Local rabbits breeds - cultural heritage within *"functional food"* idea

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Poland: Łukasz Migdał
Sylwia Pałka
Władysław Migdał

Czech Republic: Darina Chodova
Eva Tumova

Slovakia: Radoslav Zidek

Hungary: Istvan Nagy

UNIWERSYTET ROLNICZY
im. Hugona Kołłątaja w Krakowie

Dear readers,

Here we present you results of our analysis we performed on local rabbits breed from Visegrad countries: Popielno White rabbits from Poland, Moravian Blue from Czech Republic, Pannon White from Hungary and Blue of Holic and Rex from Slovakia.

We hope that results and information about meat quality, fatty acids profile and results from meat quality analysis will encourage you to more often use rabbits meat in your kitchen

Also please visit our project website:

https://rabbits.urk.edu.pl/

In the website you will be able to find more detailed information about project and results in every language of V4 group: Polish, Czech, Slovak and Hungary and also English version

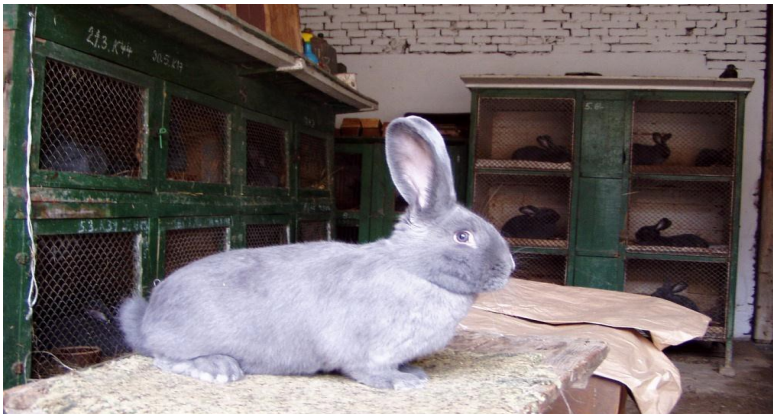
Rabbit (*Oryctolagus cuniculus*) is member of family *Leporidea* of the order *Lagomorpha*. Today is a animal reared on farm, laboratory animal, pet and also symbol of fertility and wellness. About 500 thousands years ago rabbits were inhibited Iberian Penisula and the south of France based in fossils. Probably about 1000 years BC rabbits spread across Mediterranean region thanks to Phoenician sailors and traders who were catching rabbits and freed on many islands where thanks to their prolificacy were used as a source of meat for crews of Phoenician's ships. Origin of rabbit is probably Asia, however it's hard to set because of fragility of its bones. Over 100 breeds from all around the world were selected from European rabbit from Mediterranean area. This theory were set based on discover and description of fossils of giant ancestor of rabbits – *Nuralagus rex* on Minorca in 2011. The tradition of rabbit meat consumption is from Stone Age and in Mediterranean rabbit was most important hunting animal from all small animals. During time of Roman empire rabbits were kept in special closed fenced areas called "leporarien". This was only for keeping and growing animals as a source of meat – first selections based on specific traits were made in French monasteries about 600 year, and this form were very popular during Middle Ages. During this time rabbit meat were recognize as fasting meat and were allowed by Catholic Church to eat each Friday and during Lent. In XII century rabbits were brought to England where at first were hunting animals and later were kept as source of meat and fur. During XV century and voyages across oceans rabbits spreads around the world. In some parts like in Australia they became pest and caused harm to local flora and fauna. From the beginning of XIX century rabbits were used as a farm animals kept for meat and fur and also today are kept as pets (Kowalska, 2013; Petracci et al., 2018).

