The effect of thermal processing of pork for institutional purposes

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Abstract

Pork meat is an important source of protein for humans. With the exception of vitamin C, it contains almost all the vitamins (in particular vitamin B6, vitamin B12, riboflavin and niacin) or their pro-vitamins, and is also a valuable source of minerals (in particular phosphorus, potassium and zinc) (Murphy et al. 2011). Consumption of pork in Slovakia is higher than the consumption of any other kind of meat. Statistical data show that pork consumption in Slovakia in 2012 was 30 kg per year *per capita*. In the Czech Republic, pork consumption in the same period, i.e. in 2012, was 41.3 kg per year *per capita*. The present extensive work provides specialists and research workers data on the chemical composition of thermally-processed pork that has been lacking to date. In the present study, a total of 39 samples (18 samples of pork leg, 9 samples of pork shoulder and 12 samples of pork side) were analysed. The monitored parameters included meat yield following various types of thermal processing (boiling, stewing, roasting and frying). The content of dry matter, protein, total lipids and ash in individual samples and in broth before and after thermal processing was analysed.

Beef, chemical composition, pork, poultry, thermal processing

Introduction

Pork in human nutrition

Consumption of pork (on the bone) in Slovakia in 2012 was 30 kg *per capita* which is around 10 kg less than the EU average (40.4 kg) for the same period. Pork consumption in the Czech Republic in 2012 was 41.3 kg, i.e. slightly above the EU average (CSA 2014). These consumption figures mean that more pork was eaten than any other kind of meat in both Slovakia and the Czech Republic. Almost ten times more pork was consumed in Slovakia than beef or veal (3.6 kg) and almost twice as much as poultry (17.7 kg) which shows that pork is extremely popular with consumers. Such consumption of pork is also higher than the recommended annual limit of 22.2 kg. The estimated pork consumption *per capita* in selected EU countries is shown in Fig. 1.

The highest consumption among European Union countries (55.3 kg *per capita* per year) was, according to the available statistical data from 2012, seen in Austria (Fig. 1). Germany (53.8 kg) and Spain (51.6 kg) ranked second and third in pork consumption, respectively. Surprisingly low consumption of pork in 2012 was seen in France, the largest EU country, where only 33 kg *per capita* was consumed (Eurostat 2013). This suggests that, in contrast to the Slovaks, French consumers showed no particular preference towards pork. Beef, veal and poultry have a much greater and more significant share in their total consumption of meat, a fact that is also connected with the French consumer's higher standard of living.

Materials and Methods

Three cuts of pork purchased on the retail network were used in this experimental study:
Pork leg – samples I, II, III (Plate VIII, Fig. 2), pork shoulder – samples I, II, III (Plate VIII, Fig. 3), pork side – samples I, II, III (Plate VIII, Fig. 4).

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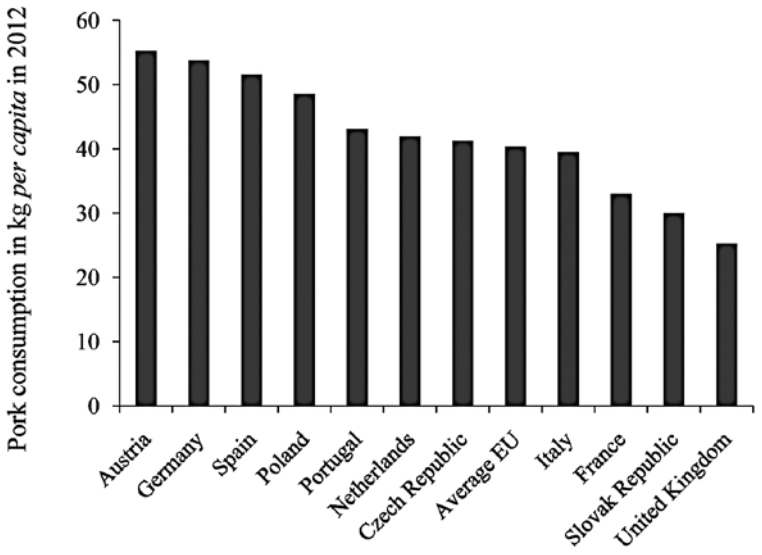

Fig. 1. Consumption of pork meat *per capita* in selected EU countries in 2012 (Eurostat 2013)

Totally 39 samples for the analysis were prepared:
- 18 pork leg samples - untreated, boiled, broth, stewed with juice, roasted with juice, fried
- 9 pork shoulder samples - untreated, stewed with juice, roasted with juice
- 12 pork side samples - raw, boiled, broth, roasted with juice

Various types of thermal processing for the above cuts of meat were used: boiling (treatment time: 2 hours), stewing (treatment time: 1 hour 15 min), roasting (treatment time: 1 hour 15 min) and frying (treatment time: 15 min).

