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THE KMC POTATO PROTEIN CONCENTRATE AS A SEPARATE FEED PRODUCT IN THE SEGES FEEDSTUFFS DATABASE

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Main conclusion

On the basis of fifteen samples taken from five different animal feed companies, the solanine content of the KMC Potato Protein Concentrate does not exceed 1,520 ppm.

This is confirmed by KMC's own analyses, taken over a number of years. The maximum content is around 1,500 ppm, which is far lower than the maximum level of 4,000 ppm, as indicated in the SEGES Feedstuffs Database.

The content of solanine, a productivity-inhibiting substance, varied to some extent from one batch to the next, as indicated in the animal feed companies' group average.

As a result, the KMC Potato Protein Concentrate will be set up in the SEGES Feedstuffs Database as a separate feed product, with its own data sheet and specification of the solanine content as not exceeding 1,520 ppm.

Abstract

Based on the study, it can be ascertained that the solanine content does not exceed 1,520 ppm, which is why it makes sense to create the KMC Potato Protein Concentrate as a separate feed product in the Feedstuffs Database, specifying this maximum content of solanine.

This report describes a round of analysis in which SEGES Danish Pig Research Centre, assisted by a number of animal feed companies, collected samples and conducted chemical analyses of fifteen samples of the potato protein concentrate marketed by the company KMC. The samples were taken to analyse the content of solanine and substantiate KMC's assertion that its potato protein concentrate

usually has a content of solanine (a digestion-inhibiting substance) which is far below what is specified in the Feedstuffs Database for potato protein concentrate.

On this basis, it is assessed that the KMC Potato Protein Concentrate should be set up in the SEGES Feedstuffs Database with its own data sheet. The most common nutrients usually specified in data sheets in the Feedstuffs Database were chemically analysed as well.

Background

Potato protein concentrate, also simply referred to as 'potato protein', is a dried by-product from the manufacture of potato starch derived from tubers of the potato plant (*Solanum tuberosum*). This feed product contains roughly 77% digestible crude protein with a favourable amino acid composition [1] [2] [3] and high ileal digestibility [4] [5].

In terms of nutrition, potato protein can replace a wide range of vegetable and animal protein sources, such as powdered skimmed milk, fish meal and soy protein concentrate in feed compounds for weaners [1] [5] [6] [7] [8] [9] [10] [18]. The product can contain digestion-inhibiting substances such as trypsin inhibitors (TI) and glycoalkaloids (GA). The two most prevalent glycoalkaloids in potatoes are α-Solanine and α-Chaconine [11], but usually the glycoalkaloid content is defined only as solanine.

The trypsin inhibitor content in potato protein has no practical significance for the admixture of the feed product in weaner feed, whereas the content of solanine along with its price determine the amount that should be admixed.

Solanine is a poisonous substance found in many varieties of the Solanaceae (nightshade) family, such as potatoes. Solanine tastes bitter and irritates the mucous membranes, which can inhibit appetite [12] [13] as a result. Solanine can also cause intestinal pain and diarrhoea. The amount of solanine in potato protein varies. The SEGES Feedstuffs Database indicates that the content in potato protein varies from 800 ppm to 4,000 ppm. This wide range is set up to include the extremes.

In an experiment conducted by Tuśnio et al. [14], the potato protein contained 677 ppm of solanine. In a previous trial conducted by the National Committee for Pig Production, Denmark [1], the potato protein contained 1,555 ppm and 2,975 ppm of solanine, respectively. However, an experiment conducted by Pastuszewska et al. [2] showed a vast difference in the solanine contained in the three plants that were tested, varying from 927 ppm to 2,632 ppm. Finally, another experiment detected a level of 3,030 ppm in early-weaned pigs [6].

The solanine content of green potatoes is increased significantly by exposure to light, but presumably the content is also due to differences in the quality of the potato plant [2]. Similarly, it is believed that damage to potatoes during harvest and poor storage conditions are other contributing factors [15] [16]. Moreover, KMC specifies that solanine content is affected by cultivation factors and that it differs from one potato variety to another.

