The analysis of the body composition changes during growth in pigs using the visual image analysis

Analýza jatečných těl prasat pomocí obrazové analýzy

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Abstract

The aim of the study was to estimate the live weight and lean meat percentage (LMP) using image analysis. The image analysis technique is based on finding certain anatomical proportions in pigs. The test was carried out with the use of 72 hybrids pigs. At the age of 120 and 170 days and at an ABW 64 and 110 kg, the animals were individually weighed and photographed. The total of 7 linear and 4 areal dimensions were measured on the live animals. Using correlation analysis, the relationship between average body weight (ABW), carcass quality and body measurements was determined. The study found higher positive correlation coefficients between the measured length dimensions and the weight of the main carcass parts. Video image analysis appears to be a suitable method for the body parts weight determination. However, the presumption of a reliable LMP estimation wasn't confirmed in any of the measurements.

Keywords: pig, video image analysis, carcass body, carcass weight, lean meat percentage

Abstrakt

Cílem práce bylo na základě obrazové analýzy odhadnout živou hmotnost a zmasilost prasat nalezením určitých anatomických rozměrů. Do testu bylo naskladněno 72 zvířat. Ve věku 120 dní a 170 dní byla zvířata individuálně vážena. Na živém zvířeti bylo změřeno 7 délkových a 4 plošné rozměry. Korelační analýzou byla určena závislost mezi hmotností, kvalitou jatečně upraveného těla a tělesnými rozměry. Byly zjištěny vyšší kladné korelační koeficienty mezi naměřenými délkovými rozměry a hmotností hlavních partií jatečného těla. Video analýza obrazu se jeví jako vhodná metoda pro určování hmotností jednotlivých částí těla. Ovšem předpoklad spolehlivého odhadu podílu svaloviny nebyl potvrzen ani v jednom měření.

Klíčová slova: prase, video analýza obrazu, JUT, porážková hmotnost, zmasilost

Detailní abstrakt

Cílem práce bylo na základě obrazové analýzy odhadnout živou hmotnost a zmasilost prasat nalezením určitých anatomických rozměrů. Na základě těchto výsledků by bylo možno určit optimální dobu porážky ve vztahu k systému SEUROP a maximálně využít produkční schopnost finálních hybridů prasat. Do testu bylo naskladněno 72 zvířat hybridní kombinace (ČBUxČL)x(BOxPN) ve věku 70 dní a průměrné hmotnosti 22 kg. Ve věku 120 dní a 170 dní při průměrné hmotnosti skupiny 64 kg a 110 kg byla zvířata individuálně vážena a fotografována z výšky 240 cm. Na živém zvířeti bylo změřeno 7 délkových a 4 plošné rozměry. Po dosažení průměrné živé hmotnosti 110 kg byla zvířata poražena a poté byla provedena jatečná disekce na jednotlivé partie jatečného těla. Korelační analýzou byla určena závislost mezi hmotností, kvalitou jatečně upraveného těla a tělesnými rozměry ve 120 a 170 dnech věku. Byly potvrzeny závislosti mezi 6 délkovými rozměry (L1, L2, L4, L5, L6, L7) zjištěnými ve 120 dnech věku a živou hmotností při porážce a hmotnosti jatečně upraveného těla a pravé půlky, korelační koeficienty se pohybovaly od 0,29 do 0,49. Závislosti mezi délkovými a plošnými rozměry změřenými ve věku 170 dní a složením jatečného těla byly pozitivní u hmotnosti jatečně upraveného těla a pravé půlky mimo rozměru L4. Dále byly zjištěny vyšší kladné korelační koeficienty mezi naměřenými délkovými rozměry a hmotností hlavních partií jatečného těla. Video analýza obrazu se jeví jako vhodná metoda pro určování hmotností jednotlivých částí těla. Ovšem předpoklad spolehlivého odhadu podílu svaloviny nebyl potvrzen ani v jednom měření.

