The effect of feeding different concentrations of dried chicory roots (*Cichorium intybus L.)* for 7, 14 or 21 days prior to slaughter on the quality characteristics of meat from entire male pigs:

Part II. Sensory boar taint characterisation and chemical predictivity

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1. Background

Analytical chemists engaged in elucidating boar taint require clearly defined terminology to describe the sensory characteristics that constitute boar taint as it is in essence a sensory based off-flavour phenomenon. The development of such descriptors with definitions and references by sensory analysis has much potential in the further understanding of sensory boar taint perception and its level of negative effect on consumer acceptability of pork (Bonneau et al., 2000; Dijksterhuis et al., 2000). Sensory profiling, a method by which a panel uses a developed sensory vocabulary to describe perceived sensory characteristics in a sample set has been utilised in the present research (ISO, 1985; ISO, 1994; Byrne et al., 2001a). The resultant profile is a perceptual map of the variations in a sample type that can be employed alone or in combination with chemical/instrumental measurements in the explanation and determination of underlying sensory and chemical relationships.

In the present experiment the overall aim was to investigate the sensory variation that resulted from the effects of bioactive feeding (dried chicory) in entire male cooked pork. Specifically the aim was to determine the lowest possible level and shortest possible duration of dried chicory feeding prior to slaughter to result in chemical and sensory boar-taint reduction as previously presented in Patent PA 2003-00453 “Methodologies for Improving the Quality of Meat, Health Status of animals and Impact on the Environment”. The sensory profile was carried out with the specific aim to determine the effect of bioactive feeding on the sensory ‘off-flavour’ referred to as boar taint in the meat. To achieve this aim a descriptive sensory vocabulary was developed with an expert sensory panel and subsequently the panel were utilised to develop a sensory profile for the meat samples. In the analyses of the sensory profiling data a multivariate strategy involving Partial Least Squares Regression (PLSR) was utilised to determine precisely how the various feeding treatments were described and discriminated from a sensory perspective with respect to boar taint. In addition, the predictive nature of boar taint relevant chemical measurements for the sensory profiling attributes was investigated.

2. Material and methods

2.1. Meat Samples

Pork muscles *Longissimus dorsi* (*LD*) were provided by The Danish Institute of Agricultural Sciences (DIAS), Dept. of Food Science, Research Centre Foulum, Denmark. Muscles were derived from animals fed one of four (2.5, 5, 10 or 20 % dried chicory, according to energy level) different feeding treatments for either 7, 14 or 21 days prior to slaughter and compared with muscles derived from control pigs fed concentrate without chicory (see Table 1).

2.2. Sample preparation

All muscles were stored vacuum packed in darkness at –20^{o}C. Muscles were held at 4^{o}C for approx. 12 h prior to handling to allow ease of cutting. Visible fat and connective tissues were removed and muscles were cut into chops (approx. 1 cm thickness). Individual chops were subsequently vacuum packed in oxygen impermeable plastic laminate bags. The vacuum-packed chops were then frozen at –30^{o}C and stored for up to one week prior to use in profiling.

Prior to cooking treatment, all frozen vacuum packed chops were placed in a 25^{o}C water bath until a core temperature of between 18 and 20^{o}C had been reached. Subsequently chops were removed from their plastic vacuum bags and batch cooked in convection ovens set to 150^{o}C. The ovens utilised were determined to have comparable heating cycles. The heating/cooking process at 150^{o}C utilised took a total of 8 min, 4 minutes per side. The final internal temperature reached over all chop batches cooked was found to vary between 78 and 82^{o}C. After cooking the samples were immediately (within 5 min) served to the panelists such that the mean serving temperature of the samples was 68^{o}C.

2.3. Sensory vocabulary development

Prior to sensory profiling a sensory panel (10 persons selected for sensitivity to skatole and androstenone, see Weiler et al., (2000) participated in the development of a sensory vocabulary to describe and discriminate the effects of conventional and bioactive feeding on the general flavour characteristics and in particular boar taint in the pork meat of the present study (see Byrne et al., 1999a,b; Byrne et al., 2001b). The panel was recruited from the public and students of the Royal Veterinary and Agricultural University, Frederiksberg, Denmark. All sensory work was carried out in the sensory laboratory at the University, which fulfils requirements according to the international standards (ASTM, 1986; ISO, 1988). Panel input, panel leader input, and multivariate statistical analyses were utilised to select a set of 32 descriptors plus an overall impression question (Table 2) (see Byrne et al., 2001b). Each of the final list of terms was defined by a reference material and terms were divided into their modality of sensory assessment, i.e. odours, tastes, flavours and aftertastes (Table 2).

2.4. Sensory profiling

Sensory descriptive profiling of 1.0 kg of LD from all animals from all treatments using a 10-member expert panel was carried out (e.g. ISO, 1985; Meilgaard et al., 1999; Byrne et al., 2001a) was carried out over four 2-hour (replicate) sessions by the trained panel. All sessions took place on weekday mornings in the sensory laboratory at The Royal Veterinary and Agricultural University, Frederiksberg, Denmark, which fulfils requirements according to the international standards (ASTM, 1986; ISO, 1988). The design was balanced between the different dietary treatments and periods of feeding prior to slaughter. In total 13 (control and 2.5, 5, 10, 20% chicory for 7, 14, 21 days) samples covering all sources of variation were assessed per profiling day/session (Table 1). The balanced block design ensured an even distribution of samples, in that each of the panelists was exposed to all sources of variation at each profiling session.

2.5. Chemical analysis

Blood samples from *Vena jugularis* for plasma were collected just before slaughter for all the pigs after feeding for 7, 14 or 21 days with chicory as well as for the control pigs. Skatole and Indole in blood plasma was measured according to the HPLC method described by Hansen-Møller (1998) and modified by omitting the column switching procedure and injecting the protein-precipitated plasma directly on a Hypersil 3 μm 3 x 60 mm column. The lower limit of quantification was 0.12 $\mu g\ L^{-1}$.

Backfat samples were collected 45 minutes post slaughter. Skatole equivalents in backfat were measured by the automatic spectrophotometric method described by Mortensen and Sørensen (1984).

2.6. Sensory Data acquisition

Quantitative data was collected using the FIZZ Network data acquisition software (BIOSYSTEMS, Couternon, France). Unstructured line scales of 15 cm anchored on the left side by the term ‘none’ and on the right side by the term ‘extreme’ were used for the scoring of each sensory term (Meilgaard et al., 1999).

2.7. Data analyses

Quantitative ANOVA Partial Least Squares Regression (APLSR) was performed to visualize and determine the descriptive ability of the sensory profiling data for the sample treatments in the LD muscles. APLSR analysis of the sensory descriptors was performed where the X-matrix was set as design main effect 0/1 variables for feeding treatments (Control, 2.5, 5, 10, 20% chicory and 7, 14, 21 days) and the Y-matrix was designated as the level of scale use corrected sensory data, averaged over assessor (10) (Martens and Martens, 2001).

To determine the predictive ability of the sensory data for selected boar taint relevant chemical measurements (*skatole and indole in blood* and *skatole in back fat*), Partial Least Squares Regression (PLSR) was performed where the X-matrix was set as the mean over assessor level of scale use corrected sensory characteristics (odour/flavour/taste/aftertaste) plus the passified (included to aid in interpretation only) design main effect 0/1 variables for feeding treatments (control, 2.5, 5, 10, 20% chicory and 7, 14, 21 days) and the Y-matrix was designated as selected boar taint relevant chemical measurements (*skatole and indole in blood* and *skatole in back fat*) (see Martens and Martens, 2001).

To derive significance indications for the relationships determined in the quantitative APLSR and predictive PLSR, regression coeffecients were analysed by jack-knifing which is based on cross-validation and stability plots (Martens & Martens, 2000 and 2001). This allowed determination of the regression coefficients ($\hat{b}$) with uncertainty limits that correspond to ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\ \hat{s}(\hat{b})$. From these, the significances ($p < 0.05$) of the variable relationships in the X- and Y-matrices were determined, i.e. $\alpha \approx 0.05$, defined as the Type I probability that the observed effects could have been caused by random measurement errors.

For contextual validation in the regression analysis, the conventional loading plot was replaced by a plot of correlation loadings. This allowed easier interpretation since it revealed both the structures in the data and their degree of fit at the same time. All multivariate analyses were performed using the Unscrambler Software, Version 9.1 (CAMO ASA, Trondheim, Norway). In all regression analysis data were analysed unstandardised, centred and with full cross-validation.