A special grade of potato protein (Protastar) is currently on the market. This product is subjected to a process that removes solanine by acid treatment with subsequent extraction and decantation. This lowers the solanine content to less than 40 ppm.

According to the SEGES Feedstuffs Database, the solanine content of ready-made feed may be up to 200 ppm. This limit was found based on several experiments, including an experiment conducted by the National Committee for Pig Production, Denmark [1]. In the experiment, three groups of feed with solanine content of 0, 101 and 193 ppm, respectively, were compared. In the two groups of pigs

receiving feed containing solanine, the feed intake and daily gain registered throughout the growth period from 8 kg to 20 kg was lower than for the group whose feed contained 0 ppm of solanine.

Apparently, very young weaners have a lower solanine tolerance. In early-weaned piglets (15–20 days old), a US experiment detected adverse effects on feed intake and daily gain at a solanine level of 119 ppm in the feed [6]. This contrasts with the Danish experiment [1] involving somewhat older piglets and is supported in subsequent experiments [14] where no adverse productivity effects were detected in 15 kg piglets at a solanine content of 118 ppm in the feed. Based on the above-mentioned experiments and on a minimum weaning age in Denmark of 21 days, the recommended maximum limit for solanine content in weaner feed of 200 ppm appears reasonable.

The company KMC contacted SEGES Danish Pig Research Centre in 2020 to request that its potato protein product be set up in the SEGES Feedstuffs Database and that the product be given its own page. KMC asserted that the solanine content of its product never exceeded 1,500 ppm, as it disclosed that its product was admixed at a lower percentage than the quality shows.

As animal feed companies use the recommended maximum solanine content of 200 ppm in weaner feed and, at the same time, due to a precautionary principle, assume that potato protein has a solanine content of 4,000 ppm, the maximum content of potato protein in weaner feed is set at 5%. If the solanine content in the KMC Potato Protein Concentrate is demonstrably less than 1,500 ppm, a maximum of 5% admixture in weaner feed is unnecessarily cautious.

For this reason, a collaborative study was launched by SEGES Danish Pig Research Centre and a number of Danish animal feed companies which use this type of potato protein to examine the solanine content of the KMC Potato Protein Concentrate. The outcome of the study is described in this report.

The purpose of the round of analysis was to determine whether the solanine content in the KMC Potato Protein Concentrate is lower than in ordinary potato protein which would justify giving KMC its own data sheet in the SEGES Feedstuffs Database [17].

Materials and methods

SEGES Danish Pig Research Centre and member companies of the sector organisation DAKOFO (Association of Danish Grain and Feed Companies) maintain a feedstuffs database that is updated on an ongoing basis, such as with new analysis values for each year’s harvest.

These stakeholders have agreed on a policy whereby it is possible for new animal feed products to be included in this SEGES Feedstuffs Database upon request by a company or organisation, provided that this is deemed relevant for Danish pig producers by SEGES Danish Pig Research Centre. In such instances, the animal feed products must meet the requirements outlined in Appendix 2 by means of a sample-taking procedure.

For the case in question, which involves the content of a harmful substance (solanine) and not exclusively the content of nutrients, SEGES Danish Pig Research Centre decided to tighten the requirements. This resulted in the taking and analysis of fifteen samples from five different batches, rather than the usual requirement of five samples taken from five different batches.

The following animal feed companies took samples of the KMC Potato Protein Concentrate that were subsequently submitted for analysis: Vilofoss, Vilomix, Danish Agro, Brødr. Ewers and Hornsyld Købmandsgaard.

It was assumed that the samples taken by the five companies were taken from five different batches. Three samples of the KMC Potato Protein Concentrate were taken by each company and thus from each batch during the period from July 2020 to October 2020.

Two of the companies waited to take the third sample, as agreed with SEGES Danish Pig Research Centre, as the companies were awaiting the delivery of a new batch of the animal feed product. Having two of the five companies wait to take the third sample meant that two batches (instead of just one) were included in the sample-taking so that a total of seven different batches of the KMC Potato Protein Concentrate were included in this study.