Nowadays choose of rabbit meat as main component of diet depend on consumers, on which influence ethnicity cultural origin, age, sex and economic status. For example in Turkey rabbit meat consumption is forbidden by religion, in North America low consumption is caused by

lack of tradition of eating this meat, while in Spain this meat is mostly consumed by middle age woman, focused on cooking and quality of meat. Meat consumption is still very popular in Mediterranean countries, however in households with children consumption of rabbit meat is low. However rabbit meat has very good nutritional and dietary values, consumption in Europe in lower than 3% of all meat. Every year about 1.2 billion rabbit are slaughter (FAOSAT, 2012). European Union is responsible for 28% of production (over 340 mln rabbits). One of highest exporter of rabbit meat is Hungary (2-3 place) (Kling, 2007, 2008; Szendrő, 2004). Average consumption of rabbit meat in Italy is about 6kg/per capita, 5.5kg/per capita in France, about 5kg in Spain and Hungary while in Belgium and Portugal 2kg. In Poland consumption is about 0.5 kg but last few years significant increase of consumption were observed. In diet of Poles rabbit meat is only consumed during special events or festive or local meals. According to experts rabbits meat should take place as important source of meat in human nutrition and it is caused by lower interest red meat consumption (mostly because of BSE in cattle and ASF in pigs). That's why we should use animal genetic resources, especially old native breeds and use them in extensive breeding and intensive breeding as a component in crossbreeds rabbits. Native breeds are "living" prove of hard work of generations of breeders (Krupiński et al. 2017). Animal genetic resources are defined as a species which are or may be used in food production. Global data bank for farm animal genetic resources consist 16 mammals species and 14 birds, with 6379 breeds (Weiend, Romanov, 2002). In Global databank there are 232 rabbits breed, from which 71,6% does not have estimated population size and 20.3% are critically endangered (Ducheve at al. 2006). In Europe there are over 60 breeds described and recognized by nationals breeders association (Bolet et al. 1996). European rabbit breeders association and FAO created database with over 150 local/national breeds from 11 countries.

European programme RESGEN CT 95-060 coordinated by INRA (Institut National de la Recherche Agronomique, Francja) contains information about breeds which may be used in further selection process. Results showed significant differences for growth rate, carcass quality and meat quality as well as traits specific for some breeds (Bolet et al 2000). In Czech Republic in 1997 in National Programme for the Conservation and Utilisation of Genetic Resources seven rabbits breed were registered (coordinated by Institute of Animal Science in Prague – Uhříněves). In Poland, genetic resources programme which is coordinated by The National Research Institute of Animal Production include 83 breeds, lines from Poland and one rabbit breed Popielno White rabbit. In Slovakia there are 12 breeds generated by Slovak breeders.

8weeks old Popielno White rabbit



Moravian Blue rabbit

Pannon White rabbit

For increasing rabbit meat consumption and its popularity there is need in change consumers perception of rabbit meat. Promotional actions should not only include tradition and cultural identity but also should include new recipes for rabbits meat. Even there should be change current perception of rabbit meat mostly as culinary meat (decoctions, rabbit in cream, meals from roasted) but also as a processing meat like for sausages. Without modern and innovative approach its consumption may decrease especially among young people and children. It must be stated

that dietary value of rabbit meat and mostly pro-healthy value. Rabbit meat is a white meat, lean with high dietary and culinary values with low content of cholesterol. Is easily digest, velvet and juicy meat, fine grained consistency and with specific taste and smell (Hernández, 2008; Dalle Zotte, 2002; Dalle Zotte and Szendrö, 2011). Rabbit carcasses are characterized by low content of intramuscular fat. pH as a indicator of rabbit meat quality is also a indicator of after slaughter changes in muscles. Form rabbits average pH value after 45 minutes after slaughter should be in range of 6.1 to 6.8 and after 24 h of chilling between 5.4 – 5.8 (Maj et al., 2008; Szkucik et al., 2006) pH drop depends on many factors like condition in time of slaughter, in healthy not stressed animals this process is faster and reach optimal level faster which is a sign of proper glycolysis process.

