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EXAMINING THE EFFICIENCY OF THE SEMI SUBSTITUTION OF THE MAIZE WITH A BY-PRODUCTS OBTAINED BY MANUFACTURING VEGETABLES AND FRUITS IN MIXTURES FOR GROWING AND FATTENING PIGS. III. MEAT QUALITY

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Abstract

The aim of this experiment was examine the possibilities of the maize's substitution as an energetic nutrient with by-products obtained by manufacturing tomatoes, peppers and grapes in the nutrition of swine on the meat quality. Average Chemical Content of Muscle Tissue (ACCMT) about Water Content (WC), Ash Content (AC), Protein Content (PC) and Fat Content (FC) were (72.63%; 1.15%; 23.53%; 2.69%-K group), (73.01%; 1.12%; 23.62%; 2.25%-O-I group) and (72.78%; 1.08%; 23.26%; 2.15%-O-II group), respectively. No significant difference was observed in all three groups ($p>0.05$).

In the other side, Average Chemical Content of Fat Tissue (ACCFT), about WC, AC, PC, FC were (17.80%; 0.37%; 4.89%; 76.94%-K), (19.74%: 0.44%; 5.17%; 74.65%-O-I) and (21.24%; 0.42%; 6.01%; 72.33%-O-II), respectively. Significant difference on FC was observed in all three groups ($p<0.05$).

Technological properties or physical properties of meat about pH after slaughter; pH after cooling; Ability of Binding Water (ABW) and Meat Colour (MC) were (6.16; 5.61; 7.43cm^2; 64.60-K), (6.13; 5.53; 6.91cm^2; 60.93-O-I) and (6.10; 5.50; 6.41cm^2; 58.72-O-II), respectively. No significant difference was observed in all three groups ($p>0.05$).

Key words: *Meat quality, muscle tissue, fat tissue, technological properties*.

1. Introduction

The chemical content, i.e. the nutritional value of the meat is one of the principal parameters of the meat quality. During the fattening of the pigs, changes start to happen in their bodies, like fat deposition at the expense of water, the proteins decrease at a slower rate while the ash content is almost constant. The nutrition, size and composition of the meal, has a great effect over the chemical content of the meat.

Maričić [11] has done two experiments on feeding fattening pigs with standard composition of standard raw and chemical components. In the meat of the slaughtered pigs he found 74.22% water, 1.08% ash, 22.44% protein and 2.15% fat. Manojlović [10] has done two experiments on nutrition of Swedish Landrace and Great Yorkshire pig hybrids, using mixtures of standard composition of standard raw and chemical components. The water content in the meat of slaughtered pigs ranged 73.22-74.20%, protein 22.12-22.05% and fat 3.55-2.60%. Đurica [25] has done two experiments on nutrition of Sweedish Landrace pigs using mixtures of standard composition of standard raw and chemical components. The water content in the meat of slaughtered pigs was found 72.53%, 1.09% ash, 22.97% protein and 2.85% fat. Damnjanović [3] has done nutrition experiment on fattening pigs of 25-95 kg body weight, during 105 days in two phases (57 and 48 days). The water content in the meat of slaughtered pigs was about 74.96%, 1.13% ash, 23.53% protein and 0.52% fat. Šokarovski *et al.,* [22] have done nutrition experiment on fattening pigs using mixtures of standard composition of standard raw and chemical components. In the meat of the slaughtered pigs they found water content ranging 73.35-73.65%, 22.71-23.76% protein, 1.46-2.15% fat. Stanković *et al.,* [21] have done nutrition experiment on white meat and Durock cross breed pigs using mixture of standard composition of standard raw and

chemical components. The water content in the meat of the slaughtered pigs ranged 70.81-73.56%, 21.93-24.61% protein, 1.11-1.25% ash and 2.76-3.47% fat. The colour, tenderness, flavour and smell are the most important physico-chemical properties of the meat (Pribiš and Rede [17,18, 19]). Myoglobin is the basic pigment of the muscle tissue giving the colour of the meat. It represents 1% of the total protein in meat. Electrochemical reaction right after slaughter is quite high (>6), the glycogen content is still high, and the myofibrils are in a relaxed state. The muscle is sticky, doesn't exude water, it is slender and has darker colour.