3. Results and Discussion

3.1. Data analysis strategy

A multivariate data analytical strategy was utilised in the investigation of the sensory profiling and chemical data of the present study. Initially, quantitative ANOVA-Partial Least Squares Regression was performed to investigate and determine the significance ($P<0.05$) of the association of the main design variation (% chicory and days of feeding prior to slaughter) and the sensory profiling data. Two separate models were derived, the first where retronasal based sensory characteristics (*Odour, Flavour, Taste* and *Aftertaste*) were included and the second where *Textural* characteristics alone were included. In both models the hedonic measurement *Overall Impression* was included as an indication of the direction of highest impression/liking associated with the objective sensory profiling characteristics.

Subsequently the predictive relationships between the sensory data and measurements of selected boar taint marker compounds (*Skatole* and *Indole*) were determined by PLSR.

3.2. Sensory profiling of M. longissimus dorsi

3.2.1. Retronasal Sensory Characteristics, Odour/Flavour/Taste/Aftertaste

From the 3 significant Principal Component (PC) APLSR model score plot (Figure 1), PC 1 (50% explained variance) was seen to differentiate the main design variation from the Control via low chicory feeding (A=2.5 and B=5%) to high chicory feeding (C=10 and D=20%), (Figure 1). In contrast PC 2 (11% explained variance) was seen to differentiate systematically (Day 7 via Day 14 to Day 21) the effect of days of feeding chicory prior to slaughter. PC3 was not found to contain additional interpretable information.

Overall, it is clear that feeding chicory at A=2.5 and B=5% has a similar effect when compared to the Control samples. Whereas feeding higher levels of chicory (C=10 and D=20%) were more discriminated from the control that the lower chicory levels. With respect to days of chicory feeding, it was clear that a stepwise increase in discrimination from day 7 to day 21 was achieved. Thus, the longer the level of chicory feeding the more effect was displayed. Of note was the tendency of the 10 and 20% chicory fed samples to have the most effect in terms of discrimination across PC1 (Figure1.).

From the 3 significant PC APLSR model correlation loadings plot (Figure 2), where the sensory descriptors are displayed in relation to the main design aspects (% chicory and days of feeding), it was clear that all boar taint related odour and flavour descriptors (i.e. *Manure/Stable-*

odour/flavour, Piggy/Animal-odour/flavour, Urine-odour) were highly correlated with the control fed samples (Figure 2). Whereas, a systematic decrease in the perception of these boar taint descriptors was clearly displayed across PC1 with increasing level of chicory feeding (A=2.5 to D=20%). With high chicory feeding boar taint descriptors are replaced to a point where the samples were highly positively correlated with *Fresh Cooked Pork Meat-Odour/Flavour* and were judged to have a high *Overall Impression* or liking.

With respect to increasing days of chicory feeding at all levels, it appeared that this also improved the sensory characteristics of the samples per se, particularly in relation to the terms *Astringent-Aftertaste* associated with Day 7 to *Bouillon-Taste* and *Pork Fat-Flavour* associated with 21 Days of chicory feeding (Figure 2).

Thus, the highest levels of chicory feeding for a longer time were most effective in removing sensory descriptors associated with boar taint and ensuring samples that were characterised as having *Freshly Cooked Pork* notes and a high *Overall Impression*/liking by the sensory panel.

To illustrate the significance ($P<0.05$) of design effects for the key descriptors as discussed in Figure 2, regression coefficient plots (see section 2.7 data analysis) were extracted from the APLSR model (displayed as Figures 7, 8, 9). Thus, in Figure 7 the boar taint descriptor *Manure/Stable-Odour* is displayed in relation to the main design effects, chicory % and time of feeding. As previously noted in Figure 2, chicory has a boar taint reducing effect compared to control samples from 2.5% chicory onwards to a significant level ($P<0.05$) at C=10 and D=20% chicory. This is clearly illustrated in Figure 3 by the key boar taint descriptor *Manure/Stable-Odour*. With respect to days of chicory required to reduce boar taint, all days have a large decreasing effect with day 21 having a significant effect.

To illustrate the effect of increased positive notes with increasing % and time of chicory feeding, Figure 4 displays the exact opposite effects for improving *Cooked Pork-Flavour* when compared to *Manure/Stable-Odour* in Figure 3. The same can be said for Figure 5 which displays clearly that the panel had a significant ($P<0.05$) increase in *Overall Impression*/liking for the samples at C=10 and D=20% chicory feeding for 21 days.

3.2.2. Textural sensory characteristics

From the 2 significant PC APLSR model correlation loadings plot (Figure 6), where the *Texture* (*Hardness*, *Fibrous*, *Tenderness*) and *Overall Impression* descriptors are displayed in relation to the main design aspects (chicory % and days of feeding), it was apparent that increased chicory feeding (particularly at 10%) and/or time decreased perceived *Hardness*, *Fibrousness* and increased/improved *Tenderness* and *Overall Impression*.

Figure 7 displays the effects of chicory feeding level and time for *Overall Impression* specifically as a regression coefficient plot. From this it appears that C=10% chicory was the most effective in improving sample *Texture* in terms of *Overall Impression*. With respect to days of feeding, Day 21 appeared to be the most effective, however significance could not be assigned.

3.2. Sensory and chemical predictive relationships

From the 2 significant PC APLSR model correlation loadings plot (Figure 8), where the sensory descriptors (and the main design aspects chicory % and Days feeding to aid in interpretation) are displayed in relation to the boar taint marker measurements, *Skatole* and *Indole in blood* at slaughter and *Skatole in back fat* (Figure 8), it was clear that all boar taint related odour and flavour descriptors (i.e. *Manure/Stable-odour/flavour, Piggy/Animal-odour/flavour, Urine-odour*) were highly correlated with all 3 chemical measurements (Figure 8).

Thus, to determine exactly which sensory descriptors can be predicted significantly ($P<0.05$) by these chemical measurements individually, regression coefficient plots were extracted for *Skatole in back fat* (Figure 9), *Skatole in blood* (Figure 10) and *Indole in blood* (Figure 11). Overall, it was clear that both *Skatole* measurements were equally effective in significantly ($P<0.05$) predicting the same set of sensory descriptors. Thus, *Skatole* was significantly positively correlated with the boar taint descriptors *Piggy/Animal-Odour/Flavour, Manure/Stable-Odour and Urine-Odour*, and significantly negatively correlated with the positive descriptors *Cooked Pork-Odour* and *Nutty-Odour* characteristics resulting from high levels and time of chicory feeding (see Figure 2). In contrast measured *Indole in blood* was only predictive of the term *Piggy/Animal-Flavour* (Figure 11). Thus, it was clear that *Skatole* measurements were more relevant to prediction of the boar taint aspects of the samples in the present study when compared to the *Indole* measurement. This may also be a reflection of the fact that *Skatole* is reported as having larger contribution to boar taint per se than *Indole* (see e.g. Bonneau, 1982).

4. Conclusions

Chicory feeding in dried form at all levels and times (A=2.5%, B=5%, C=10%, D=20% and 7, 14, 21 days) reduced sensory boar taint and increased fresh cooked characteristics relative to control feeding in pork entire male LD muscles. This effect was found to be significant at 10 and 20% chicory and 21 days of feeding. *Tenderness* was also seen to be improved with high chicory feeding and this was found to be significant in the 10% chicory fed samples.

Specifically from an odour/flavour perspective the non-bioactive control fed pigs were found to have a higher level of boar taint as described by the terms *Manure/Stable Odour/Flavour, Piggy/Animal-Odour/Flavour* relative to the pigs fed chicory, which were characterised as high in freshly *Cooked Pork Odour/Flavour* and displaying a higher *Overall Impression*/liking.

Skatole blood and *back fat* where both determined to be equally effective in significantly predicting the majority of the key boar taint descriptors versus Indole which could predict only a single descriptor (*Piggy/Animal-Flavour*) in the present study. This was postulated as reflective of the reported relative contributions of skatole and indole, respectively to the sensory boar taint phenomenon.

A key aspect of boar taint reduction in the present study was the panels indication that the chicory fed samples achieved a high *Overall Impression*/liking. The importance being that chicory having clearly reduced boar taint from a sensory perception perspective, did not lead to the imparting/introduction of 'new' off-flavours in the cooked meat samples. The 'bitter' nature of chicory roots may have been expected to be an issue, this proved not to be the case with the chicory concentrations utilised in the feeding period 7 to 21 days.