The initial weight of leg meat for the experiment was 23.79 kg, and 1 500 g for each individual type of thermal processing was used. The initial weight of shoulder meat for the experiment was 15.36 kg, and individual samples for thermal processing weighed 1 500 g each. The side meat we used for thermal processing weighed 16.61 kg, and samples for individual thermal processing weighed 2 000 g each.

The description of heat operations used:
- Boiling – the technology of food preparation in which the food items used are subjected to the action of hot liquid (water, wine, milk, etc.) at 100 °C or more (under normal atmospheric pressure of 101.325 KPa) in a closed pot. The food items boiled must be completely immersed in the liquid.
- Roasting – thermal processing of food in which the food items are subjected to the action of hot air and partly of hot fat at temperatures of 180 – 230 °C in a closed space (oven, pan), on a grill or on a spit in an open space.
- Stewing – thermal processing of food in a closed pot in which heat is transferred to food items through a small amount of a hot liquid and hot steam at 100 °C.
- Frying – thermal processing of foods in a small amount of hot oil at temperatures of 180 – 200 °C (Decree No. 981/1996-100).

Methods of determination

The determination of water and dry matter content - homogenised samples were dried with sand to a constant weight loss at 105 °C. Three parallel replicates for each sample were analysed.

The determination of total lipids - extraction of the dried sample was done using a Twiselmann extractor with petroleum ether, followed by the gravimetric method. Two parallel replicates for each sample were performed.

The determination of protein – Kjeldahl method for the determination of total nitrogen and multiplication by a factor of 6.25 was done. Three parallel replicates for each sample using the Kjeltec 1030 system were performed.

The determination of ash – heating of dried samples in a muffle furnace at 550 °C (Dubravický et al. 1989) was used. Two parallel replicates for each sample were performed.

The experimental results were processed and the following parameters evaluated by statistical and mathematical methods (Eckschlager eta al. 1980):
a) Arithmetic mean ($\bar{X}$)

$$\bar{X} = \frac{\sum_{i=1}^{n} Xi}{n}$$

b) Standard deviation (s_D)
$s_D = k_n . R$
where k_n is the coefficient 0.5908 for n = 3
$R = x_{max} - x_{min}$

c) Relative standard deviation (s_r) in %

$$s_r = \frac{S_D}{\bar{X}} .100$$

d) Standard uncertainty of measurement

$$U_{Ai} = \sqrt{\frac{1}{n(n-1)}} \cdot \sum_{i=1}^{n} \left(X_i - \bar{X} \right)$$

$U = k \cdot u_A$, where k is the expansion coefficient, k = 2, i.e. 95% probability that the true value lies within the interval of uncertainty.

Results and Discussion

The inputs and trimmings and yields of pork leg, shoulder and side are shown in Table 1 and 2. The lowest dry matter content in (raw) pork was found in leg meat (27.3% on average). A higher dry matter content was seen in shoulder meat (37.4% on average), and the highest in the side meat (57.8% on average). Following thermal processing, the highest dry matter content was seen in a roasted pork side (73.7%) and the lowest in a stewed pork leg (34.4%) (Fig. 5).

Table 1. Inputs and trimmings of pork leg, shoulder and side

Sample		Input [g]	Trimming (bones) [kg]	Trimming (bones) [%]	Input into experiment [kg]
Leg	I	8.72	0.80	9.2	7.92
	II	8.72	0.66	7.6	8.06
	III	8.70	0.89	10.2	7.81
	Arithmetic mean	8.71	0. 78	9.0	7.93
Shoulder	I	5.25	0.15	2.8	5.10
	II	5.35	0.19	3.5	5.16
	III	5.24	0.14	2.7	5.10
	Arithmetic mean	5.28	0.16	3.0	5.12
Side	I	6.00	0.42	3.0	5.59
	II	5.97	0.35	6.9	5.62
	III	5.85	0.45	5.9	5.41
	Arithmetic mean	5.94	0.40	5.2	5.54

Table 2. Yields of thermally-processed pork in %

Type of thermal processing	Samples I	Samples II	Samples III	Arithmetic mean	S_D	Sr [%]	Standard uncertainty of the measurement
			Leg				
Boiled	60.7	60.7	61.3	60.9	0.35	0.6	0.00
Stewed	60.7	60.0	60.0	60.2	0.41	0.7	0.08
Roasted	57.3	56.0	56.0	56.4	0.77	1.4	0.08
Fried	64.7	75.4	72.3	70.8	6.26	8.8	0.00
			Shoulder				
Stewed	62.7	63.0	63.0	62.9	0.18	0.3	0.00
Fried	58.4	56.7	58.3	57.8	0.94	1.6	0.00
			Side				
Boiled	69.0	72.5	70.0	70.5	2.07	2.9	0.00
of which bones	5.5	6.2	5.4	5.7	0.47	8.2	0.00
Fried	63.5	62.2	55.0	60.2	5.02	8.3	0.08
of which bones	8.7	9.6	11.8	10.0	1.83	18.3	0.08