Introduction

Growth is a fundamental property of every living organism and represents an important part of the animal’s development. Wagner et al. (1999) point to the fact, that growth of the body’s individual tissues is not uniform. During the first stage of the growth period, the body weight gain is made up mostly of muscle tissue. During the second phase, upon reaching carcass maturity, the live weight gain is mainly composed of fat. Fat tissue, when compared with muscle tissue, has a higher energy value and therefore its synthesis requires a higher amount of nutrients. This leads to an increased feed conversion ratio (FCR) and increased costs with increasing live weight (Sprysl et al., 2010). However, the increased cost isn’t reflected in a higher price of the slaughtered animal. It is a fact that with increasing ABW the LMP (and thus the price per kg) decreases. In order to achieve optimal economical parameters, it is necessary to select the optimum slaughter weight in relation to the LMP. An important parameter here represents the range of the carcass weight at which the breeder is not penalized. This range can vary greatly, for example in the Czech Republic the carcass weight without penalty is 82-100 kg (Sprysl et al., 2007). If the carcass weight doesn’t fall into this range, the final price is lower by 2.5-15%. This forces the farmers to select suitable animals for slaughter from several successive turnovers. Such practice, however, leads to an increase in labor costs.

At the moment there is a lot of attention paid to the automated systems used for animal selection. These systems are based on classification of animals depending on their body weight, measured while they are passing through selective pens. An improved method is represented by measuring the body size via image analysis (VIA) together with animal weighing.

In order to evaluate the carcass body, Branschied et al. (1999) and belly (Stupka et al. 2004) used the VIA method in their work. The basic principle of this method is to scan the carcass using a camera (Davies, 2009). The camera scans certain body parts and subsequently evaluates the lean meat content by computer analysis. This method was also used by Schofield et al. (1999), who worked with live animals and used it in order to predict the live weight. However due to the low quality of photos (bad lighting, low system lifespan) the use of this system proved to be problematic.

Automated camera systems have been undergoing a rapid development during the last decade (Parson et al., 2007; McFarlane et al., 2005). The current systems are able to measure the physical dimensions, nonetheless the relationship between the dimensions and body conformation hasn't been sufficiently described. Another important factor represents the selection of measurement locations. It is necessary to find easily identifiable dimensions with a sufficiently close relationship to the carcass composition (the LMP, weight and important parts proportion).

The aim of this work was to use image analysis to find suitable body measurements and shape indexes, on the basis of which it would be possible to predict the weight and carcass composition in pigs. This system would allow to select the pigs for slaughter according to their optimum slaughter weight and carcass quality (Stupka et al., 2008). That would lead to a better classification and therefore to improving the pork production economy.

The main hypothesis is that image analysis may be used for measuring the body dimensions of live animals, quality, i.e. the carcass value, can be predicted based on the body size.

Materials and Methods

The test was carried out at the experimental Pig Testing Station in Ploskov-Lány.

The test included a total amount of 72 test animals of the (LWS x PN) x (LWDxL) genotype. The animals were penned at an age of 80 days and ABW of 25 kg.

The weaners were divided into individual pens and penned in pairs. They were watered and fed ad-libitum. The complete feeding mixture (CFM) was a three component (wheat, barley, soy) one, supplemented with premix. The nutrient composition was 160g/kg of protein, 13.2 MJ / kg of MEP and 0.924 LYZP / MEP - ratio.

At the age of 120 and 170 days and at an ABW of 64 and 110 kg respectively, the groups of animals were individually weighed and photographed in the medial plane from the height of 2.400 mm.

The digital images, along with the NIS AR program (version 3.2) were used in order to determine 7 linear and 3 areal dimensions (Figure 1).

Linear dimensions: L1-shoulder width, L2-fore flank width, L3- central trunk width, L4-rear flank width, L5-ham width, L6-central trunk length, L7-total body length (Doeschl-Wilson et al., 2005).

Areal dimensions: A1-shoulder area, A2-central trunk area, A3-ham area, A4-total body area.