Overall, it is postulated that the chicory fed pigs may be expected to also have a more acceptable sensory character due to boar taint reduction than the pigs feed non-bioactive control from a consumer perspective, based on the indication from the *Overall Impression* measurement in the present study. Chicory feeding therefore must be seriously considered to have the potential for utilisation as a major aspect of a strategy for boar taint reduction in entire male pork.

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TABLES

Table 1. Experimental design as compared to the control (no chicory feeding) to determine the effect of feeding increasingly lower concentrations of dried chicory for shorter durations prior to slaughter on the sensory characteristics of meat from entire male pigs

No. of feeding days before slaughter	7	14	21
A=2.5%[a,b]	A07[c]	A14	A21
B=5%	B07	B14	B21
C=10%	C07	C14	C21
D=20%	D07	D14	D21

[a] % = level of dried chicory
[b] Diets made up to 100% with required % concentrate based on energy level
[c] *n*= 4, animals utilised per treatment in sensory profiling and from chemical analysis

Table 2. List of 32 sensory descriptive characteristics plus an overall impression question, with definitions developed for the evaluation of pork meat chops, oven cooked at 150^{o}C for 8 min., derived from entire male pigs fed 4 different feeding treatments 2.5, 5, 10 and 20% dried chicory for 1, 2 and 3 weeks prior to slaughter (see Table 1).

Term [a b]		**Definitions and reference materials**[c]
Odour		***Aromatic associated with:***
Fresh pork odours		
1.	Fresh cooked pork meat like-O	Oven cooked pork meat with no on surface browning
2.	Nutty-O	Crushed roasted hazel nuts
Boar taint odours		
3.	Piggy/Animal-O	Cooked pork meat from entire male pigs
4.	Gamey-O	Freshly cooked game meat as exemplified by deer, pheasant or wild boar
5.	Urine-O	Male pig urine
6.	Parsnip-O	Cooked parsnip/earthy/sweet
7.	Manure/stable-O	Male pig excrement/faeces (presented in sealed vessel with perforated cover for assessment)
8.	Sweat/Musty-O	Stale damp/moist old fabric/cloth sealed in plastic for 5 days/moist celler/Old human body sweat/Swiss cheese
Feeding treatment odours		
9.	Chicory (solid)-O	Flaked fresh chicory root
10.	Feedy-O	Blended barley grains and water (50/50)
11.	Hay/Silage-O	Dry hay/fermented hay (silage)
Texture		***Textural impression associated with:***
Initial mastication		
12.	Hardness-Tx	Force required to bite completely through the sample with molars
13.	Tenderness-Tx	Ease with which the meat is divided into fine particles when chewed
During mastication		
14.	Fibrous-Tx	The amount of fibers appearing during mastication

[a] Suffix to sensory terms indicates method of assessment by panellists; -O = Odour, -F = Flavour,-T = Taste, -AT = Aftertaste, -Tx = Texture.
[b] Concentrations in g/l were devised to ensure panellists' could recognise clearly the sensory note involved.
[c] Definitions of sensory terms as derived during vocabulary development.

Table 2. continued over page

Table 2. (contd.). List of 32 sensory descriptive characteristics plus an overall impression question, with definitions developed for the evaluation of pork meat chops, oven cooked at 150^{o}C for 8 min., derived from entire male pigs fed 4 different feeding treatments 2.5, 5, 10 and 20% dried chicory for 1, 2 and 3 weeks prior to slaughter (see Table 1).

Term [a b]		**Definitions and reference materials**[c]
Taste		***Taste associated with:***
15.	Sour-T	Ymer/natural yoghurt/formage frais
16.	Sweet-T	Sweet fresh cooked pork
17.	Bouillon/Umami-T/	The 'blooming' flavour enhancing taste of monosodium glutamate, a solution 0.5g/l MSG in water
Flavour		***Aromatic taste sensation associated with:***
Fresh pork flavours		
18.	Fresh cooked pork meat like-F	Oven cooked pork meat with no on surface browning
19.	Pork fat-F	Freshly cooked pork fat
Boar taint flavours		
20.	Piggy/Animal-F	Cooked pork meat from entire male pigs
21.	Manure/stable-F	Male pig excrement/faeces. Reference presented in sealed vessel with perforated cover for assessment aim to allow it to evoke 'flavour'.
Feeding treatment flavours		
22.	Livestock/Barny-F	Flavour of white peper just after the initial soapy notes and before the strong peppery notes
23.	Hay-F	Flavour of dried grass
24.	Spicy-F	Spicy flavour from salami
25.	Chicory (flesh/solid)-F	Dried chicory root flakes after soaking in boiling water
Other-flavours		
26.	Cardboard like-F	Wet cardboard
27.	Sour (Old)	Sourness of old Ymer/natural yoghurt
Aftertaste		***Aftertaste sensation associated with:***
28.	Astringent-AT	Solution 0.02g/l aluminum sulphate in water. Drying sensation in mouth and on teeth.
29.	Fresh sour/Lactic-AT	Ymer/natural yoghurt
30.	Flat Bitter-AT	Bitter aftertaste from chicory
31.	Salty-AT	Sodium Chloride (NaCl) (basic salt) (0.5g/l) aftertaste
32.	'Bad' Aftertaste	Intensity of a negative lingering aftertaste
Preference		***Preference associated with:***
33.	Overall Impression	Question: to which degree do you like the pork sample you have just tasted in the context of pork of this type? Scored as dislike very much to like very much on an unstructured 15cm line scale.

[a] Suffix to sensory terms indicates method of assessment by panellists; -O = Odour, -F = Flavour,-T = Taste, -AT = Aftertaste, -Tx = Texture.
[b] Concentrations in g/l were devised to ensure panellists' could recognise clearly the sensory note involved.
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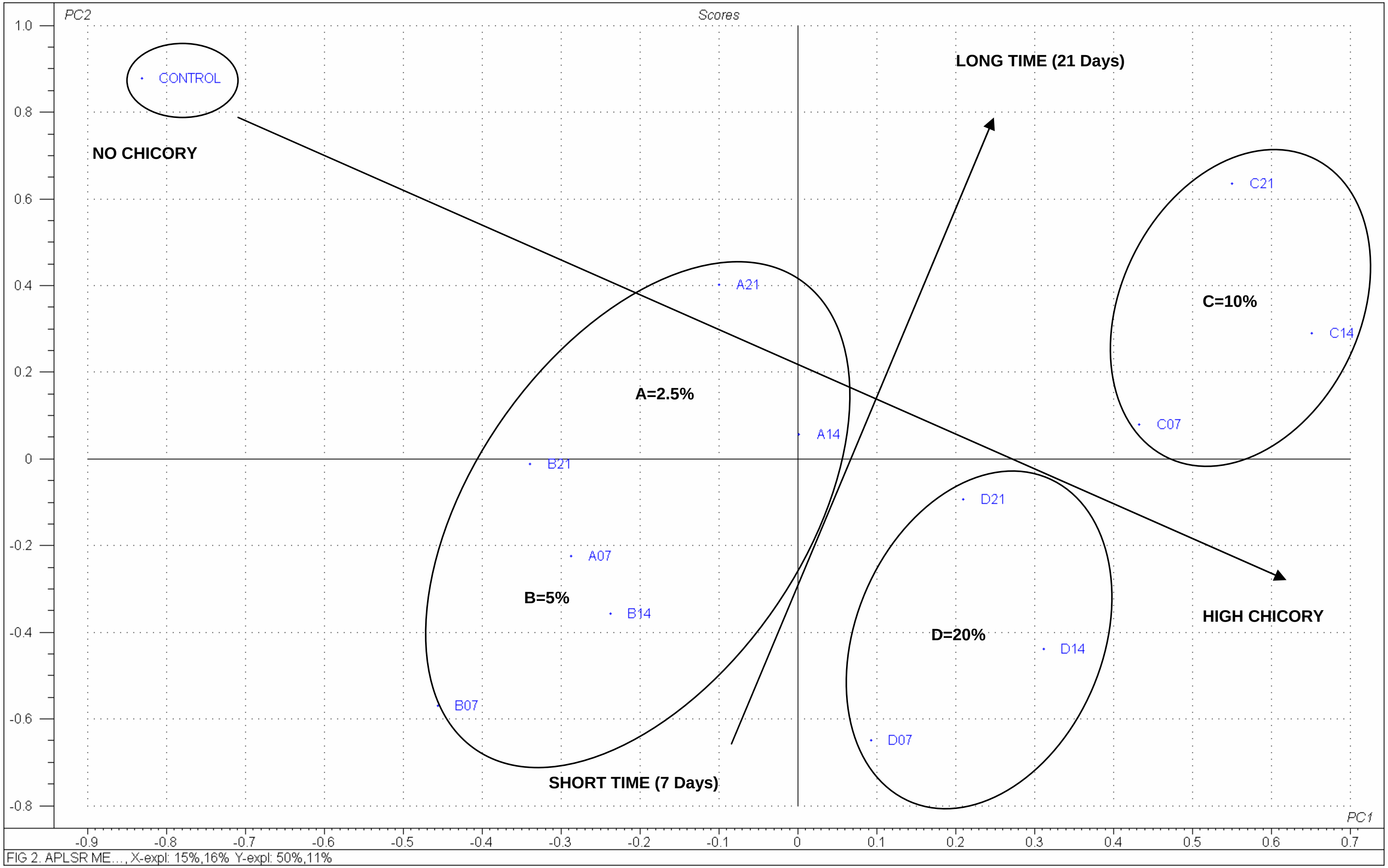

