: mācību grāmata augstskolām. Latvijas Republikas Centrālā statistikas pārvalde. (Econometrics: a Textbook for Universities. Central Statistical Bureau of the Republic of Latvia) Riga, 2003, 207 p. (in Latvian)
13. Arhipova I., Bāliņa S. Statistika ekonomikā un biznesā. Risinājumi ar SPSS un Microsoft Excel. (Statistics in Economics and Business. Solutions with SPSS and Microsoft Excel) Teaching aid. 2nd edition. Riga: Datorzinību centrs, 2006. 364 p. (in Latvian)