Nutritional value is a effect of considerable amount of components. Amount of protein in rabbit meat differ for cuts (like loin, hind leg) 20 - 25 % and is higher compared to other farm animals. In rabbits protein level of exogenous amino acids like: valine, leucine, isoleucine, phenylalanine, tryptophan, lysine, threonine and methionine is about 2% higher compared to other farm animals. Rabbits meat contain more lysine (2.12g.100g-1), leucine (1.73g.100g-1), valine (1.19g.100g-1), isoleucine (1.15g.100g-1), threonine (2,01g.100g-1) and phenylalanine (1,04g.100g-1) compared to other meats (Hernández and Dalle Zotte, 2010). Biological value of rabbit meat is high and is very often recommended as a first meat for toddlers. Moreover, this protein is not allergenic and its digestibility is nearly 90% while e.g. beef digestibility is around 62% and chicken meat between 79-90%. Energetic value of rabbit meat is 618 (Salvini et al., 1998) – 638, kJ (Kowalska 2006).

Rabbit meat is easily digestible and has a very high nutritional value evaluated with chemical composition of meat. The basic parameters of the chemical meat composition are the content of water, dry matter, fat, crude protein and ash. Rabbit meat is high in protein, low in fat and also

low in cholesterol (approximately 59 mg/100 g muscle, Gondret et al. 1998).

The water content of the meat is determined indirectly, by determining the dry matter and then calculating the water content. The dry matter was determined by drying the samples at 105 ° C to constant weight (AOAC, 1995).Rabbit meat contains between 63.6 and 76.8% of water, with this value varying for individual muscles (Tůmová et al., 1996). The water content is the smallest in the muscles of the chest, while the muscles of the loin have the highest water content. Higher water content in meat can be observed in slow-growing breeds of rabbits compared to fast-growing ones (Bernardini et al., 1994; DalleZotte 2002). In our project, the highest water content was detected in MBF of Blue of Holic rabbit (75.54 %) and also in MBF of Rex (75.34 %). On the other hand, Blue of Holic had the lowest water content in MLL (72.43 %).

In rabbits, carcass contains four main adipose depots: visceral, subcutaneous, intermuscular and intramuscular. The main part of visceral fat is the perirenal fat, representing about 50–60% of the total carcass fat content (Pla et al. 2004) and also scapular fat.An important component of fat is also intramuscular fat, which is distributed between the muscle fibers and is obtained by the Soxhlet method (AOAC 1995). The content of intramuscular fat affects the taste, tenderness and juiciness of meat.In rabbit meat, the fat content is between 0.6 – 14.4 % (Dalle Zotte 2002) and the individual valuable parts differ significantly in their fat composition. In general, the thighs contain more fat (3 %) than loin (1.2 %; Metzger et al. 2006). However, in our case, only MBF of the thigh muscle was analyzed, so the difference between MBF and MLL were not so significant, because most of the fat in the thigh muscle occurs between the muscle bundles. The highest fat content in our project was detected in MLL of Blue of Holic (2.27 %), while the lowest in MBF of Rex (0.69 %).

The nutritionally most important component of meat is protein. Rabbit meat is characterized by a higher protein content (18.1 – 23.7 %) compared to the meat of other livestock and is also characterized by high digestibility of up to 95% (Hernández et al., 2007). Crude protein is detected by the Kjeldahl method (factor used - 6.25; AOAC 1995).In general, the loin muscle contains a higher protein content than the muscle of the thighs. The highest protein content is found in the parts of carcass with the lowest fat content, because the content of protein decreases with increasing amount of fat. The highest protein content was determined in MLL of Popielno White (23.33 %) and the lowest in MBF of Blue of Holic (20.93 %).

The last but also a very important component of meat is ash. Ash content is determined by burning the homogenized sample at 550 ° C in an oven to constant weight for at least 4 hours. The ash content therefore indicates the content of inorganic substances in the meat.In the case of rabbit meat, the ash content is around 1.31 % andaccording to Gasperlin et al. (2006), ash content is not related to an individual's genotype. Likewise, in our experiment, the individual genotypes did not differ in terms of ash content.

