Effect of Fresta® F Plus on ammonia emissions from finisher facilities

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Abstract

The effect of Fresta® F Plus on ammonia emissions from finisher facilities was investigated in co-operation with the Austrian company DELACON Biotechnik GmBH that produces Fresta® F Plus. The addition of 150 mg Fresta® F Plus per kg feed did not result in significant differences in ammonia emissions between the control and trial sections. Nor did the results show any significant differences in pH in the slurry.

Fresta® F Plus consists of saponins and ethereal oils, and supposedly inhibits the urease activity in pig slurry. This will reduce the transformation of the urea in the urine to ammonium ions and carbonate ions, which will then reduce pH and ammonium concentrations in the slurry resulting in a lower emission of ammonia from the pig house.

Fresta® F Plus is also supposed to improve digestibility of the feed and thereby also improve the pigs' productivity, but the trial was not designed to document improvements in productivity.

The trial was conducted in six identical sections with 32 place units each for finishers. Each section was divided into two pens. Three sections functioned as trial sections and three as control sections. The trial comprised a total of 192 pigs.

The trial was financed partly by DELACON Biotechnik GmBH and received financial support from the Pig Levy Fund and the EU and the Rural Development Programme under the Danish Ministry of Food, Agriculture and Fisheries and has project ID DSP09/10/58 and file no. 3663-D-07-00234.

Background

DELACON Biotechnik GmbH is an Austrian company that produces additives for feed to improve animal productivity or reduce the impact of livestock production on the environment. Fresta® F Plus consists of ethereal oils and saponins that supposedly increase the digestibility of feed and reduce the effect of urease in the slurry.

Several investigations have been made of a similar product called Aromex® Solid also produced by DELACON. A Spanish investigation [1] demonstrated a significantly higher digestibility of 3% of both energy and protein. Other studies, among these one conducted by Danish Pig Production [2], demonstrated a tendency to improved production results. Aromex® Solid and Fresta® F Plus contain comparable active compounds according to DELACON.

The Danish Agriculture & Food Council represents the agricultural and food industry of Denmark and is the result of a merger between the *Danish Agricultural Council, Danish Bacon and Meat Council, Danish Pig Production* and *Danish Agriculture*. The organisation also undertakes a range of key tasks for the *Danish Dairy Board*.

Agriculture and food are Denmark's largest industry and innovation grouping employing some 150,000 people and exporting agricultural products and equipment to a value of around €15 billion.

The effect on ammonia concentration in the pig facility of Aromex® ME Plus that also contains active compounds comparable with those of Fresta® F Plus was investigated in an Austrian study [3]. This trial revealed a distinct 38% reduction in ammonia concentration in the entire growth period. The concentration was measured continuously, and demonstrated a highly uniform reduction over the entire growth period. In this trial, the concentrations were recorded in the pens and not by the suction points and the ammonia emission was therefore not recorded. If it is possible to demonstrate that the reduction in ammonia concentration affects ammonia emissions, it could be financially interesting to add Aromex® ME Plus to finisher feed to reduce ammonia emissions.

The aim of this trial was to test the effect of Fresta® F Plus from the company DELACON Biotechnik GmBH on ammonia emissions under Danish production conditions. Fresta® F Plus contains active compounds comparable with those of Aromex® ME Plus, but is a less concentrated product and a 50% higher dosage is therefore required than in the Austrian study [3]. The trial was not designed to demonstrate improvements in productivity.

Materials and method

The trial was conducted in six identical sections at Experimental Station Grønhøj, which is owned by Pig Research Centre. The design of the facilities is described in Appendix 1.

The trial comprised two groups; control and trial. Three replicates (blocks) were completed, and one block consisted of a control section and a trial section. The three blocks were initiated at the same time, and the trial period ran from December to February.

When the trial began, 32 pigs, divided between female pigs and castrates, were transferred to two pens in each section. The trial thus comprised 192 pigs. The six sections were divided into three blocks of two sections each and treatments were randomised between the two sections within the block. When pigs were transferred, the animals were sorted according to size to make the blocks as identical as possible in terms of size. The pigs had ad lib access to feed and water.

The feed was optimised according to the Danish recommendations for finishers in the weight interval 30-105 kg [4]. 150 mg Fresta® F Plus per kg feed was added to the feed for the trial group. Fresta® F Plus was added via a premix consisting of 62.5% wheat bran, 30% calcium carbonate and 7.5% Fresta® F Plus. 2 kg premix per tonne of feed was mixed into the feed.