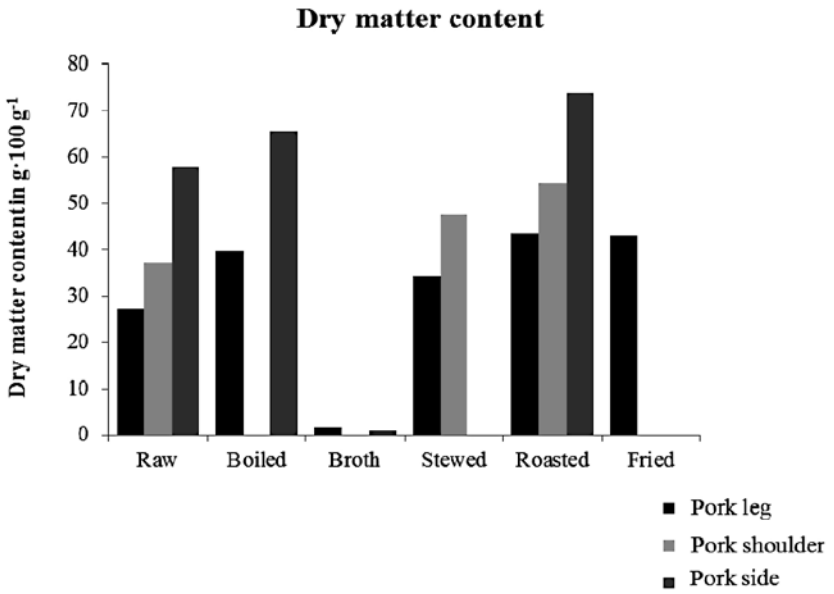

Fig. 5. Dry matter content (g·100 g^{-1}) in the samples of pork leg, shoulder and side

The highest protein content in raw pork samples was found in pork leg (19.6%) and the lowest in pork side (12.5%). The protein content in pork shoulder was 17.1%. The highest protein content in thermally-processed samples was in roast pork leg (34.6%), the lowest in boiled pork side (13.7%) (Fig. 6).

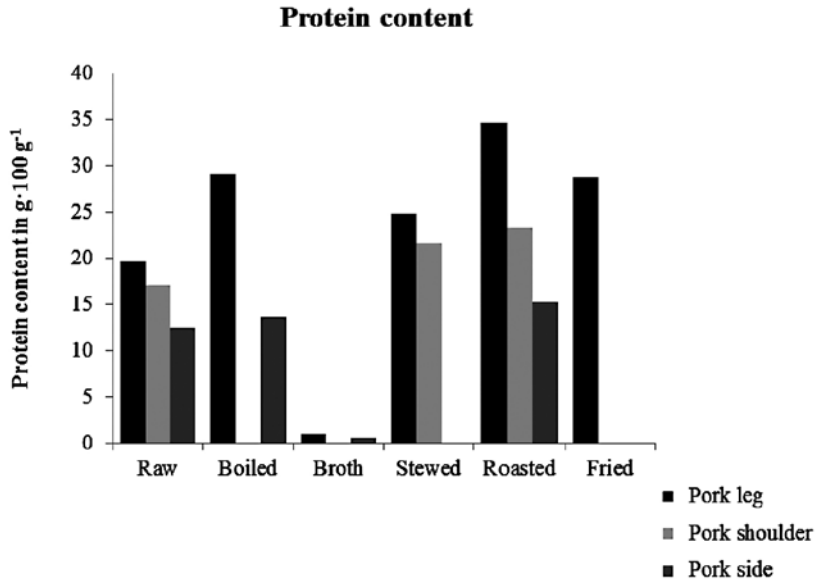

Fig. 6. Protein content (g·100 g^{-1}) in the samples of pork leg, shoulder and side