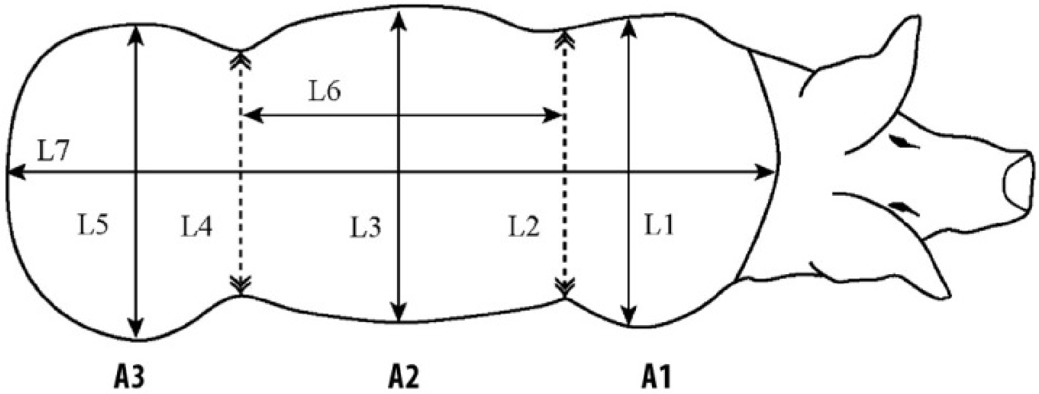

Figure 1. Linear and areal dimensions determined at the age of 120 and 170 days (Doeschl-Wilson et al., 2005)

Obrázek 1. Délkové a plošné rozměry stanvené ve věku 120 a 170 dnů (Doeschl-Wilson et al., 2005)

Results and Discussion

Table 1 shows the results of determining the linear and areal dimensions at the age of 120 and 170 days.

Apart from the absolute values of the measured dimensions, it is interesting to compare their variability in individual animals. The results show the maximum variability (maximum SD) in the dimensions L7 (total body length) and L6 (trunk central length) in both of the observed weights. These differences are also emerging in the corresponding areal dimensions, namely A4 (total body area) and A2 (fore flank area). Table 1 also shows index of dimension changes for the measurements taken at the age of 170 days, as compared to the ones taken at 120 days of age.

When comparing the body proportions gain it is evident, that particular length proportions increased at an interval of 2.6 to 14.2 %, with the highest index being observed in the L2 (fore flank width) and L1 (shoulder width) dimensions. On the other hand, the lowest proportions gain was observed in the L7 (total body length) dimension. Regarding the areal dimensions, the highest increase was demonstrated in the A2 (central trunk area) dimension. With the increasing age of the animal almost all of the body proportions increased as well, with the exception of the total body length and shoulder area, which remained in essence unchanged.

Table 1.Observed values of the pig body measurements at the age of 120 and 170 days.

Tabulka 1. Délkové a plošné rozměry měřené ve věku 120 a 170 dnů

		120 days		170 days		index 120/170
		mean	sd	mean	sd	
L1	mm	250.5	21.8	285.1	19.3	113.8
L2	mm	234.4	18.9	267.7	18.1	114.2
L3	mm	243.9	17.6	272.5	16.7	111.7
L4	mm	224.9	17.6	254.0	15.8	112.9
L5	mm	268.0	19.1	289.3	13.7	107.9
L6	mm	314.6	34.1	340.5	28.1	108.2
L7	mm	731.4	61.4	750.3	39.1	102.6
A1	cm^2	443.0	81.0	439.1	70.5	99.1
A2	cm^2	750.5	108.4	901.4	100.5	120.1
A3	cm^2	544.5	85.7	613.2	54.9	112.6
A4	cm^2	1738.0	244.2	1953.7	163.9	112.4

The total body length reached only 3% of the total gain. Similar results were published by Kernerová et al., (2006), who state that the intensive growth period takes place during the first three months of the pig's life and then starts do decline until the 7th month of age. On the other hand, Wagner et al. (1999) described the change of animal proportions in this age range to reach from 10 % to 13 %. The abdominal area increased by 20 % and the ham area by 12 %, which is in accordance with the results published by Kernerová et al., (2006). These authors also point out that not only the initial length increases, but there is also a significant increase in the size of the abdomen and the ham. Doeschl-Wilson et al. (2005) state that the L3 dimension is dramatically affected by the digestive tract content.

The table 2 shows that the study found strong positive correlations between the body proportions and live weight at 120 and 170 days of age, cold carcass body weight, right half carcass weight and total weight of the joint. Further positive correlations were found for the weight of individual carcass body parts. Concerning the weight of the neck and the shoulder there were also strong positive correlations found with the exception of the L6 (cental trunk length) dimension. The same finding applies also to the total weight of the ham and the belly, with the exception of the L6 and L7 dimensions. On the other hand, there were weak negative correlations observed for the lean meat share in the half pork carcass, mainly in the L4 (rear flank) dimension.