Table 1. Chemical composition of muscles of local rabbit breeds

Breed	muscle	Water (%)	Dry matter (%)	Fat (%)	Crude protein (%)	Ash (%)
Termond White	*MLL*	74.27±0.85	25.73±0.85	1.30±0.59	22.46±3.39	1.39±0.06
	MBF	74.11±0.53	25.89±0.53	1.21±0.71	21.52±2.35	1.20±0.04
Pannon White	*MLL*	73.67±0.75	26.33±0.75	0.81±0.18	22.89±1.40	1.39±0.06
	MBF	73.01±0.82	26.99±0.82	1.29±0.42	21.75±1.01	1.47±0.05
Popielno White	*MLL*	73.04±0.68	26.96±0.68	0.86±0.27	23.33±1.81	1.53±0.10
	MBF	72.57±0.98	27.43±0.98	1.43±0.60	22.39±0.60	1.46±0.06
Moravian Blue	*MLL*	73.91±0.49	26.09±0.49	1.13±0.34	22.42±1.48	1.30±0.03
	MBF	72.71±0.49	27.29±0.49	1.58±0.48	21.27±0.94	1.29±0.16
Rex	*MLL*	73.08±1.75	26.92±1.75	1.07±1.04	22.20±1.15	1.53±0.15
	MBF	75.34±1.18	24.66±1.18	0.69±0.33	21.13±1.15	1.60±0.08
Blue of Holic	*MLL*	72.43±2.54	27.57±2.54	2.27±2.38	21.97±1.67	1.52±0.09
	MBF	75.54±1.25	24.46±1.25	0.79±0.49	20.93±1.33	1.60±0.05

MLL - m. longissimus lumborum, MBF- m. biceps femoris

High energy value of rabbit meat is not because of high fat content but mostly because of high content of proteins. Carcasses of rabbits slaughtered at 2,5 -2,7 kg contain 3 – 6 % of fat. Rabbits fat is soft, white and stored mostly as perirenal fat, near stomach, behind shoulders. This fat has very favourable profile of fatty acids and is characterized by high content of unsaturated long-chained fatty acids omega 3 and omega 6. Those fatty acids, especially omega 3 are essential for proper brain functions, decreasing glucose and cholesterol level, regulate blood pressure. Over 60% of all fatty acids are unsaturated fatty acids (UFA), that's why rabbit meat is more prone to oxidation process during storage and processing (Dalle Zotte, 2002). Moreover in rabbit fat are presented favourable odd - chained fatty acids with linear and branched structure, not present in pork, beef and chicken meat (Leiber et al., 2008). Muscle fat from rabbits is pro-healthy, mostly because of high content of linoleic acid. In intramuscular fat there is 3% of linoleic acid and in spare fat up to 6%. In our experiment content of linoleic acid in meat from loin (m. longissimus lumborum) and hind leg (m. biceps femoris) were highest for Pannon White rabbits (3% and 3,1%, respectively) then Termond White (2,2% and 2,5%, respectively) then similar content in Popielno White rabbits (2,1% and 2,2%, respectively), Blue of Holic (1,7% and 2,1%, respectively), Rex (1,9% and 2,2% respectively) and lower content in Moravian Blue (1,7% and 1,9%, respectively).

From many years analysis between so-called life-style diseases (chronic environmental diseases) especially cardiovascular have been carried out. Changes in our way of living, especially what happen during last year when pandemic situation forced society to stay at home and also eating preferences lead to searching for meat with less fat content and with favourable fatty acids profile. However recent research like made by Hooper and colleagues in 2001 where they analysed projects focused on fat consumption and diseases showed only weak relationship between fat consumption and level of cholesterol in blood and possibility of occurrence of heart diseases. In this way the fatty acid profile seems to be

more important. In project we analysed fatty acids profile from samples collected from two different muscles from native rabbits from V4 group. First muscle, *m. longissimus lumborum* is a part of loin which is considered as most valuable cut in rabbits carcass, second one *m. biceps femoris* is part of hind leg – a cut with higher content of meat in carcass. Analysis were performed on University of Agriculture in Kraków in Depertment of Genetics, Animal Breeding and Ethology. Lipid extraction from meat according to Folch et al. 1957 and esterification according to AOAC (1995). The fatty acid methyl esters were separated by gas chromatography using a TRACE GC ULTRA (Thermo Electron Corporation, Milano, Italy). Individual fatty acid methyl esters (FAME) were identified by comparison with a standard mixture of 37 FAME components (Supelco, Sigma-Aldrich Co., St. Louis, MO, USA) and CLA isomers (Sigma-Aldrich Co.). From all identified fatty acids every rabbits breed were characterized by higher content of monounsaturated fatty acid 18:1 n-9 – oleic acid and 18:2 n-6 – linoleic acid. However, studies showed that not only content of single fatty acids is important but total amount of different group of fatty acids. In table 2 we presented sum of saturated (SFA), unsaturated (UFA) fatty acids also monounsaturated (MUFA), polyunsaturated fatty acids (PUFA) and polyunsaturated fatty acids n-3 (PUFA n-3) and n-6 (PUFA n-6)