Figure 1. Explained variance in PC1 = 50, PC2=11, PC3=5% thus 3PCs = 66%. Sample scores derived from APLSR where X = Design main effects and Y = Level corrected sensory descriptors (29) plus *Overall Impression*, averaged over assessors/replicates. The model indicated 3 significant PCs with full cross validation.

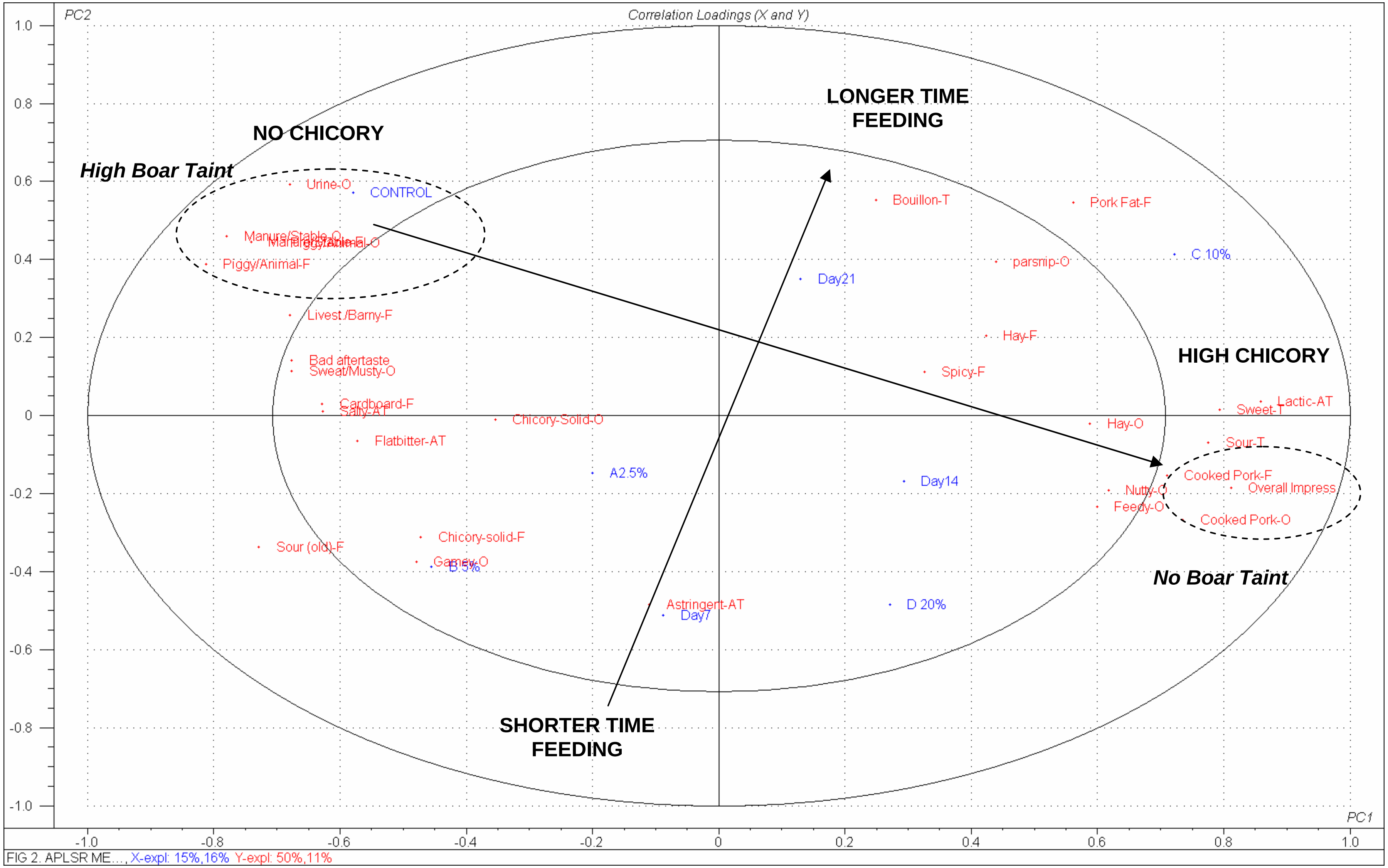

Figure 2. Explained variance in PC1 = 50, PC2=11, PC3=5% thus, 3PCs = 66%. Correlation loadings plot derived from APLSR where X = Design main effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Y = Level corrected sensory descriptors (29), plus *Overall Impression*, averaged over assessors/replicates. The model indicated 3 significant PCs with full cross validation. Ellipses represent r^2 = 50 and 100 %

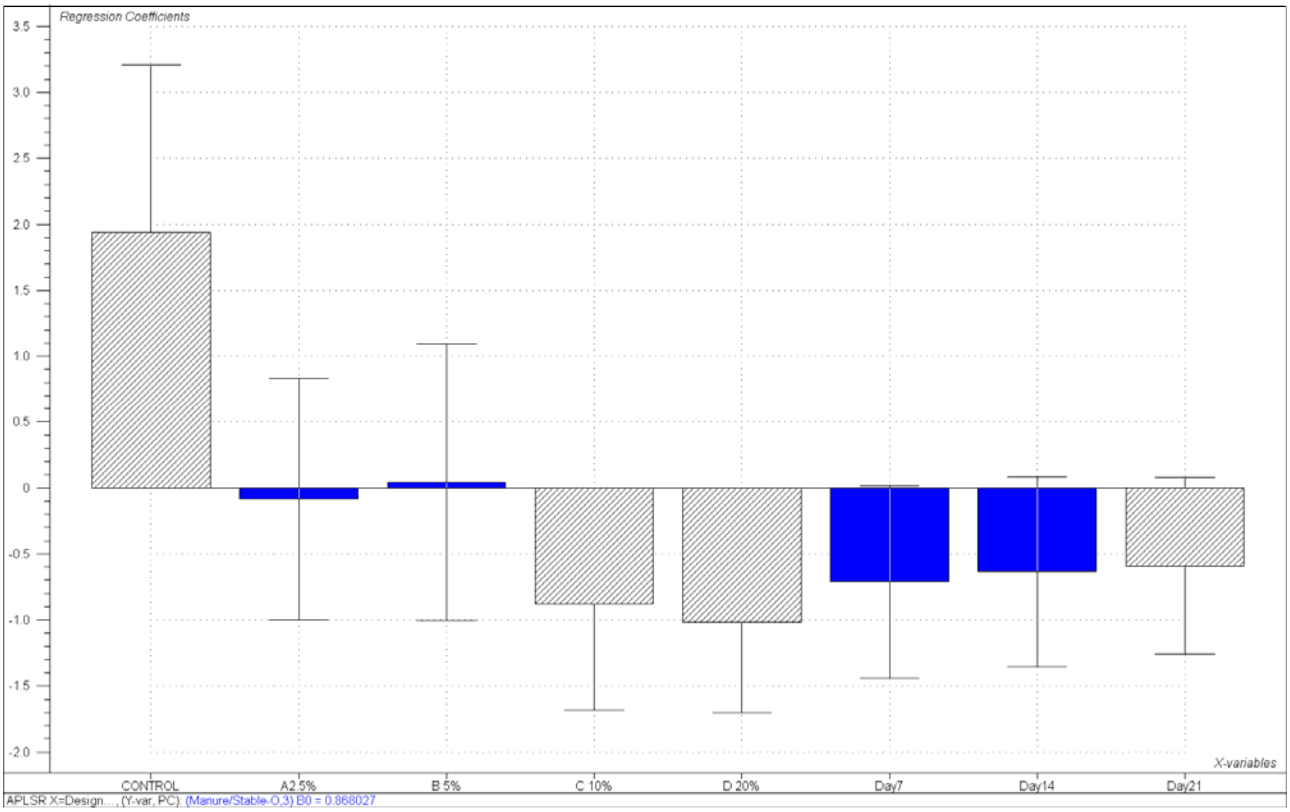

Figure 3. Regression coefficient plot of the boar taint descriptor *Manure/Stable-Odour* from APLSR analysis where X=Design main effects A, B, C, D = 2.5, 5, 10, 20 % chicory, respectively, and 7, 14, 21 = Days of chicory feeding prior to slaughter and Y= Level corrected sensory data mean over assessors. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\ \hat{s}(\hat{b})$ (Martens & Martens 2001).