The diet was based on wheat, barley, soybean meal and rape seed cake, and was heat-treated (81°C) and pelleted. The feed was produced at Danish Agro's facilities in Janderup. The feed for the entire growth period was produced at one time, ie. the feed for both groups was produced on the same day. The trial feed was produced last at the feedstuff factory to prevent any trace of Fresta® F Plus from being mixed into the control feed.

The feed was supplied pneumatically in the same feed pipeline (feeding system from Schauer). This system blows the feed pipe line empty between each feeding, and there is therefore little risk of cross-contamination of feed between the sections.

The composition of the feed and analysed content of nutrients is shown in Appendices 2 and 3. Nutrient analyses were performed by Eurofins.

pH in slurry

Every two weeks, starting 14 days into the trial, pH in the slurry was recorded in slurry samples drawn from the slurry pit 5 cm below the slurry surface. During sampling, slurry was pumped up into a test tube through a pipe with a diameter of 1.5 cm. Three samples were taken for each pen and each sample was taken from two points in the pen as shown in Appendix 4. pH was recorded in three pooled samples, ie. from the lying area, from the middle of the pen and from the dunging area. The pH metre was calibrated before each recording day.

Composition of slurry

Slurry was emptied twice during the growth period; the first time after 45 days and the second time 44 days later when pigs finished the trial (day 89). All chambers were emptied on the same day. The depth of the slurry in the slurry pits was recorded just before they were emptied. The slurry from each section was emptied into an empty container and stirred. During stirring, two samples were taken from each section. The samples were frozen, and when the trial ended all samples were submitted to Eurofins for analyses of total nitrogen, ammonium nitrogen and pH.

Ammonia and carbon dioxide

Ammonia and carbon dioxide concentrations in the air intake and the exhaust air were recorded with a VE

18 multi sensor from VengSystem A/S. This equipment consists of pumps that via Teflon tubes pump approx. two litres of air per minute from the air intake and from the exhaust of the sections to the device analysing the content of ammonia and carbon dioxide in the air. A Polytron 1 from Dräger with a recording range of 0-50 ppm was used for recording ammonia concentration and a Vaisala with a recording range of 0-5000 ppm was used for recording carbon dioxide concentration.

A manifold installed just before the ammonia and carbon dioxide devices ensured alternating intake of air for analysis from the six sections. Air intake alternated every ten minutes, and the value recorded last was the one stored. After each recording period, outdoor air was led through the ammonia and carbon dioxide recording devices for ten minutes. The air was preheated to 34°C before it was pumped into the recording devices. The aim of these procedures was to make the operation of the ammonia sensor reliable. The manifold was imbedded in a steel case that could be heated electrically whereby the air was preheated.

Once a week in the morning, control recordings were made of the ammonia concentration with Kitigawa detection tubes.

Temperature and ventilation output
Outdoor temperature and temperature in the pig house were recorded with a VE 10 temperature sensor from VengSystem A/S. In each section, the ventilation output was recorded with a Fancom recording wing. Data on outdoor temperatures and temperatures in the pig house and ventilation output were recorded electronically. Furthermore, temperature and relative humidity were recorded with a multi meter TSI VelociCalc 8347 during control recordings of ammonia concentration in the sections.

Equipment for electronic recording of data
A BUS system was installed to which the VE18 multi sensor, temperature sensors, Fancom ventilation control and a computer were attached. New data were stored from each chamber every other hour and this process was safeguarded by computer software from VengSystem A/S.

Calculation of emissions
Previous studies demonstrated a linear correlation between handheld ammonia recordings with Kitigawa detection tubes and ammonia emissions recorded electronically with Veng equipment. The correction line between the weekly recordings made with Kitigawa and Veng was determined, and the data recorded electronically with Veng equipment was adjusted according to the correction line. Subsequently, ammonia emissions were calculated on the basis of ammonia concentration, ventilation output and the number of pigs in the section with the following equation:

$$\text{g } NH_3\text{-N/hour per pig} = \frac{M \times V \times Q \times P}{R \times T \times N \times 1{,}000}$$

M: Molar weight of N, 14.007 g/mol
V: Concentration, ppm = ml/m^3
Q: Ventilation output, m^3/hour
P: Pressure, 1 atm.
R: Gas constant, 0.0821 (litre x atm)/(mol x K)
T: Temperature in Kelvin, K
N: Pigs in the section

Statistics
pH and composition of slurry were subject to an analysis of variance with the MIXED procedure in SAS. The statistical model included group and block and the pigs' age as class variables.