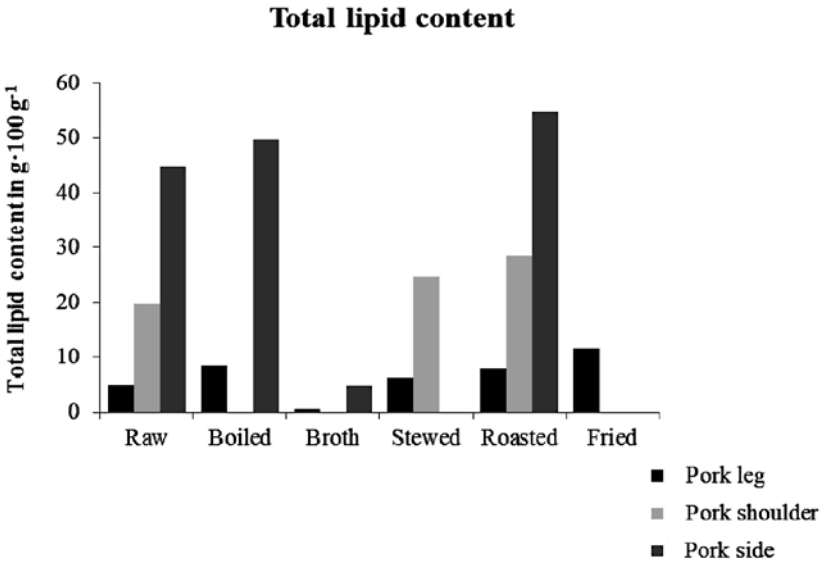

Fig. 7. Total lipid content (g·100 g^{-1}) in samples of pork leg, shoulder and side

The total lipids were calculated by converting collected solidified fat to 100 g broth. While the highest total lipid content in raw pork was found in pork side (44.90%), the lowest total lipid content was analysed in pork leg (5.03%). Pork shoulder meat contained 19.70% total lipids. The highest and the lowest content of total lipids after thermal processing was found in roasted pork side (54.70%) and the stewed sample of pork leg (6.33%), respectively (Fig. 7).

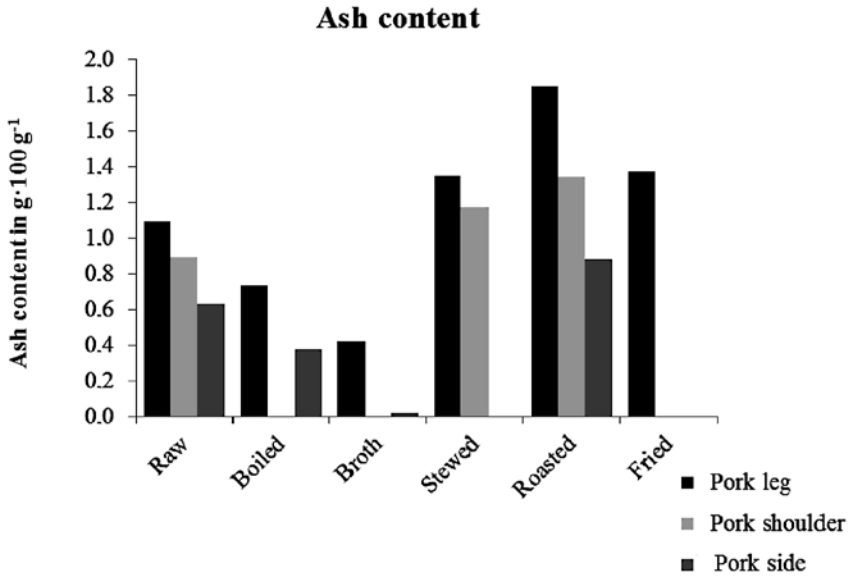

Fig. 8. Ash content (g·100 g^{-1}) in samples of pork leg, shoulder and side

The highest ash content in raw pork was found in samples of pork leg (1.09%), the lowest in pork side samples (0.63%). Raw pork shoulder meat contained 0.89% of ash. In thermally-processed pork, the highest and the lowest ash content was recorded in samples of roasted pork leg (1.85%) and boiled pork side (0.38%), respectively (Fig. 8).

Conclusions

The lowest weight losses during the thermal processing in pork were recorded when meat samples were boiled (for 2 hours). The losses in boiled pork leg and pork side were 13.04% and just 9.83%, respectively. The highest weight loss occurred during the roasting (for 1 hour 15 min.) of pork side meat (37.57%). During the roasting of pork leg the total weight loss where similar to raw pork (32.66%). The highest protein content was found in pork leg. While the raw pork leg protein content was 19.60%, boiled samples contained 29.10%, stewed samples 24.80%, roasted samples 34.60% and fried samples 28.80% protein. The protein content in broth was only 1.10%. The high content of proteins, which were further concentrated during thermal processing, and the low total lipid content document the high nutritional value of pork leg meat. The lowest protein content was in raw pork side

(12.50%). Its protein content was 13.70% and 15.30%, respectively after boiling and after roasting. The protein content of broth was 0.60%. The highest total lipid content in raw pork was found in pork side (44.90%). Its total lipid content was 54.70% after roasting and 49.80% after boiling. The total lipid content in pork side broth was 4.80%. The lowest total lipid content was found in raw pork leg (5.03%). The total lipid content in pork leg was 6.33% after stewing, 7.88% after baking and 8.40% after boiling. Fried pork leg contained 11.74% and broth just 0.67% total lipids.

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Fig. 2. Pork leg

Fig. 3. Pork shoulder

Fig. 4. Pork side