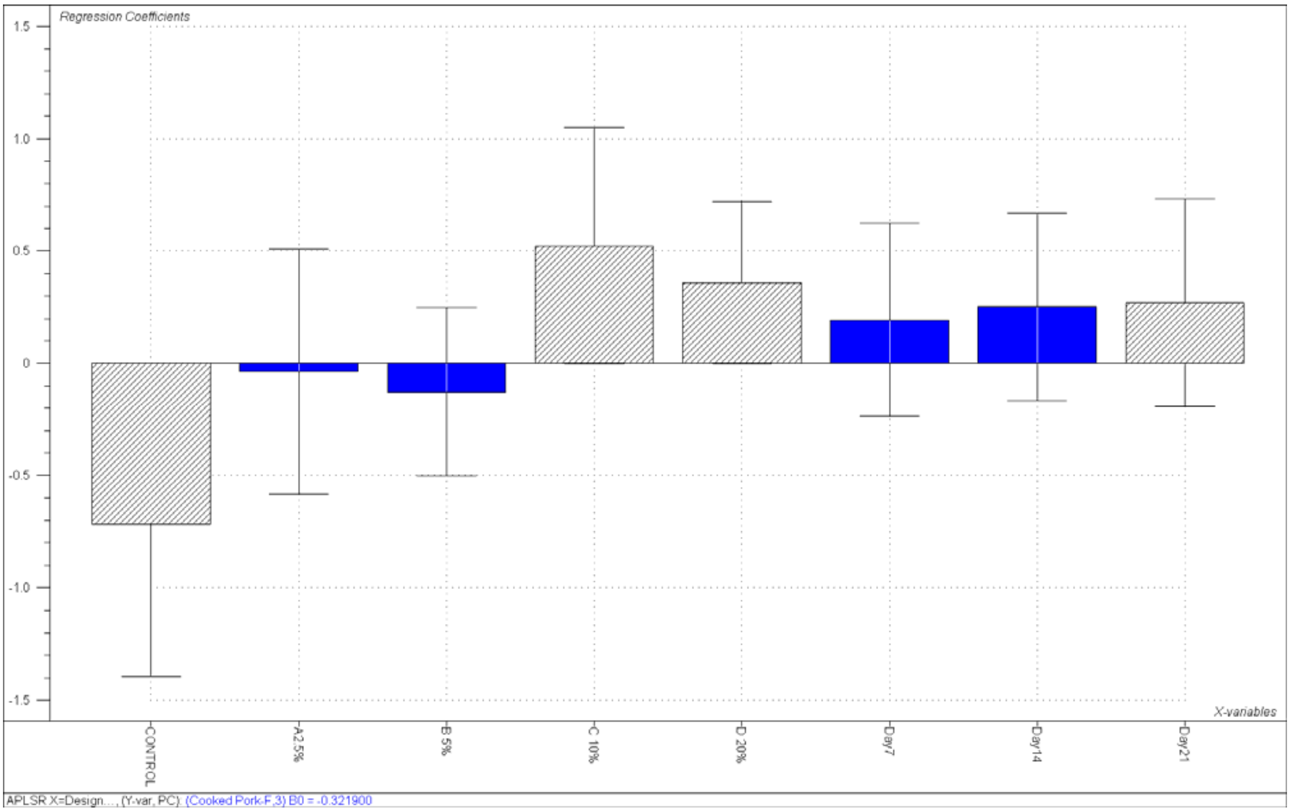

Figure 4. Regression coefficient plot of the freshly cooked meat descriptor *Cooked Pork-Flavour* from APLSR analysis where X=Design main effects A, B, C, D = 2.5, 5, 10, 20 % chicory, respectively, and 7, 14, 21 = Days of chicory feeding prior to slaughter and Y= Level corrected sensory data mean over assessors. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\, \hat{s}(\hat{b})$ (Martens & Martens 2001).

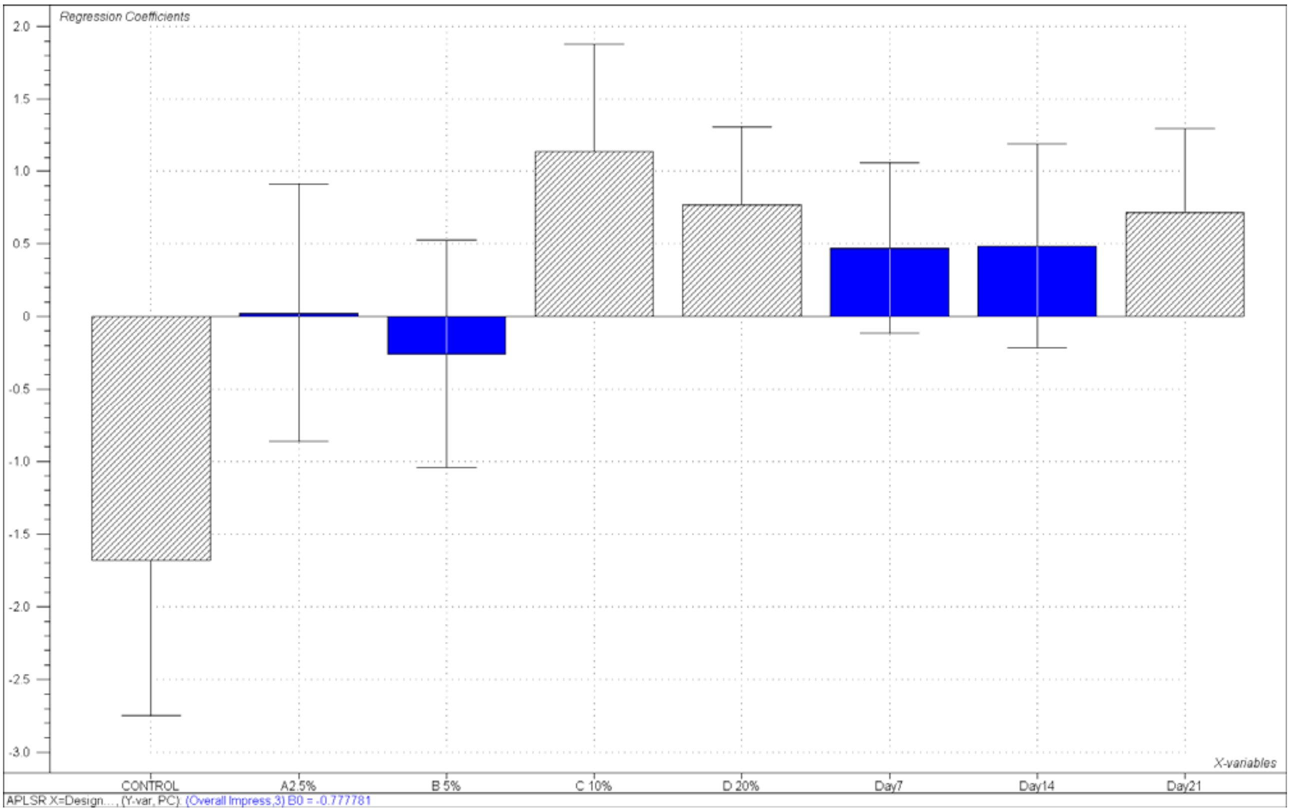

Figure 5. Regression coefficient plot of the hedonic descriptor *Overall Impression* from APLSR analysis where X=Design main effects A, B, C, D = 2.5, 5, 10, 20 % chicory, respectively, and 7, 14, 21 = Days of chicory feeding prior to slaughter and Y= Level corrected sensory data mean over assessors. Striped bars indicate a significant difference (*P*<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\, \hat{s}(\hat{b})$ (Martens & Martens 2001).