According to the data from the literature, the electrochemical reaction of the meat of the fattening pigs is 5.67-5.87% (Manojlović, [10]), 5.92% (Damnjanović, [2]), 5.90 (Maričić, [11]) and 5.59 (Đurica, [25]). The colour of the meat, in the same literature, is in the limit of 62.00-65.61 (Manojlović, [10]), 61.41 (Damnjanović, [2]), 62.56 (Maričić, [11]) and 46.87 (Đurica, [25]). Some authors have investigated the water binding ability of the water, and it ranged 7.93-8.45 (Živković *et al.,* [24]), 8.07-8.81 (Kralik *et al.,* [9]), 6.60-7.31 (Domaćinović *et al.,* [4], 6.71-7.23 (Petričević *et al.,* [13]), 9.57-9.66 (Petričević *et al.,* [14]), 6.70 (Kosovac *et al.,* [8]) and 7.60-8.40 (Urbanczyk *et al.,* [23]).

2. Materials and Methods

With the objective to examine the possibility of maize's substitution with by-products obtained by manufacturing tomatoes, peppers and grapes in the nutrition of swine an experiment by group control system was carried out on the productive results and health conditions at the producing condition on the pigs farm ZZ "Edinstvo", village Chelopek, Tetovo region, R. Macedonia. The experiment was carried out on growing and fattening pigs about 60 days old and with average weight of 27.00+0.64-27.69$\pm$0.71 kg. For the experiment we used mongrels from Suisse and Dutch breed with equalized genetic potential. Each group consisted of equal number of males and females.

The experiment of the growing and fattening pigs was carried out on 48 pigs divided into 3 groups, each group consisting of 8 pigs of different sex. The experiment lasted 100 days in 2 phases, each lasting 50 days. The weight of the pigs and the amount of consumed feed were measured on a regular basis during the experiment. The growing and fattening pigs were fed with suitable whole mixture with standard composition of standard raw and chemical components (Table 1). Two mixtures used during the experiment completely satisfied the needs of the pigs (AEC [1]; NRC [12]; Regulation [16]). Those are whole mixture for growing and fattening pigs for 1-50 days, and whole mixture for fattening pigs for 50-100 days experimental period.

The main aim of the research was to determine how the maize substitution with by-products, obtained by manufacturing tomatoes, peppers and grapes in the nutrition of growing and fattening pigs, influence the production results and the pig's health condition and to determine weather it is practical to use mixtures with by-products in the nutrition of pigs. To this end minimal corrections were made in the mixtures. The experimental pigs from the experimental control group were fed with mixtures not containing any of the above mentioned by-products, whereas the experimental groups were fed only with mixtures where maize was substituted with different quantities of the specified by-products. There are 6, consisting 9%, from the examined by-products in the mixtures for swine nutrition.

Table 1. Composition of mixture for nutrition of growing and fattening pigs, [%]

Feeds	from 25-60 kg			from 60-100 kg		
	K	O-I	O-II	K	O-I	O-II
Maize	61.20	55.20	52.20	63.90	57.90	54.90
By product of tomatoes	-	2.00	3.00	-	2.00	3.00
By product of peppers	-	2.00	3.00	-	2.00	3.00
By product of grapes	-	2.00	3.00	-	2.00	3.00
Wheat bran	12.00	12.00	12.00	15.00	15.00	15.00
Soya bean meal	16.00	16.00	16.00	10.00	10.00	10.00
Sunflower meal	5.00	5.00	5.00	7.00	7.00	7.00
Fish meal	1.00	1.00	1.00	-	-	-
Soya oil	2.00	2.00	2.00	1.00	1.00	1.00
Limestone	1.20	1.20	1.20	1.40	1.40	1.40
DCaP	0.70	0.70	0.70	0.70	0.70	0.70
Salt	0.40	0.40	0.40	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50	0.50

In the end of the experiment, the pigs were transported to the slaughter, afterwards the randman and the meat rate of the halves were measured at the slaughter line. The experimental animals were individually weighed before slaughter, than the warm halves were measured after slaughter. The meat production or the randman is calculated by deviding the weight of the warm halves with the weight of the individuals before slaughter. After refrigerating the halves on 4°C during 24 hours, separation of the halves to their basic parts has been done and the relative and absolute rate of the parts in the halves were measured. Every part has been separated and its muscle, fat and bone tissue measured.

Chemical analysis of the muscle and fat tissues was done using standard procedures and methods (Regulation [15]). The moisture, fat and ash content was determined using standard methods (ISO [5,6,7]). The protein content was determined by Kjeldal method using KjelFoss Automatic 16210.

