Prediction of physiological phosphorus content in pork meat

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Introduction

Within the frames of control of meat products' quality, the content of the so-called phosphorus added (PA) is determined; it is added to meat as food additive in a form of polyphosphate preparation. Its aim is to bind water and improve consistency of the product. The analytical methods are not suitable for differentiation between the added phosphorus and natural phosphorus content, present in meat. As physiological phosphorus of animal tissues is a constituent of protein structures, its concentration in meat products may be estimated from the concentration of protein. In Polish Standard, amended in 1999 (1), the percentage of phosphorus added to meat product (PA) is calculated from the following formula:

$$PA=2.29\ (PC - 0.01\ BC) \qquad (1)$$

where:
PC is total phosphorus content, determined by analytical method;
BC is crude protein content, determined by Kjeldahl method, adopting the coefficient of protein nitrogen calculation into protein, being equal to 6.25;
2.29 is the coefficient of phosphorus calculation into P_20_5.

The coefficient 0.01 was established as the mean of the results of experimental studies on phosphorus: protein content ratio, being conducted in the years 1990 – 1991 (2). In the mentioned studies, the following results were obtained for pork meat: ham muscles – 0.0104 (dark muscles) and 0.0101 (bright muscles), musculus longissimus dorsi (loin) – 0.0097, shoulder muscles – 0.0100, neck – 0.0101 and belly – 0.0095.

In connection with the information obtained from the industry, concerning the cases of calculation of the phosphorus content in the products, to which polyphosphates were absolutely not added, it was decided to conduct the new studies on relationship between physiological phosphorus concentration and protein content, employing well-characterized research material, representing pigs from the national population with the increased meatiness (3).

Material and methods

Experimental material included 36 carcasses of pigs differentiated in respect of gender (15 hogs and 21 gilts) with post-slaughter weight (PSW) from 62.2 kg to 95.2 kg and meatiness from 43.5% to 59.8%, measured as the lean meat percentage (LMP), determined on the ground of dissection, being performed by the method of Walstra and Merkus (4). The carcasses were cut into particular elements: loin (ML), ham (MH), shoulder (MS), neck (N), belly (B), jowl (J), shoulder hock (HS) and leg hock (HL). The muscles of loin, ham and shoulder and the whole of tissues of the remaining elements were subjected to tests, and the following determinations were performed: total phosphorus content (PC) – by weight method, after converting it to choline phosphomolybdate, crude protein content (BC) – by Kjeldahl method and collagen content (CC) – by hydroxyproline method. The content of muscular protein (BM) was calculated from difference BC – CC, and indices in form of ratio: phosphorus content: crude protein content (PBC) =PC x BC^{-1} and phosphorus content: muscular protein content (PBM)= PC x BM^{-1}, and collagen content: total protein content (CBC) = (CC x BC^{-1})×100%.

Results and discussion

The preliminary analysis of the results of tests revealed a lack of significant differentiation of particular elements due to the gender of animals; it allowed showing them together in the table.

Table. Results of studies

Paramiters		Phosphorus Content	Crude Protein Content	Collagen Content	Relation (CC×BC $^{-1}$) × 100%	Muscular Protein Content	Relation PC×BC^{-1}	Relation PC×BM^{-1}
Carcass Cuts		PC % ×10^{-1}	BC %	CC %	CBC %	BM %	PBC [-] × 10^{-2}	PBM [-] × 10^{-2}
Loin ML	$\bar{x}$	2.03	21.4	0.9	4.2	20.5	0.95	1.00
	S	0.06	1.2	0.2		1.3	0.05	0.05
Ham MH	$\bar{x}$	2.03	20.3	0.8	3.9	19.6	1.00	1.04
	S	0.09	1.2	0.1		1.2	0.06	0.06
Shoulder MS	$\bar{x}$	1.98	19.6	1.1	5.6	18.6	1.01	1.07
	S	0.07	1.0	0.2		1.2	0.05	0.06
Neck N	$\bar{x}$	1.64	17.0	1.3	7.6	15.7	0.97	1.05
	S	0.10	1.1	0.2		1.1	0.06	0.06
Belly B	$\bar{x}$	1.14	14.8	3.1	20.9	11.7	0.76	0.98
	S	0.12	1.5	0.5		1.5	0.09	0.08
Jowl J	$\bar{x}$	1.22	13.7	2.3	16.8	11.4	0.88	1.07
	S	0.17	1.6	0.5		1.8	0.08	0.09
Shoulder Hock HS	$\bar{x}$	1.27	19.3	6.1	31.6	13.2	0.65	1.05
	S	0.06	0.7	0.9		0.9	0.05	0.05
Leg Hock HL	$\bar{x}$	1.33	17.6	4.2	23.9	13.4	0.75	1.00
	S	0.06	0.8	0.7		0.8	0.04	0.06