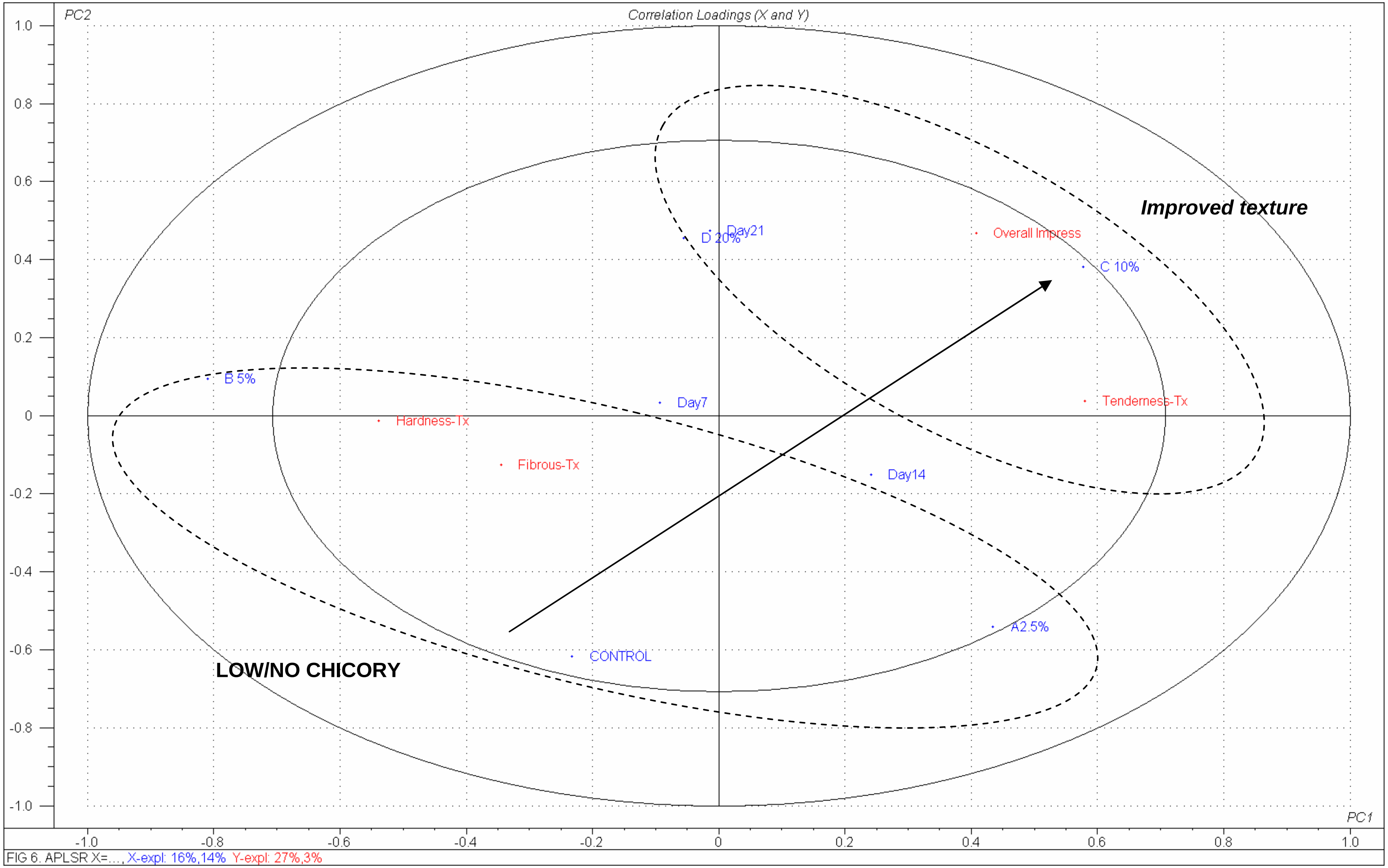

Figure 6. Explained variance in PC1= 27% PC2 = 3%, PC3= 3%, thus 3PCs = 33%. Correlation loadings plot derived from APLSR where X = Design Main Effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Y = Level corrected sensory *Texture* descriptors (*Hardness, Tenderness and Fibrous*) plus *Overall Impression*, averaged over assessors. The model indicated 3 significant PCs with full cross validation. Ellipses represent r^2 = 50 and 100 %.

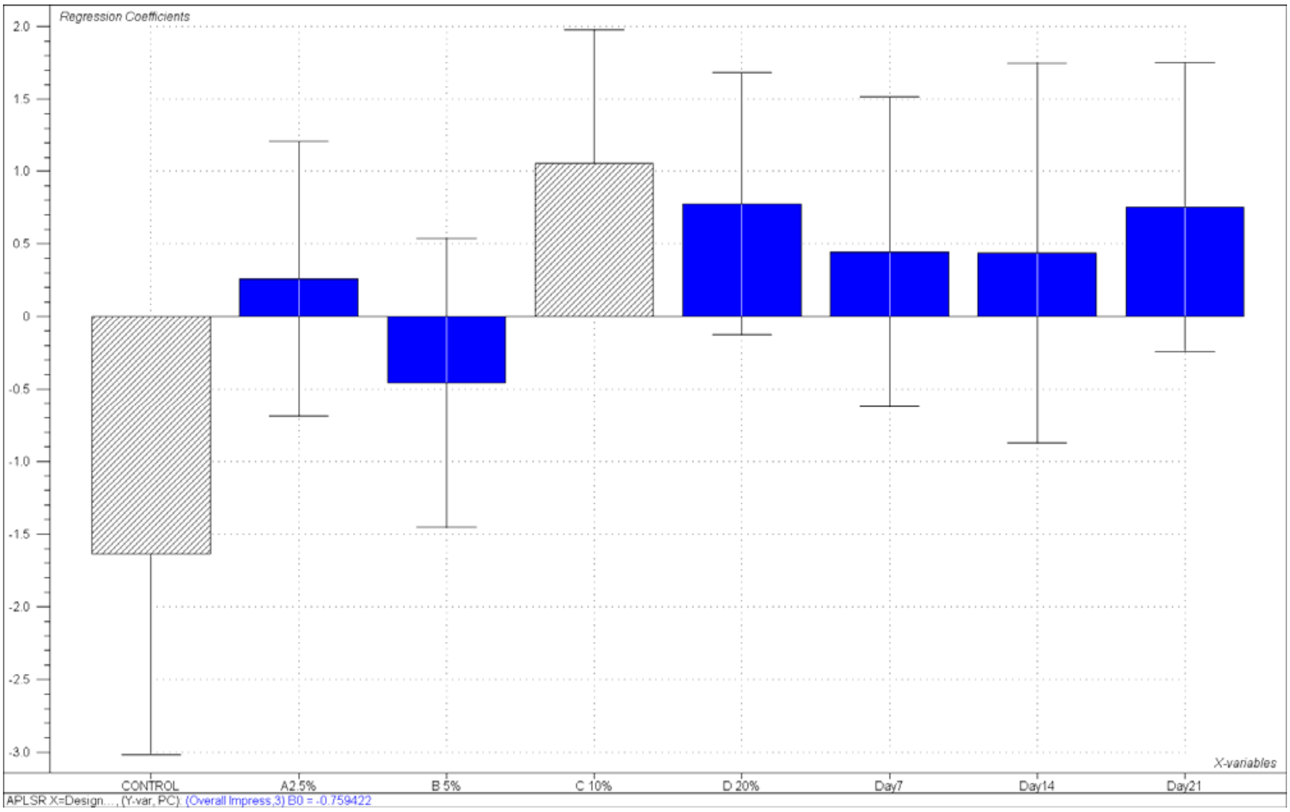

Figure 7. Regression coefficient plot of the hedonic descriptor *Overall Impression* from APLSR analysis where X=Design Main effects A, B, C, D = 2.5, 5, 10, 20 % chicory, respectively, and 7, 14, 21 = Days of chicory feeding prior to slaughter and Y= Level corrected sensory *Texture* descriptors averaged over assessors. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\,\hat{s}(\hat{b})$ (Martens & Martens 2001).