A positive finding based on the results of our observation is the fact, that at the age of 120 days (weight of about 64kg) there were already some high correlations with the body weight reached at the age of 170 days. However, at the age of 120 days there was no relationship between the measured propotions and the lean meat share. The same conclusion was also reached by Doeschl-Wilson et al. (2005).

Table 2. Correlative coefficients between the observed measurements and selected quantitative indicators of carcass body at the age of 120 days

Tabulka 2. Korelační koeficienty mezi měřenými ukazately měřenými ve 120 dnech a parametry jatečné hodnoty

		L1	L2	L3	L4	L5	L6	L7	A1	A2	A3	A4
Weight at 120 days	kg	0.48	0.47	0.49	0.43	0.48	0.22	0.41	0.47	0.41	0.47	0.5
Weight at 170 days	kg	0.36	0.37	0.39	0.38	0.42	0.18	0.32	0.35	0.35	0.39	0.41
Carcass weight	kg	0.34	0.35	0.36	0.34	0.39	0.15	0.29	0.33	0.3	0.37	0.38
Weight of the right half	kg	0.34	0.34	0.37	0.33	0.4	0.15	0.29	0.34	0.31	0.37	0.38
Lean meat content - ZP	%	-0.02	-0.04	0.01	-0.05	-0.01	0.03	0.05	0	0.01	0.05	0.02
Lean meat content - FOM	%	-0.17	-0.21	-0.12	-0.25	-0.18	0.01	-0.08	-0.23	-0.06	-0.15	-0.16
Height of the backfat 1	mm	0.06	0.07	0.12	0.12	0.02	-0.04	-0.02	0.04	0.05	0	0.03
Height of the backfat 2	mm	0.13	0.16	0.05	0.12	0.09	0.15	0.09	0.14	0.13	0.02	0.11
Height of the backfat 3	mm	0.12	0.16	0.13	0.23	0.15	0.07	0.08	0.11	0.13	0.09	0.13
Ham total	kg	0.31	0.29	0.33	0.31	0.37	0.09	0.2	0.29	0.25	0.29	0.31
Ham meat-bone	kg	0.06	-0.05	0.09	0.01	0.13	-0.04	-0.04	0.05	0.09	0.01	0.06
Belly whole	kg	0.22	0.26	0.28	0.26	0.26	0.08	0.2	0.22	0.21	0.28	0.27
Neck whole	kg	0.39	0.36	0.42	0.33	0.34	0.18	0.39	0.41	0.34	0.35	0.41
Neck meat	kg	0.23	0.14	0.21	0.08	0.08	-0.12	0.07	0.13	0.03	0.13	0.12
Shoulder whole	kg	0.34	0.31	0.31	0.32	0.41	0.12	0.27	0.32	0.25	0.38	0.35
Shoulder meat	kg	-0.02	-0.09	-0.05	-0.08	0.04	-0.12	-0.1	-0.1	-0.06	0.02	-0.06
Joint whole	kg	0.36	0.36	0.37	0.31	0.39	0.26	0.36	0.34	0.38	0.39	0.42
Joint meat	kg	0.25	0.21	0.21	0.08	0.18	0.08	0.23	0.2	0.19	0.26	0.26
Main meat parts	kg	0.13	0.04	0.11	0.01	0.14	-0.04	0.04	0.08	0.08	0.11	0.11
Main meat parts	%	0.13	0.02	0.13	-0.02	0.2	-0.09	0.16	0.16	-0.01	0.18	0.13
Ham meat	%	0.02	-0.11	0.09	-0.01	0.18	-0.07	0	0.1	0.02	0	0.05
Neck meat	%	0.23	0.15	0.22	0.07	0.06	-0.19	0.14	0.19	-0.08	0.18	0.1
Shoulder meat	%	-0.11	-0.17	0.14	-0.15	0.04	-0.18	-0.08	-0.14	-0.2	0.03	-0.13
Joint meat	%	0.29	0.26	0.25	0.08	0.21	0.09	0.39	0.3	0.16	0.36	0.32