Ammonia emissions were subject to an analysis of variance with the MIXED procedure in SAS. The statistical model included group and block as class variable and date as random variable.

Results and discussion
The production results were not subject to statistical calculations as the trial was designed to analyse the expected effect on ammonia emissions [3] and therefore only included three replicates, which are too few to test effects on productivity. The pigs had an average weight of 28.3 kg when the trial began and 111.9 kg by the end of the trial. The average production results are shown in Appendix 5.

Feed analyses
The analysed content of nutrients of the diets is shown in Appendix 3. The analysed protein content corresponded well with the guaranteed content in both diets.

It was not possible to analyse for the content of Fresta® F Plus as the product consists of several compounds, for instance ethereal oils and saponins. DELACON Biotechnik GmbH received two blinded feed samples taken during production of the feed according to the Theory of Sampling principle [5] at the feed-

stuff factory. DELACON analysed the content of carvon in the feed samples via gas chromatography with mass spectrometric detection (GC-MS). Carvon is the main ethereal oil in Fresta® F Plus. In the trial feed, they found 0.45 µg/g (= 0.45 mg/kg) feed in which the expected content was 0.75 µg/g. However, DELACON expected it to be possible to analyse only approx. 65% of the theoretical content in finished feed, corresponding to 0.50 µg/g. DELACON concluded that the inclusion of Fresta® F Plus in the trial feed seemed correct. In the control feed, the content of carvon was below the detection limit of 0.1 µg/g and DELACON concluded that the control feed as expected contained no Fresta® F Plus.

pH in slurry
pH in slurry samples taken 5 cm below the slurry surface every other week is shown in table 1.

Table 1. pH in slurry.

Group	**1 - Control**	**2 – Fresta® F Plus**
Samples	36	36
pH	7.43	7.39

There were no significant differences in pH in the slurry between the two groups, ie. the recordings did not indicate a smaller decomposition of urea to ammonia ions and carbonate ions in the slurry from pigs given feed including Fresta® F Plus.

Composition of slurry
In table 2, the content of total N and ammonium N is shown. The analysed content of nitrogen in slurry is stated ex pig house.

Table 2. Total N and ammonium N in slurry

Group	**1 - Control**	**2 - Fresta® F Plus**	**1 - Control**	**2 - Fresta® F Plus**
Growth period	Day 1-45	Day 1-45	Day 46-89	Day 46-89
Samples	6	6	6	6
Total nitrogen, g/kg slurry	6.12[a]	5.74[c]	7.51[b]	7.84[b]
Ammonium N, g/kg slurry	4.16[a]	3.85[c]	5.69[b]	5.89[b]

a,b and c,b in the same row are significantly different $p<0.001$.
a,c in the same row are significantly different $p<0.05$.

The content of total N and ammonium N in the slurry significantly depended on whether recordings were made on slurry from the first half of the growth period or the second half. In the last half of the growth period, the slurry had a higher content of 1.74 g total N per kg and 1.79 g ammonium N per kg.

Interaction was also observed as slurry from pigs given Fresta® F Plus had a significantly lower content of total N and ammonium N in the first half of the growth period (day 1-45). However, the levels recorded in the trial blocks were numerically higher in the last half of the growth period (day 46-89), but this was not significant. There is no immediate explanation of this interaction.

Ammonia emissions based on Veng recordings
In Appendix 6, the average housing temperature, air output, concentration of carbon dioxide and ammonia and the ammonia emission per pig/hour are shown for each block. In figure 1, the ammonia emission per pig/hour is shown correlated with days after transfer to the finisher facility for each group. The ammonia emission per pig/hour is shown with the mean value per day in the figures.