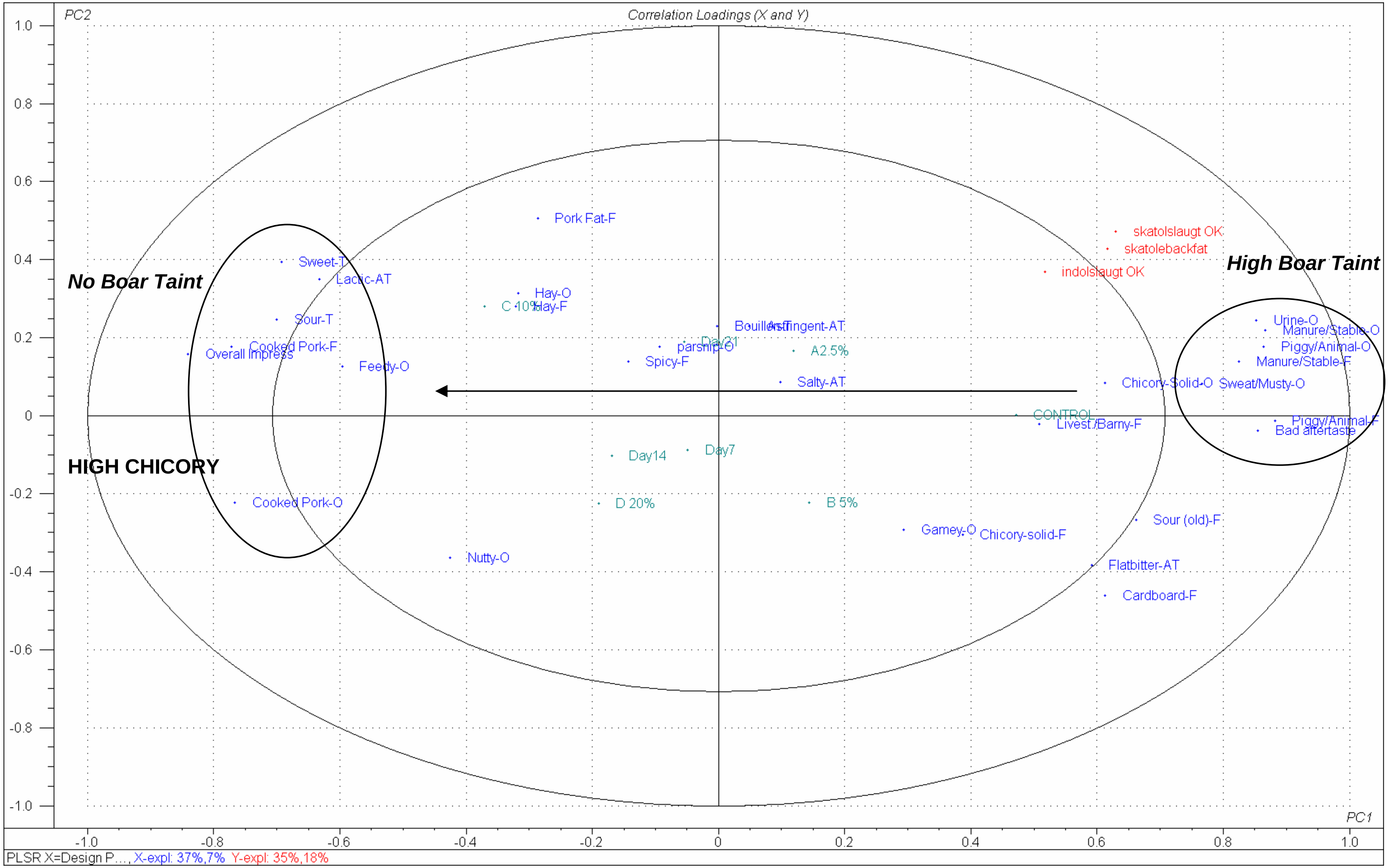

Figure 8. On average explained variance in PC1=35%, PC2=18%, thus, 2PCs = 53%. Correlation loadings plot derived from APLSR where X = Design main effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Level corrected sensory descriptors (29), plus *Overall Impression*, averaged over assessors versus Y= Selected chemical measurements, *Skatole* and *Indole in blood* at slaughter and *Skatole in back fa*t. The model indicated 2 significant PCs with full cross validation. Ellipses represent r^2 = 50 and 100 %.

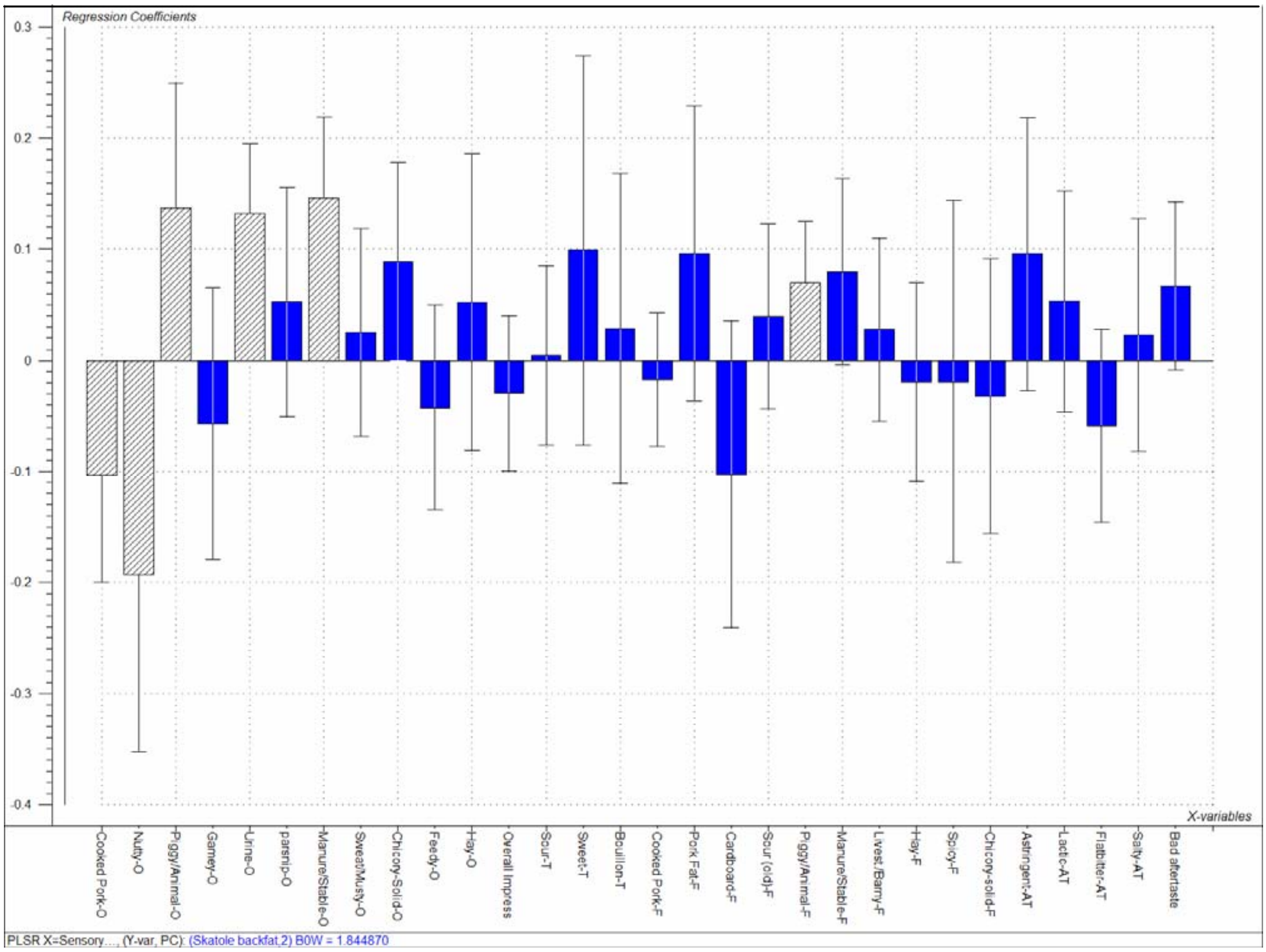

Figure 9. Regression coefficient plot *Skatole in back fat* from APLSR analysis where X = Design main effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Level corrected sensory descriptors (29), plus *Overall Impression*, averaged over assessors and Y= Selected chemical measurements, *Skatole* and *Indole in blood* at slaughter and *Skatole in back fat*. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\,\hat{s}(\hat{b})$ (Martens & Martens 2001).