It is easy to notice that together with the increase of collagen content in meat, phosphorus: total protein content (PBC) ratio is decreasing; it indicates that proteins of connective tissue do not bring or bring considerably less phosphorus to the system than muscular proteins do. It also results that total protein content itself is not a parameter suitable for predicting phosphorus content in meat products. Much smaller differentiation and lack of noticeable relationship of phosphorus: muscular protein ratio and collagen level, allowed supposing it would be easier to predict phosphorus content in meat, based on the content of muscular protein (BM) in meat. This speculation was confirmed by correlation calculus, being performed on individual results of determination of phosphorus content (PC), crude protein content (BC) and muscular protein content (BM) for all the examined samples. The regression equations have a following form:

$$PC=0.0104\ BC - 0.0274 \quad (2)$$

with coefficient of determination $R^2=0.585$ and standard error of estimation 0.0243 and

$$PC=0.0100\ BM + 0.0340 \quad (3)$$

with coefficient of determination $R^2=0.907$ and standard error of estimation 0.0115.

Significantly higher coefficient of determination $R^2=0.930$ and lower error of estimation 0.0100 is obtained when considering, besides of muscular protein, also collagen content in equation (3). Then, the equation has a following form:

$$PC=0.00880\ BM - 0.003845\ CC + 0.0311 \quad (4)$$

It should be, however, mentioned that the equation, although being correct from calculating viewpoint, has a doubtful chemical sense as it is difficult to imagine “negative phosphorus” and such phosphorus would accompany collagen, occurring in connective tissue of meat. It may be supposed that sing “ – “ in the equation (4) results from natural highly significant negative correlation between muscular protein (BM) and collagen (CC) in different tissues, constituting the composition of meat. It may be also supposed that the proteins of smooth muscles which accompany collagen in connective and fat tissue are also accompanied by other quantities of phosphorus than in case of proteins of striated skeletal muscles.

Statistically significant effect of meatiness and LMR post-slaughter weight of carcass PSW on total phosphorus content PC and PBM index was found.
The universal equation for predicting of physiological content in pork meat, being the detailed equation (4) has a following form:

$$PC=0.00895\ BM - 0.00366\ CC - 0.000257\ LMP - 0.000178\ PSW + 0.0578 \quad (5)$$

It explains 93.3% variability with standard error of estimation equal to 0.00985. Alternative equation, describing the same percent of variability with the same error has a following form:

$$PC=0.00895\ BC - 0.01260\ CC - 0.000296\ LMP - 0.000178\ PSW + 0.0570 \quad (6)$$

Conclusions

1. Any effect of pig gender on phosphorus content in meat was not found.
2. Variability of phosphorus content in meat of particular elements of carcass, making the univocal estimation of phosphorus content on the ground of protein analysis, was found.
3. It was found that determination of crude protein alone was not sufficient for predicting of physiological phosphorus content in pork meat and its products.
4. Satisfactory estimation of physiological phosphorus content in pork meat based on total protein and collagen content was obtained.
5. Influence of carcass meatiness and post-slaughter weight of pigs on relative and absolute phosphorus content in meat was demonstrated and considered in the universal equation of pigs on relative and absolute phosphorus content in meat was demonstrated and considered in the universal equation of estimating physiological phosphorus content in meat.

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