KMC was unaware of which companies were helping SEGES Danish Pig Research Centre take samples, nor did KMC know during which period the sample were being taken.

All fifteen samples from the five animal feed companies were sent to the Grønhøj Research Station after which a technician correctly split the samples according to the principles outlined in Pierre Gy's sampling theory. The technician subsequently sent the split samples to Eurofins Steins Laboratorium A/S for chemical analysis.

Potato protein belongs to a group of animal feed products in which the EDOMi (enzyme digestible organic matter, ileum) analysis does not yield usable results due to a very high protein concentration in proportion to the volume of enzymes stipulated as being required in the analytical method. A possible solution model could be to test the diluted versions of the potato protein products marketed in Denmark, which would require the same scope of sample-taking as in this round of analysis. Until such testing is carried out, all of these products are assigned the value of 90% for EDOM and EDOMi, after which the energy content/value is calculated.

Results and discussion

Table 1 presents the analysis results concerning the solanine content of the fifteen samples of the KMC Potato Protein Concentrate. These are specified for each individual analysis result, as the mean value for each animal feed company (mean value of three analysis results), and as a mean value for all seventeen analysis results.

In addition, the company average and the mean value of all fifteen samples are specified for both solanine and the nutrients analysed (Appendix 1a and Appendix 1b).

Table 1. The solanine content of the individual samples of the KMC Potato Protein Concentrate, of the five mean values per batch (sample-taking site) and of the total mean value of the seventeen sample results.

Ingredient	Vilofoss			Vilomix		
Solanine (mg/kg = ppm). Results of the individual feed samples (three per company)	1,110	1,400	1,100	1,050	1,260	1,180
Solanine (mg/kg = ppm). Mean value of three analysis results from the same batch	1,203			1,163		
Solanine (mg/kg = ppm). Mean value of all seventeen samples from seven different batches, including the two reanalysis values	1,144 [1]					

Table 1 (cont.). The solanine content of the individual samples of the KMC Potato Protein Concentrate, of the five mean values per batch (sample-taking site) and of the total mean value of the seventeen sample results.

Ingredient	Danish Agro			Brødr. Ewers			Hornsyld Købmandsgaard		
Solanine (mg/kg = ppm). Results of the individual feed samples (3 per company)	1,000	1,030	914	1,340	1,520 1,240[a]	1,500 1,280[a]	876	857	797
Solanine (mg/kg = ppm). Mean value of 3 analysis results from the same batch	981			1,453			843		
Solanine (mg/kg = ppm). Mean value of all 17 samples from 7 different batches, including the 2 reanalysis values	1,144 [1]								

Analysis certificates issued by Eurofins Steins Laboratorium A/S indicate the results of solanine analyses in mg/100 g samples. In the table, this is recalculated to mg/kg samples, as the solanine content is normally indicated in ppm (mg/kg).

[a]) These two values are the result of reanalysis

[1]) Dispersion: +/- 228 ppm

As is apparent from Table 1, the average content of solanine in the seventeen samples taken is 1,144 ppm. KMC's assertion that solanine levels never exceed 1,500 ppm in this animal feed product is more or less supported by this round of analysis. However, the result of one of the samples is notably 1,500 ppm, whereas a single sample result exceeded this with a content of 1,520 ppm.

The table includes the original fifteen analysis results and the results of the two reanalyses for calculating the mean value, as in principle, 1,520 ppm could just as well have been the correct level as could the reanalysis result of 1,240 ppm.

The analysis certificate issued by the laboratory indicates that the measurement uncertainty for a solanine analysis result is 21%, which is relatively high. By comparison, the measurement uncertainty for crude protein is 2%.