Table 2. Fatty acids content in muscles of local rabbits breeds

Breed	muscle	SFA	UFA	MUFA	PUFA	PUFA n-3	PUFA n-6	PUFA n-6/n-3	PUFA/MUFA	PUFA/SFA
TW	*MLL*	42.48± 0.84	57.46± 0.94	27.54± 1.29	29.92± 0.81	2.12± 0.21	27.53± 1.06	12.99	1.09	0.70
	MBF	41.60± 0.53	58.32± 0.45	24.59± 0.64	33.74± 0.36	2.22± 0.11	31.17± 0.47	14.02	1.37	0.81
PAW	*MLL*	35.46± 0.49	64.46± 0.69	22.00± 0.44	42.46± 0.83	2.68± 0.22	39.33± 1.14	14.68	1.93	1.20

	MBF	37.29± 0.56	62.64± 0.41	18.35± 0.35	44.29± 0.46	2.50± 0.11	41.36± 0.61	16.53	2.41	1.19
PW	*MLL*	43.99 0.43	55.96± 0.34	28.44± 0.47	27.52± 0.29	1.88± 0.06	25.40± 0.38	13.51	0.97	0.63
	MBF	43.58± 0.47	56.36± 0.51	27.73± 0.72	28.63± 0.42	1.80± 0.09	26.55± 0.55	14.75	1.03	0.66
MB	*MLL*	40.70± 1.10	59.25± 0.68	34.45± 1.03	24.80± 0.46	2.27± 0.14	22.29± 0.61	9.81	0.72	0.61
	MBF	37.53± 0.81	62.42± 0.80	34.38± 1.21	28.04± 0.52	2.61± 0.22	25.16± 0.71	9.66	0.82	0.75
BH	*MLL*	41.15± 0.24	58.78± 0.92	22.26± 0.78	36.52± 1.06	5.51± 0.32	30.77± 1.47	5.58	1.64	0.89
	MBF	41.26± 0.41	58.66± 1.04	18.50± 1.05	40.17± 1.13	6.20± 0.43	33.70± 1.56	5.44	2.17	0.97
Rex	*MLL*	40.33± 0.57	59.62± 2.06	22.17± 1.48	37.46± 2.45	5.78± 0.85	31.48± 3.43	5.45	1.69	0.93
	MBF	41.98± 0.40	57.97± 1.29	20.71± 1.46	37.26± 1.33	5.28± 0.67	31.78± 1.83	6.02	1.80	0.89

TW- Termond White, PAW - Pannon White; PW - Popielno White; MB - Moravian Blue, BH - Blue of Holic; *MLL* - *m. longissimus lumborum, MBF- m. biceps femoris*; SFA – saturated fatty acids; UFA – unsaturated fatty acids; PUFA – polyunsaturated fatty acids.

In our analysis we also included Termond White rabbit for a comparison. This breed is commonly used commercial rabbit breed on farms. Therefore, this breed was under selective pressure for better growth rate and daily gains. Here in Table 1 we presented data for most important groups of fatty acids and ration commonly used for assessing its nutritional values. During last years many factors and ratios were analysed and used for analysis of influence of different kind of fatty acids on health. Those ratios have universal meaning for most products that are included into human diet. According to nutritional recommendations, the correct ratio between PUFA—MUFA should be within the range of 0.4–1, while the ratio of n-6 PUFA to n-3 PUFA should be 2.5–8.0.