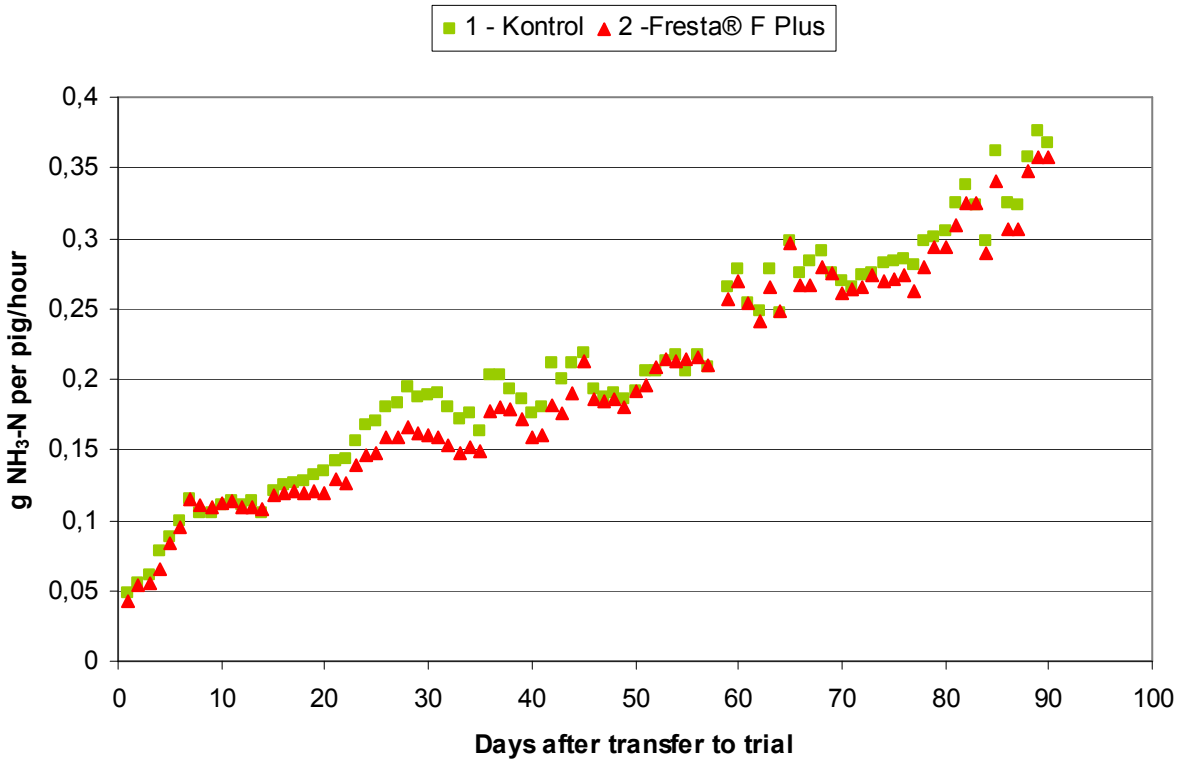

Figure 1. Ammonia emissions from blocks 1-3.

As shown in figure 1, ammonia emissions were almost identical between the two groups. As shown in Appendix 6, the ammonia emission was higher in the trial group than in the control group in block 1, whereas in blocks 2 and 3 it was lower in the trial group.

In table 3, the average ammonia emissions for the control and trial groups are shown.

Table 3. NH_3 recordings.

Group	**1 – Control**	**2 - Fresta® F Plus**
Ammonia emission, g NH_3-N per pig per hour	0.209	0.197

There were no significant differences between the groups. Ammonia emissions in the weight interval 28.3-111.9 kg averaged 435 g per produced pig. In the period 32-107 kg, which is the average growth period in production of finishers, ammonia emissions in this trial averaged 390 g per produced pig.

Ammonia emission based on nitrogen balance
The emission of nitrogen was calculated on the basis of the nitrogen balance in this trial. Nitrogen intake was calculated on the basis of feed consumption and the feed's content of crude protein. The deposit of nitrogen in the pigs was calculated on the basis of total gain and the theoretical deposit of nitrogen per kg gain. Finally, nitrogen ex pig facility was calculated on the basis of the recorded amount of slurry and the analysed nitrogen content of the slurry (see table 4).

Table 4. Nitrogen balance.

Group	**1 - Control**	**2 - Fresta® F Plus**
Total gain, kg	7690	7763
Feed days	8315	8226
N intake through feed, kg	532.8	531.0
÷ Deposit of nitrogen in pigs[1], kg	227.6	229.8
N ex pig	305.2	301-2
÷ Total N in slurry[2], kg (N ex pig facility)	264.4	262.0
Calculated N emission, kg	40.8	39.2
Calculated N emission, g per pig/hour	0.204	0.199

[1]) 29.6 g N per kg gain.
[2]) Volume of slurry: 1.02 kg/l based on random recordings.