Table 3 shows the correlation coefficients of the measurements obtained at the age of 170 days and the selected carcass value parameters. The study found similar trends as the ones observed at the age of 120 days, with the exception of the L4 dimension. There were higher correlation values found for the dimensions L1, L2 and L3, obtained by measuring the height of backfat in the plane of the bissection. Concerning the total weight of the ham, there were positive correlations found for the L1, L6 and L7 dimensions. The weight of the meat of the ham was influenced by the L1, L2, L3, L6 and L7 dimensions. The only dimensions that showed no influence on the total weight of the belly were the L1 and L4. The weight of the neck showed correlations for the L1, L2, L6 and L7 dimensions, however the weight of the meat of the neck was influenced only by the L1 and L7 dimensions. The total weight of the shoulder and the weight of the meat in the shoulder showed highest correlations between the measured values, with the exception of the dimension L6. The weight of the joint was influenced by the L1, L2, L5, L6 and L7 dimensions, while the weight of the meat in the joint was affected by the L1, L5, L6 and L7 dimensions. The weight of the main meat parts was influenced by all of the monitored measurements, except for the L4 dimension. The percentage content of the main meat parts, ham, shoulder, neck, joint and the lean meat share showed negative correlations.

Doeschl-Wilson et al. (2005) carried out a similar observation and reached a conclusion that the correlations are sufficient in order to determine the individual main meat parts. Especially the L5 dimension proved to have a high predictive value concerning the total content of the main meat parts.

Table 3: Correlation coefficients between the obtained measurements and selected quantitative indicators of carcass body at the age of 170 days

Tabulka 3. Korelační koeficienty mezi měřenými ukazately měřenými ve 170 dnech a parametry jatečné hodnoty

		L1	L2	L3	L4	L5	L6	L7	A1	A2	A3	A4
Weight at 120 days	kg	0.3	0.31	0.28	0.29	0.29	0.24	0.34	0.25	0.22	0.08	0.27
Weight at 170 days	kg	0.35	0.36	0.29	0.22	0.32	0.25	0.39	0.29	0.24	0.16	0.33
Carcass weight	kg	0.34	0.33	0.26	0.17	0.29	0.28	0.39	0.24	0.23	0.14	0.29
Weight of the right half	kg	0.32	0.31	0.25	0.14	0.28	0.3	0.4	0.23	0.23	0.13	0.28
Lean meat content - ZP	%	-0.09	-0.27	-0.24	-0.24	-0.17	0.16	0.03	-0.27	-0.06	-0.11	-0.19
Height of the backfat 1	mm	0.25	0.33	0.33	0.12	0.13	0.17	0.09	-0.11	0.23	0.13	0.14
Height of the backfat 2	mm	0.29	0.35	0.25	0.15	0.15	0.05	0.1	0.13	0.12	0.1	0.17
Height of the backfat 3	mm	0.23	0.39	0.32	0.2	0.21	-0.01	0.08	0.18	0.16	0.24	0.26
Ham total	kg	0.31	0.24	0.21	0.08	0.18	0.27	0.32	0.15	0.18	0.05	0.19
Ham meat-bone	kg	0.43	0.25	0.31	0.18	0.2	0.27	0.25	0.13	0.25	0.06	0.23
Belly whole	kg	0.21	0.27	0.25	0.17	0.26	0.34	0.43	0.21	0.31	0.14	0.32
Neck whole	kg	0.32	0.25	0.17	0.01	0.17	0.25	0.32	0.08	0.13	0.04	0.13
Neck meat	kg	0.28	0.14	0.18	-0.01	0.12	0.17	0.34	0.15	0.12	0.19	0.2
Shoulder whole	kg	0.44	0.42	0.35	0.31	0.42	0.1	0.35	0.37	0.15	0.31	0.36
Shoulder meat	kg	0.61	0.37	0.3	0.25	0.4	0.19	0.3	0.27	0.23	0.35	0.37
Joint whole	kg	0.27	0.26	0.18	0.11	0.28	0.27	0.35	0.2	0.19	0.15	0.25
Joint meat	kg	0.36	0.19	0.14	0.12	0.32	0.27	0.35	0.25	0.21	0.13	0.28
Main meat parts	kg	0.48	0.27	0.27	0.17	0.3	0.26	0.34	0.23	0.24	0.18	0.3
Main meat parts	%	-0.11	-0.33	-0.2	-0.17	-0.12	-0.17	-0.22	-0.15	-0.25	-0.2	-0.28
Ham meat	%	-0.04	-0.21	-0.04	-0.08	-0.15	-0.06	-0.19	-0.18	-0.11	-0.26	-0.23
Neck meat	%	-0.23	-0.32	-0.19	-0.3	-0.23	-0.2	-0.1	-0.14	-0.28	-0.1	-0.26
Shoulder meat	%	0.08	-0.15	-0.13	-0.04	0.04	-0.24	-0.22	-0.06	-0.2	0.07	-0.13
Joint meat	%	-0.13	-0.28	-0.25	-0.16	0.01	-0.06	-0.08	0.03	-0.17	-0.15	-0.17