For setting up the ingredient in the SEGES Feedstuffs Database, the value from the reanalysis will overwrite the original value so that the average solanine content will be calculated on the basis of the fifteen values and not (as in Table 1) on the basis of seventeen values. For the same reason, the solanine value for the KMC Potato Protein Concentrate indicated in the SEGES Feedstuffs Database will deviate from the mean value calculated in Table 1. There is a certain difference between the five company averages which indicates a variation in the feed product's solanine content from one batch to another. The three analysis results taken from the same batch and by the same company are relatively close to one another.

The results substantiate that the KMC Potato Protein Concentrate must be set up as a separate table value in the SEGES Feedstuffs Database with a maximum solanine content of 1,520 ppm.

The concentrations of certain micro and macro minerals detected deviated from the values previously used when the feed product Potato Protein Concentrate was set up in the SEGES Feedstuffs Database. The origin of the samples underlying the former table values is uncertain, whereas the present results were determined pursuant to contemporary requirements for sample-taking and the quality control of laboratory results.

Conclusion

Based on this round of analysis, the KMC Potato Protein Concentrate has a solanine content in the finished product of less than 1,520 ppm. This maximum content is on a par with what KMC specifies it has seen in its own quality analyses over the years. Based on this, the quality substantiates that the product is to be set up in the SEGES Feedstuffs Database with its own data sheet.

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Sabine Stoltenberg and Che-Chun Shih study Animal Science at the University of Copenhagen and took part in the sample-taking process and writing the report as trainees employed by SEGES Danish Pig Research Centre.

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Appendix 1a

Analysed content based on all fifteen samples. The solanine content also includes the two reanalysis samples, which explains the seventeen sample results on average for solanine.

Note that in this Appendix, the rough average is calculated on the basis of the individual samples' current water content. When the ingredient is set up in the SEGES Feedstuffs Database, the mean values are indicated as standardised dry matter content.

Ingredient	Expected value	Analysed value[1]
Crude protein (% of product)	77.30	77.41
Crude fat (% of product)	2.00	2.71
Crude ashes (% of product)	2.10	1.77
Water (% of product)	10	9.72
Solanine (ppm)	800–4,000 [2]	1144.35
Calcium (g/kg)	0.45	0.48
Phosphorous (g/kg)	3.87	1.75
Sodium (g/kg)	0.09	0.25
Potassium (g/kg)	6.66	5.75
Magnesium (g/kg)	0.45	0.33
Iron (mg/kg)	144	77.15
Copper (mg/kg)	9.90	46.73
Zinc (mg/kg)	18.90	26.70
Lysine (g/kg)	61.07	61.10
Methionine (g/kg)	17.60	17.93
Cysteine (g/kg)	12.37	12.85
Threonine (g/kg)	45.05	47.83
Tryptophan (g/kg)	10.07	12.17
Isoleucine (g/kg)	44.84	44.36
Leucine (g/kg)	79.63	83.68
Histidine (g/kg)	17.01	17.13
Phenylalanine (g/kg)	48.71	51.60
Tyrosine (g/kg)	44.84	44.90
Valine (g/kg)	54.89	52.54

[1] Mean value for seventeen samples of the KMC Potato Protein Concentrate, including the two reanalysis values

[2] Potato protein without source of origin varies from 800 ppm to 4,000 ppm of solanine