PUFA/MUFA ratio in our analysed breeds showed that only for Pannon White rabbits and *MLL* from Termond White this ratio was too high. n-6 PUFA to n-3 PUFA ratio was higher in all analysed breeds however in Moravian blue this ratio was nearly recommended value. It must be stated that high values of this ratio is because of high level of PUFA n-6 where highest amount of 18:2 n-6 – linoleic acid. This acid is considered as essential fatty acids (EFA) for human and must be ingested. Linoleic acid is a precursor in synthesis of arachidonic acid (AA). This acid play important role in organism as can be converted to bioactive compounds called eicosanoids (prostaglandins. leukotriens). Of course exceed level of eicosanoids may be harmful for organisms as it plays important role in chronic diseases and inflammation (Whelan and Fritsche, 2012). PUFA/SFA is one of most common index where values for meat varies between 0.63 to 1.2 which fit 0.11 – 2.042 values known for different meat type.
In Table 3 we presented calculated indexes commonly used for evaluation of fatty acids quality and influence on human health

Table 3. Indexes calculated for local rabbits breeds compared with other livestock animals

Breed	muscle	IV	AI	TI	h/H	NV	D9-desaturase	CI	Meat Softness Index
TW	*MLL*	64.74	0.52	1.13	1.57	0.77	0.28	1.75	0.82
	MBF	67.66	0.51	1.09	1.65	0.74	0.27	1.79	0.73
PAW	*MLL*	74.76	0.41	0.87	2.27	0.57	0.27	2.20	0.67
	MBF	72.80	0.43	0.95	2.17	0.61	0.24	1.85	0.52
PW	*MLL*	64.10	0.57	1.22	1.44	0.81	0.28	1.64	0.82
	MBF	65.33	0.57	1.21	1.43	0.82	0.28	1.53	0.81
MB	*MLL*	63.66	0.54	1.12	1.47	0.82	0.29	1.73	0.94

	MBF	66.83	0.47	0.97	1.72	0.72	0.29	1.78	1.00
BH	*MLL*	52.92	0.54	0.91	1.68	0.93	0.25	2.88	0.58
	MBF	56.03	0.54	0.89	1.71	0.92	0.22	3.10	0.47
Rex	*MLL*	56.31	0.50	0.85	1.83	0.83	0.26	3.09	0.61
	MBF	61.81	0.52	0.93	1.72	0.82	0.24	3.05	0.55
beef	*MLL*	48.12	0.47	1.12	1.98	0.64	0.31	2.38	0.92
pork	*MLL*	63.30	0.31	0.91	2.86	0.40	0.37	0.57	1.78
lamb	*MLL*	51.50	0.37	1.04	2.34	0.54	0.32	2.83	1.08
goat	*MLL*	53.07	0.29	0.76	3.20	0.40	0.35	3.19	1.29
goose	*MLL*	66.49	0.40	0.95	2.31	0.48	0.37	0.68	1.57
horse	*MLL*	83.05	0.40	0.54	2.07	0.71	0.29	10.42	0.98

beef - native polish red cattle; pork - native puławska breed; lamb - native polish mountain sheep; goat - native karpacka breed; goose - native zatorska breed; horse – polish coldblooded. AI: atherogenic index—(C12:0 + 4 C14:0 + C16:0) [(MUFA + SSPUFA (n6)+ (n3)];. TI: thrombogenic index—(C14:0 + C16:0 + C18:0) +0.5xMUFA + 0.5x n6PUFA + 3x n3PUFA; D9-desaturase index—(C14:1n9 + C16:1n9 + C18:1n9) / (C14:1n9 + C18:1n9 + C18:1n9 + C14:0 + C16:0 + C18:0); CI: consumer index—(C18:3 + C20:5 + C22:6); Meat softness index—(C16: 1 + C18: 1) / (C16:0 + C18: 0); NV: nutritional value of lipids—(C12:0 + C14:0 + C16:0) / (C18:1 c9 + C18:2 n-6); h/H: ratio of hypo- and hypercholesterolemic acids—(C18:1 c9 + C18:2 n-6 + C18:3 n-6 + C18:3 n-3 + C20:2 n-6 + C20:3 n-6 + C20:4 n-6 +C20:3 n-3 + C20:4 n-3 + C20:5 n-3 + C22:4 n-6 + C22:5 n-6 + C22:5 n-3 + C22:6 n-3) / (C12:0 + C14:0 + C16:0).