Nitrogen emission calculated on the basis of the nitrogen balance also shows that the emission was almost identical between the groups, and there was no significant difference between the groups.

The nitrogen emissions based on the nitrogen balance corresponded with the ammonia emissions calculated on the basis of the ammonia concentration and ventilation output (Veng recordings).

The emission of nitrogen from the pig facility, which is the percentage of N ex animal that evaporates, averaged 13.2% according to the nitrogen balance. This is close to the standard of 14% in facilities with 1/3 drained floor and 2/3 slatted floor.

Conclusion

The addition of 150 g Fresta® F Plus per kg finisher feed did not significantly reduce ammonia emissions from finishers.

No significant differences in pH in slurry were demonstrated.

There was a good agreement between the calculated ammonia emissions based on the recorded ammonia concentrations and ventilation output and the calculated nitrogen emission based on the nitrogen balance in the trial.

References

[1] Galvez, J., A. Daza og C.A. Rodriguez, 1999. Effect of Aromex® (essential oils) on the performance parameters of fattening pigs and on the digestibility of different chemical parameters of the Diet. Trial EU 1/99, Animal Production department, Politécnica University of Madrid.

[2] Hansen, C.F. og J. Callesen, 1999. Firmaprodukter til slagtesvin – Aromex og Bio-Mos. Meddelelse nr. 431, Landsudvalget for Svin.

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Appendix 1. Design of facilities

Number of sections	6
Space per section	4.84 m × 6.00 m
Floor-to-ceiling height	2.50 m
Pens per section	2
Pigs	16 pigs per pen, 32 pigs per section
Pen size	2.40 m × 4.80 m
Lying area	1/3 drained floor made of concrete elements, slot width 15 cm and slat width 1.8 cm
Dunging area	2/3 concrete slatted floor, slot width 6.5 cm and slat width 2.0 cm
Slurry pit	One under each pen. Depth to bottom edge of slats: 60 cm. Slats have a thickness of approx. 10 cm.
Pen sides	Closed pen partitions, but open in dunging area
Sprinkling	One nozzle per pen above dunging area (no sprinkling during winter)
Ventilation	Diffuse ventilation (air intake via mineral wool and wood concrete)
Feeding	One dry feeder per pen. Dry feed ad lib
Water	One drinking bowl per pen

Appendix 2. Declared content and ingredients of the feed

Group	**1 - Control**	**2 - Fresta® F Plus**
Feed units per 100 kg	1.07	1.07
Crude protein, %	16.7	16.7
Crude fat, %	3.9	3.9
Ashes, %	5.0	5.0
Water, %	13.3	13.3
Ingredients, %		
Wheat	40.5	40.5
Barley	30.0	30.0
Soybean meal, dehulled	17.1	17.1
Rape cake, Scanola	5.0	5.0
Wheat bran	2.5	2.5
Vegetable fat	1.2	1.2
Molasses, beet	1.0	1.0
Calcium carbonate	1.33	1.32
Mono calcium phosphate	0.46	0.46
Dietary salt	0.46	0.46
L-lysine hydrochloride, 98.5%	0.14	0.14
DL-methionine, 100%	0.03	0,03
L-threonine, 98.5%	0.02	0.02
Vitamin and mineral premix[1]	0.21	0.21
Fresta® F Plus	-	0.015

[1)] Incl. xylanase and 500 FTU/kg Phyzyme XP.