The physical proterties of the meat were measured using standard methods (Ristić [20]): Electrochemical reaction was measured with Potentiometric pH-meter ULTRA X-TM 5, by directly plunging the electrode in meat; water binding ability was measured with filter-press method by Grau-Hamm, based on squeezing the free water from the meat and planimetric measuring of the surface; colour determination with Gofo photometer that measures the intensity of the light that has been reflected from the meat sample, passed through filter system and photo cells and finally gets registered on the microampermeter as an electrical impulse.

3. Results and Discussion

The chemical content of the muscle tissue (Table 2) shows similar values for water, ash and protein, while the differences are noticed in the fat content. Statistically, the differences are not significant (p>0.05).

Table 2. Chemical content of muscle tissue (CCMT), [%]

Groups		Measures of variation					
	n	X	±	Sx	Sd	Cv	Iv
Water							
K		72.63		0.32	0.72	0.99	71.00-73.18
O-I		73.01		0.31	0.70	0.96	71.80-7.70
O-II		72.78		0.23	051	0.70	72.17-73.60
Ash							
K		1.15		0.02	0.04	3.96	1.05-1.18
O-I		1.12		0.02	0.05	4.74	1.04-1.18
O-II		1.08		0.02	0.04	3.21	1.03-1.14
Protein							
K		23.53		0.19	0.43	1.88	22.41-23.68
O-I		23.62		0.24	0.55	2.28	22.48-23.90
O-II		23.26		0.29	0.65	2.79	22.21-24.05
Fat							
K		2.69		0.21	0.48	16.82	2.36-3.12
O-I		2.25		0.18	0.40	17.13	1.90-3.06
O-II		2.15		0.16	0.35	14.94	1.93-2.83

The chemical content, i.e. the nutrition value, is a very important property of the meat quality. The nutrition, especially the size and composition of the ration, have great effect over the chemical content of the meat. The water content in the meat of the experimental animals was 71.63±0.72-73.01±0.70 and the differences were not statistically significant (p>0.05). There is a great similarity in our results on water content compared to those from the literature: 74.22% (Maričić [11]), 73.22-74.20% (Manojlović [10]), 72.53% (Đurica [25]), 74.96% (Damnjanović [3]), 73.35-73.65% (Šokarovski *et al.,* [22]) and 70.81-73.56% (Stanković *et al.,* [21]). The ash content in the meat of the experimental animals was 1.08±0.04-1.15±0.04, but the differences were not statistically significant (p>0.05). There is a great similarity in our results on ash content compared to those from the literature 1.08% (Maričić [11]), 1.09% (Đurica [25]), 1.13% (Damnjanović [3]) and 1.11-1.25% (Stanković *et al.,* [21]). The protein content in the meat of the experimental animals was 23.26±0.65-23.62±0.55, but the differences were not statistically significant (p>0.05). There is a great similarity in our results on protein content compared to those from the literature: 22.44% (Maričić [11]), 22.12-22.05% (Manojlović [10]), 22.97% (Đurica [25]), 23.53% (Damnjanović [3]), 22.71-23.76% (Šokarovski *et al.,* [22]) and 21.93-24.61% (Stanković *et al.,* [21]). The fat content in the meat of the experimental animals was 2.15±0.35-2.69±0.48, with a declining tendency, though the differences were not statistically significant (p>0.05). There is a great similarity in our results on fat content compared to those from the literature: 2.15% (Maričić [11]), 3.55-2.60% (Manojlović [10]), 2.85% (Đurica [25]), 1.46-2.15% (Šokarovski *et al.,* [22]) and 2.76-3.47% (Stanković *et al.,* [21]).

The chemical content of the fat tissue (Table 3), despite the similar content of ash and protein, has a higher water content on the expense of the fat content, and the differences are statistically significant (p<0.05).

Table 3. Chemical content of fat tissue (CCFT), [%]

Groups		Measures of variation					
	n	X	±	Sx	Sd	Cv	Iv
Water							
K		17.80		0.10	0.29	1.39	17.01-18.22
O-I		19.74		0.08	0.23	1.09	19.03-20.05
O-II		21.24		0.13	0.38	1.78	20.86-22.01
Ash							
K		0.37		0.02	0.07	6.48	0.29-0.344
O-I		0.44		0.02	0.05	5.14	0.35-0.51
O-II		0.42		0.02	0.05	5.38	0.32-0.48
Protein							
K		4.89		0.06	0.17	1.67	4.45-5.21
O-I		5.17		0.08	0.23	2.35	4.79-5.55
O-II		6.01		0.10	0.28	2.82	5.76-6.24
Fat							
K		76.94	a	1.16	3.28	4.20	75.92-77.31
O-I		74.65	b	1.39	3.92	5.14	73.40-75.30
O-II		72.33	b	1.02	2.90	3.76	71.55-72.82

[a, b] p<0.05

Bigger differences were noticed in chemical content of the abdominal fat tissue. Beside the similar protein and ash content, the fat tissue contains more water on the expense of fat, and the difference is significant ($p<0.05$). Summarizing the results of the experiment, it can be stated that partial substitution of the maize with by-products from the manufacturing of grapes, tomatos and peppers has no negative effect on the chemical content of the meat of growing and fattening pigs. At the same time, positive effect on the chemical content of the fat was noticed.