As atherogenic potential of fatty acids is well documented Ulbricht and Southgate in 1991 proposed idex - index of atherogenicity (AI) which would be better to expose most important acids that have favour to adhesion of lipids to cells (mostly C12:0, C14:0 and C16:0). UFAs on the other hand are ant-atherogenic. Generally speaking consumption of products with low IA value can reduce level of e.g cholesterol. Chen and Liu 2020 summarized IA value for different meat and this ratio was between 0.165 to 1.06. For rabbits Peiretti and colleagues 2011 calculated this index for value between 0.55-0.69. We received lower values between 0.41 – 0.57. Our results proved that meat from local

rabbits breeds can be considered as good quality meat with favourable ratio of UFAs and low level of SFA.

Another index proposed by Ulbricht and Southgate in 1991 is index of thrombogenicity (TI) – index that provide information of potential influence of fatty acids on formation of clots in blood vessels. As it formula contains SFAs in denominator which are pro-thrombogenic and in numerator of equation MUFAs and n-3 and n-6 PUFAs with its anti-thrombogenic properties. Generally speaking more lower IT value is, higher chance for cardiovascular disease can be observed. Currently literature report IT for meat between 0.39 and 1.69. For rabbits results are lowest for Pannon White (0.87 for MLL and 0.95 for MBF) and highest (most favourable for health) in Popielno White rabbits (1.22 for MLL and 1.21 for MBF).

H/H (sometimes h/H) index is the hypocholesterolemic/hypercholesterolemic (HH) ratio. First used for lamb meat and later calculated for other food (Fernandez et al. 2007). Initially this index was presented to better understand influence of FAs on LDL cholesterol. Low density lipoprotein (LDL) is mainly responsible for transport of cholesterol from liver to other organs. Also is responsible for coating arteries of smooth muscles which increase chances of cardiovascular diseases. That's reason why LDL fraction is very often called "bad cholesterol". For meat this index is reported to be between 1.27 and 2.786. This index correspond to hypochlesterolemic fatty acids (cis fatty acids and PUFAs) and hipercholesterolemic fatty acids (SFAs). In our results highest values were obtained for Pannon White (2.27 for MLL and 2.17 for MBF) while lowest for Popielno White rabbits (1.44 for MLL and 1.43 for MBF).

As UFAs plays important role in human health many efforts were made for better understanding of how unsaturated fatty acids may influence health conditions. It is also important that high level of unsaturated fatty acids is linked with oxidative stability – it is prone to fast degradation reactions. Therefore iodine value (IV) were presented to calculate content

of UFAs. As value increase (higher IV) the oil/fat/meat content more UFAs and are more likely to oxidation/polymerization. We found that highest value were for Pannon White were 74.7g/100g of tissue for MLL and 72.8g/100g for MBF while for other breeds it varies between 66 and 63g/100g.

From consumer point of view softness of meat plays important role in acceptability. Available literature showed that this index is decreasing with age (Todaro et all. 2002) however for indigenous animals reports showed opposite results, where older animals had higher softness index (Zygoyiannis et al. 1992). Highest values were found in Moravian Blue 0.94 for MLL and 1.00 for MBF, while lowest for Pannon White 0.67 from MLL and 0.52 for MBF