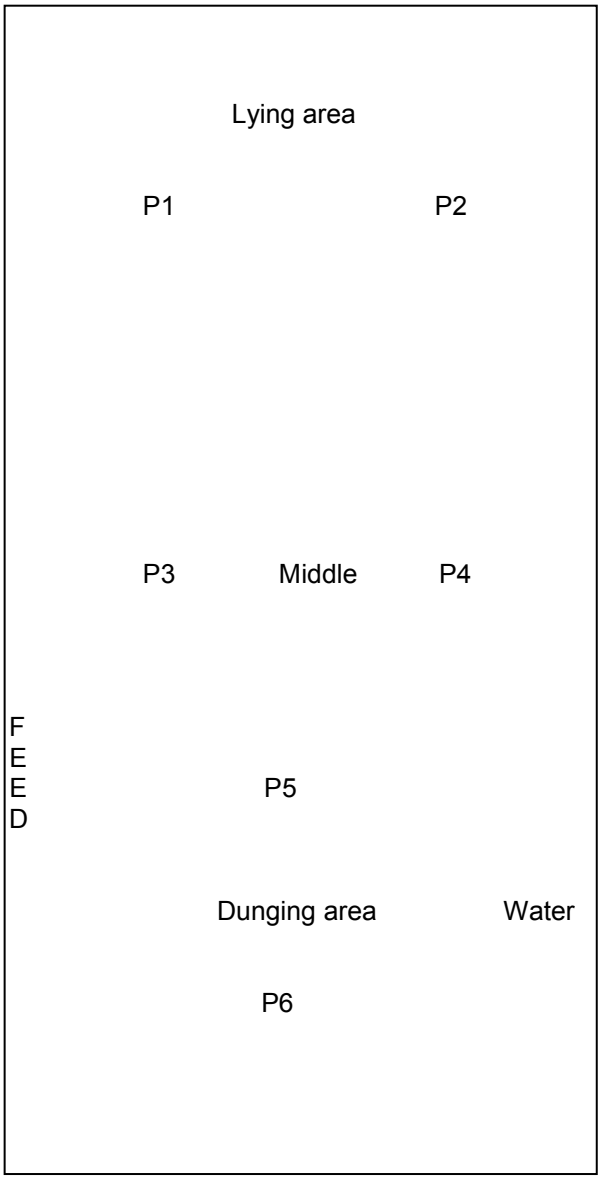
Appendix 3. Calculated and analysed content of minerals and amino acids

Group	1 - Control			2 - Fresta® F Plus		
-	Calculated g per kg	g dig. per feed unit	Analysed[1] g per kg	Calculated g per kg	g dig. per feed unit	Analysed[1] g per kg
Crude protein	167	130	168	167	130	168
Calcium	7.5	-	6.7	7.5	-	6.9
Phosphorus	4.8	2.40	4.7	4.8	2.40	4.9
Lysine	9.2	7.40	9.2	9.2	7.40	9.5
Methionine	2.8	2.30	2.6	2.8	2.30	2.8
Methionine + cysti-ne	6.0	4.77	5.7	6.0	4.77	6.0
Threonine	6.3	4.90	6.1	6.3	4.90	6.4

[1)] Four analyses per diet for crude protein and two analyses per diet for minerals and amino acids.

Appendix 4

Sampling points for pH recordings.



P1: 0.8 m from back wall; 0.6 m from partition

P2: 0.8 m from back wall; 0.6 m from wall

P3: 2.4 m from back wall; 0.6 m from partition

P4: 2.4 m from back wall; 0.6 m from wall

P5: 1.6 m from the front; 1.2 m from partition

P6: 0.7 m from the front; 1.2 m from partition

P1 and P2, P3 and P4, and P5 and P6 were taken in the same test tube before pH measurement.

Appendix 5. Production results

Group	1 - Control	2 - Fresta® F Plus
Pigs transferred to the trial	96	96
Pigs slaughtered	91	89
Start weight, kg	28.3	28.2
End weight, kg	111.3	112.6
Daily gain, g	930	941
Feed per pig, daily, FUgp	2.57	2.58
Feed per kg gain, FUgp	2.76	2.74
Average lean meat %	59.8	59.9
Dead and rejected, %	1.0	2.1

Appendix 6. Climate and ventilation conditions and average of recorded CO_2 and NH_3 concentrations

Block	Group	Days of measurement	Outdoor temp.	Indoor temp.	Ventilation per pig	CO_2	NH_3	Ammonia emission[1]
-	-	-	°C (min.-max.)	°C	m^3/hour	ppm	ppm	g NH_3-N/pig/hour
1	Control	89	÷ 2.4	17.8	555	2695	19.3	0.199
1	Fresta® F Plus	89	÷ 2.4	18.6	527	2834	22.7	0.225
2	Control	89	÷ 2.4	18.2	502	2946	21.4	0.203
2	Fresta® F Plus	89	÷ 2.4	18.2	477	2884	18.9	0.174
3	Control	89	÷ 2.4	18.4	506	2812	23.6	0.226
3	Fresta® F Plus	89	÷ 2.4	19.2	462	2960	22.1	0.192

[1]) For the entire production period, ie. averagely 28.3-112 kg.