The technological properties, i.e. physical properties, of the meat from the experimental pigs are shown in Table 4. It can be seen that the pH of the meat after slaughter and after refrigeration has similar values, and the differences between the groups are not significant ($p>0.05$). Comparing the groups in sequence, the water binding ability is in a slight decline, and the colour is getting darker. The differences in the values between the experimental groups are not statistically significant ($p>0.05$).

Table 4. Technological properties or physical properties of meat

Groups		Measures of variation					
	n	X	±	Sx	Sd	Cv	lv
pH after slaughter							
K		6.16		0.02	0.06	1.03	5.92-6.25
O-I		6.13		0.02	0.06	1.10	6.02-6.24
O-II		6.10		0.02	0.06	1.11	5.95-6.18
pH after cooling							
K		5.61		0.01	0.03	0.69	5.55-5.65
O-I		5.53		0.02	0.06	1.11	5.52-5.68
O-II		5.50		0.02	0.06	1.10	5.40-5.58
Ability of Binding Water (ABW) cm^2							
K		7.43		0.06	0.13	2.29	6.90-8.28
O-I		6.91		0.04	0.07	1.80	6.12-7.36
O-II		6.41		0.02	0.04	1.20	5.96-7.21
Meat Colour (MC)							
K		64.60		1.29	3.54	4.62	58.00-72.00
O-I		60.93		1.65	4.66	6.00	54.00-67.00
O-II		58.72		1.43	4.03	5.13	52.00-64.00

The technological properties, i.e. physical properties of the meat are important parameters in rating the total quality of the meat. The pH of the meat from the experimental animals after slaughter (6.10±0.06-6.16±0.06) and after refrigerating (5.50±0.06-5.61±0.06) have similar values, and the differences between groups are not significant ($p>0.005$). Comparing the results of the groups in sequence, the ability to bind water is in a slight decline (6.41±0.04-7.43±0.13), while the colour of the meat is little darker (58.72±4.03-64.60±3.54). The differences in the values between the experimental groups are not statistically significant ($p>0.05$). Our results on the pH of the meat from fattening pigs are similar to those found in the literature: 5.65-5.87 (Manojlović [10]), 5.92 (Damnjanović [2]), 5.90 (Maričić [11]) and 5.59 (Đurica [25]). In the same researches the colour of the meat is 62.00-65.61 (Manojlović [10]), 61.41 (Damnjanović [2]), 62.56 (Maričić [11]) and 46.87 (Đurica [25]). The ability of binding water is: 7.93-8.45 (Živković *et al.,* [24]), 8.07-8.81 (Kralik *et al.,* [9]), 6.60-7.31 (Domaćinović *et al.,* [4]), 6.71-7.23 (Petričević *et al.,* [13]), 9.57-9.66 (Petričević *et al.,* [14]), 6.70 (Kosovac *et al.,* [8]) and 7.60-8.40 (Urbanczyk *et al.,* [24]). Summarizing the results of the experiment in total, it can be stated that partial substitution of the maize with by-products from the manufacturing of grapes, tomatos and peppers has no negative effect on the technologial properties of the meat of growing and fattening pigs. At the same time, positive effect on the acceptibility of the meat was noticed.

4. Conclusions

- Based on the results in the research of the possibility of substitution of the maize as an energy food with by-poroducts from the manufacturing of tomato, peppers and grapes in the pig's diet and its effect on the production and health it can be concluded that:
- Substitution of the maize with by-products from the manufacturing of tomato, grapes and peppers has no negative effect on the chemical content of the meat, at the same time the protein content is in increase on the expense of fat in the abdominal fat. Electrochemical reaction of the meat in the experimental animals after slaughter and after refrigeration has similar values, while the water binding ability is slightly lowered, the colour little darker.The differences in the chemical and physical properties of the different experimental groups gave differences in the acceptibility of the meat.

5. References

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