Appendix 1b

Analysed contents based on three samples taken per company

Ingredient	Expected value	AN content,[1] Vilofoss	AN content, Vilomix	AN content, Danish Agro	AN content, Brødr. Ewers	AN content, Hornsyld Købmandsgaard
Crude protein (% of product)	77.30	77.57	78.3	78.0	75.97	77.2
Crude fat (% of product)	2.00	2.23	2.47	2.33	2.33	4.17
Crude ashes (% of product)	2.10	1.73	1.57	1.90	1.83	1.80
Water (% of product)	10	10.3	9.17	8.87	10.17	10.07
Solanine (ppm)	800–4,000 [2]	1,203.33	1,163.33	981.30	1,453.33	843.33
Calcium (g/kg)	0.45	0.43	0.46	0.70	0.33	-
Phosphorous (g/kg)	3.87	1.45	1.43	1.54	1.58	2.74
Sodium (g/kg)	0.09	0.26	0.28	0.30	0.29	0.13
Potassium (g/kg)	6.66	6.24	5.55	6.41	6.51	4.05
Magnesium (g/kg)	0.45	0.35	0.31	0.37	0.36	0.26
Iron (mg/kg)	144	77.27	71.97	84.90	75.03	76.60
Copper (mg/kg)	9.90	50.03	49.73	47.73	39.57	46.57
Zinc (mg/kg)	18.90	29.63	26.20	26.27	23.90	27.47
Lysine (g/kg)	61.07	63.10	62.60	62.23	58.27	59.07
Methionine (g/kg)	17.60	18.10	18.37	18.3	16.80	18.10
Cysteine + cystine (g/kg)	12.37	12.97	13.03	12.60	12.93	12.73
Threonine (g/kg)	45.05	48.97	48.43	48.23	45.67	47.87
Tryptophan (g/kg)	10.07	12.37	12.23	12.27	11.63	12.37
Isoleucine (g/kg)	44.84	45.33	44.80	44.47	43.00	44.20
Leucine (g/kg)	79.63	85.47	84.57	83.93	80.83	83.60
Histidine (g/kg)	17.01	17.80	17.47	17.60	16.47	16.30
Phenylalanine (g/kg)	48.71	53.00	51.90	51.30	50.23	51.57
Tyrosine (g/kg)	44.84	45.70	45.67	45.10	43.43	44.57
Valine (g/kg)	54.89	53.60	52.90	52.47	51.43	52.30

[1] Analysed content on the basis of three samples for each company. Reanalysis values are not included in the calculated mean values for solanine in this table.

[2] The solanine content in potato protein without a source of origin varies from 800 ppm to 4,000 ppm

Appendix 2

Requirements for inclusion in the SEGES Feedstuffs Database for SEGES Danish Pig Research Centre and DAKOFO:

For the purpose of equal treatment of all participants, this standard wording has been drawn up for companies seeking to have their product(s) included in the SEGES Feedstuffs Database or to update the information for any product(s) already included in the SEGES Feedstuffs Database:
We endeavour to have well-documented values in the SEGES Feedstuffs Database for feed products of relevance to pigs. As a minimum, the documentation must include analysis results and a thorough description of what the product is made from and where the product comes from, purged of any and all undocumented claims.

Relevance of the feed product:
We must ensure that feed products which are included in the table are relevant to Denmark's pig production, which is why we request documentation to show that the product is used to a reasonable extent. We also request a copy of all experiment results and EU authorisations associated with the product and of all analysis results involving the product which you possess. Next, we request the price at which the animal feed/product will be marketed, so we can assess whether the product will be relevant in relation to competitive sources of nutrients.
When we have received this information, we will discuss the possible inclusion of the product in the SEGES Feedstuffs Database at a department meeting.

Analysis documentation:
For this, we require a minimum of five representatively taken samples that must be taken from a minimum of five different productions/batches (with documentation of this) over a period of at least three months. 'Representatively taken samples' means that all particles must have the same probability of ending up in the final sample sent to the laboratory. The samples must be taken by an independent party.

Each of these samples must be submitted using our requisition forms to Eurofins where they will be analysed for the following:

1. Dry matter, crude protein, crude fat, crude ashes, EDOM for pigs (enzyme digestible organic matter) and EDOMi (enzyme digestible organic matter (up to and including) ileum).
2. All amino acids
3. Minerals (Ca, P, Na, K, Mg, Cu, Zn, Mn and Fe)

Grounds for the choice of laboratory: SEGES Danish Pig Research Centre has very close follow-up with this laboratory, as all analysis results for us are arrived at by means of duplicate analysis, and the analyses are conducted at a reasonable price.
SEGES Danish Pig Research Centre re-invoices the analysis and sample-taking expenses to the company seeking to have its product included in the SEGES Feedstuffs Database.

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