Conclusions

Based on the observed measuring can be stated that the differences between measuring MLLT and backfat during first and repeated injection is very low; the accuracy of the LM estimate indicates correlation r = 0.943. LM pigs´ estimation in the CR compared to the SR is, in the case of repeated injection, always higher. In regard to this study, repeatability differences and the level of LM estimate correlations it is obvious that the SR measuring of the pigs is carried out more carefully (0.964 vs. 0.930). The CR operators in comparison to those of the SR reported, in the case of repeated injections, a considerable variability, exceeding their recommended values for deviations. The CR equipment in comparison to those of the SR recognized, over repeated measurements variables with lower reliability (0.20-0.30, vs. 0-0.16%), which may be associated with differences between copies of the same equipment.

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References

Branscheid, W., Horeth, R., Dobrowolski, A., (1999) The Video Image Analysis - a methode for the determination of the commercial value of pig carcasses. Fleischwirtschaft, 79(12), 93–95.

Davies, E. R., (2009) The application of machine vision to food and agriculture: a review. Imaging Science Journal, 57(4), 197–217.

Doeschl-Wilson, A. B., Green, D. M., Fisher, A. V., Carroll, S. M., Schofield, C. P., Whittemore, C. T., (2005) The relationship between body dimensions of living pigs and their carcass composition. Meat Science, 70(2), 229–240.

Kernerova, N., Vaclavovsky, J., Matousek, V., Hanykova, Z., (2006) The use of performance test parameters for selection of gilts before their placement into breeding. Czech Journal of Animal Science, 51(6), 253–261.

McFarlane, N. J. B., Wu, J., Tillett, R. D., Schofield, C. P., Siebert, J. P., Ju, X., (2005) Shape measurements of live pigs using 3-D image capture. Animal Science, 81(3), 383–391.

Parsons, D. J., Green, D. M., Schofield, C. P., Whittemore, C. T., (2007) Real-time control of pig growth through an integrated management system. Biosystems Engineering, 96(2), 257–266.

Schofield, C.P., Marchant, J.A., White, R.P., Brandl, N., Wilson, M., (1999) Monitoring Pig Growth using a Prototype Imaging System. Journal of Agriculture, 72(3), 205–210.

Sprysl, M., Citek, J., Stupka, R., (2010) Interaction of selected production indicators of the economics of pork production. Czech Journal of Animal Science, 55(1), 1–10.

Sprysl, M., Citek, J., Stupka, R., Valis, L., Vitek, M., (2007) The accuracy of FOM instrument used in on-line pig carcass classification in the Czech Republic. Czech Journal of Animal Science, 52(6), 149–158.

Stupka, R., Citek, J., Sprysl, M., Okrouhla, M., Kures, D., Likar, K., (2008) Effect of weight and sex on intramuscular fat amounts in relation to the formation of selected carcass cuts in pigs. Czech Journal of Animal Science, 53(12), 506–514.

Stupka, R., Sprysl, M., Pour, M., (2004) Analysis of the formation of the belly in relation to sex. Czech Journal of Animal Science, 49(2), 64–70.

Wagner, J. R., Schinckel, A. P., Chen, W., Forrest, J. C, Coe, B.L., (1999) Analysis of body composition changes of swine during growth and development. Journal of animal science 77(6), 1442–1466.