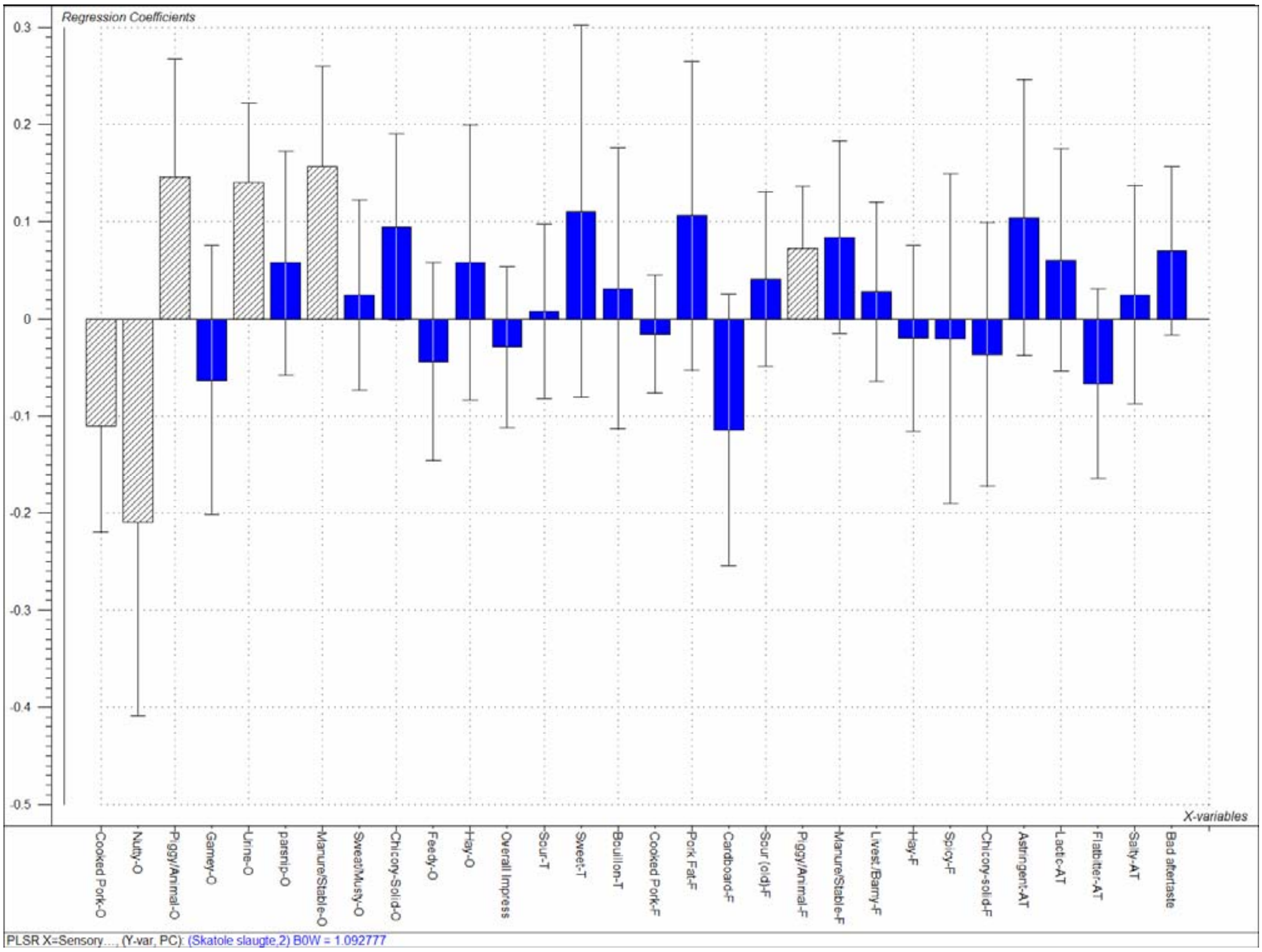

Figure 10. Regression coefficient plot *Skatole in blood at slaughter* from APLSR analysis where X = Design main effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Level corrected sensory descriptors (29), plus *Overall Impression*, averaged over assessors and Y= Selected chemical measurements, *Skatole* and *Indole in blood* at slaughter and *Skatole in back fat*. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\,\hat{s}(\hat{b})$ (Martens & Martens 2001).

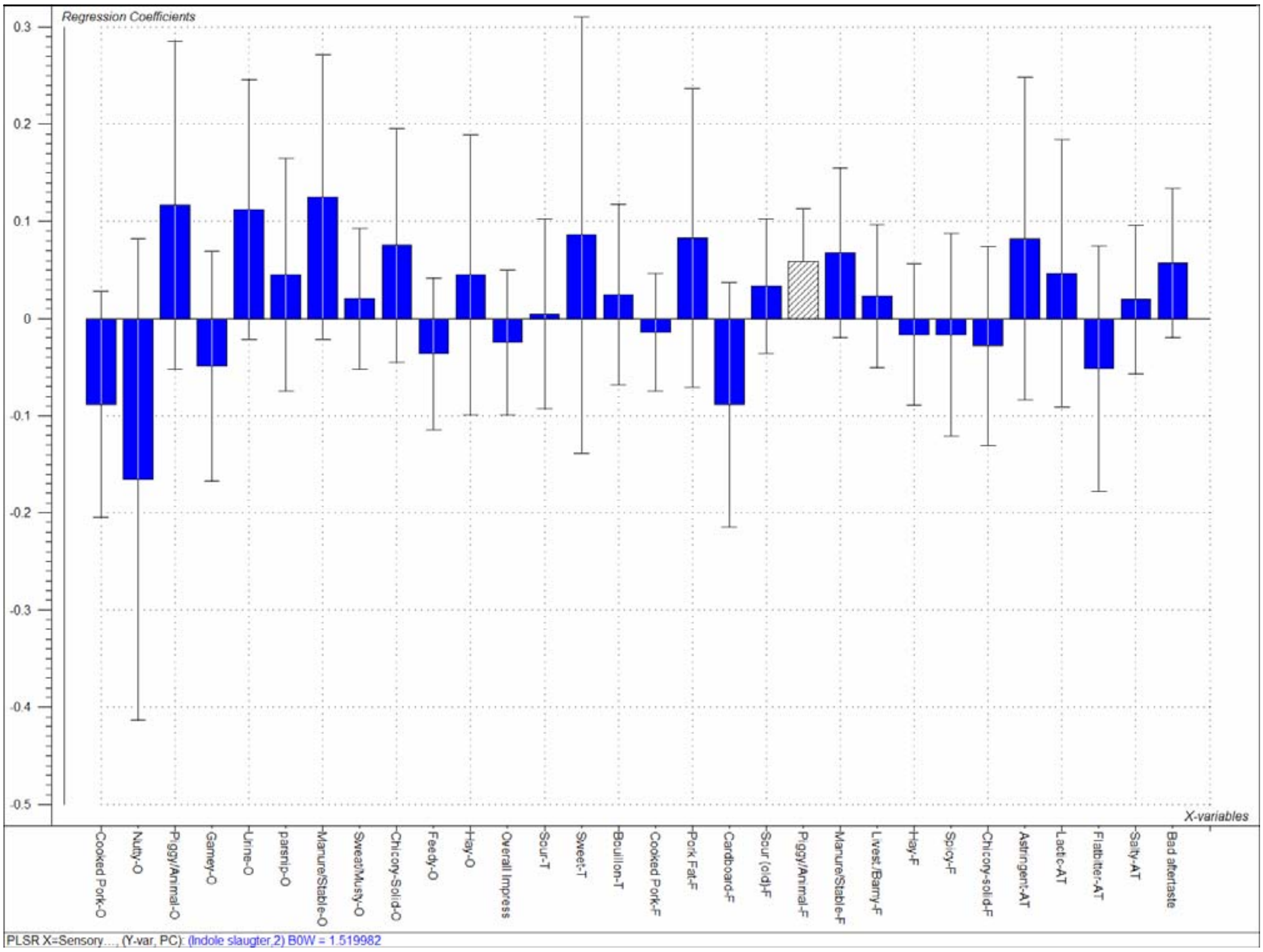

Figure 11. Regression coefficient plot *Indole in blood at slaughter* from APLSR analysis where X = Design main effects (Control, 2.5, 5, 10, 20% chicory and 7, 14 and 21 Days feeding) and Level corrected sensory descriptors (29), plus *Overall Impression*, averaged over assessors and Y= Selected chemical measurements, *Skatole* and *Indole in blood* at slaughter and *Skatole in back fat*. Striped bars indicate a significant difference (P<0.05). Error bars represent the regression coefficients ± 2 standard uncertainties estimated by leave-one-replicate-out jack-knifing, i.e. $\hat{b} \pm 2\hat{s}(\hat{b})$ (Martens & Martens 2001).