Cholesterol content in rabbit meat is low and differ between 25 and 90 mg/100g of tissue (Skřivanova et al., 2001). Average content of cholesterol is 59mg/100g (Combes, 2004). Average ash content is between 1,2 and 1,8%. Rabbit meat has high concentration of microelements (iron – 2,9 mg/100 g of meat, calcium – 13 mg/100g of meat, magnesium – 21 mg/100 g of meat, potassium - 200 mg/ 100 g of meat, zinc – 0.51 mg/100 g of meat and manganese 0.021 mg/100 g of meat) and vitamins mostly B vitamins – B_{12} and B_1, which influence on nervous and circulatory system. 100 g of rabbit meat contain 5 – 13 mg niacin (vitamin PP), which is daily requirements for this vitamin, 8% of daily requirements for vitamin B_2, 12% for vitamin B_5, 21% for vitamin B_6, 77% for vitamin B_3 and daily requirements for vitamin B_{12} (Combes, 2004). Moreover rabbit meat contains little purine compounds, which are metabolized into uric acid, that's why this meat is recommended in diet for gout, autoimmune diseases, diabetes and few types of tumor. Quality, chemical content and physicochemical depends on many factors like breed, sex, age, slaughter weight, feeding and housing system (Cavani et al., 2000). Using feeding additives rabbit meat can be enriched with many different compounds favourable for human health. This meat can be consider as "functional food" (Dalle Zotte and Szendrö 2011). As a

example we can mention increasing of polyunsaturated fatty acids (PUFA) content (mostly omega n-3) by addition to feed different sources of those fatty acids like linseed oil, fish oil or oil plants meal (Czauderna and Berladyn, 2007, Dal Bosco et al., 2004). However it must be stated that modification fatty acids profile may have negative influence on sensory quality, oxidative stability and meat processing. Unaccepted by consumers smell and taste of meat is often result of lipid oxidation. Process of lipid oxidation also affect colour, texture parameters and nutritional properties because vitamins and essential fatty acids (EFA) are degradeted. For increasing oxidative stability of rabbit meat very often anti-oxidative substations are added, like vitamin E (Dal Bosco et al., 2004, Dalle Zotte et al., 2000). According to CIElab system (which is commonly used to describe colour we see) rabbit meat is white meat however there are different results for L* value (lightness) 61,4 - 62,0 (Dalle Zotte et al., 2004); 57,95 - 59,36 (Maria et al., 2004); 54,68 - 56,79 (Failla et al., 2004) 48,36-50,84 (Dal Bosco et al., 2002). Cited above authors recorded varied a* parameter value (from 2,34 to 4,64) and b* (from -1,05 to 4,18). Texture of meat depends from many factors like water content, fat content and structure of muscles fibre. Hardness increase with age of rabbits. According to Hernandez and Lozano (2001) hardness of New Zealand rabbit meat slaughtered at 70 days of age with body weight 2kg was 5,00 kg/cm2 and shear force 2,81 kg/cm2. Ramírez et al. 2004 for rabbits slaughtered at 63 days of age reported hardness 9,65 kg/cm2, springiness – 0,43, cohesiveness – 0,47, chewiness – 1,95 kg.cm2 and shear force – 3,88 kg/cm2. Our results are presented in table 4:

Table 4. Hardness and shear force from *m. longissimus lumborum* and *m. biceps femoris* from local rabbits breeds

Breed	muscle	Shear force	Hardness	Breed	muscle	Shear force	Hardness
TW	*MLL*	1.24±0.48	14.73±1.97	MB	*MLL*	2.38±0.49	8.47±2.04
	MBF	1.09±0.21	14.16±3.18		*MBF*	4.37±1.93	10.90±2.55
PAW	*MLL*	1.25±0.34	7.38±0.83	BH	*MLL*	0.85±0.46	6.17±2.23
	MBF	3.18±1.64	9.81±2.72		*MBF*	1.21±0.23	9.00±3.92
PW	*MLL*	1.45±0.36	13.16±3.94	Rex	*MLL*	1.01±0.35	6.35±2.52
	MBF	0.92±0.34	13.69±4.07		*MBF*	1.36±0.44	12.59±5.43

Dalle Zotte (2002) defined two groups of factors influencing quality of carcass and rabbit meat from consumers point of view: first of moderate and second high influence. First are environmental factors especially temperature, season, housing system and pre slaughter conditions. Factors with high influence are mostly genetics and affecting growth rate. In this group we can find feeing system, which not only influence dressing percentage but also chemical composition and quality of carcass. Also technological factors must be highlighted as carcass storage and meat processing finally influence on quality of meat/product.

In promotional events for rabbit meat we can describe Spanish way which were implemented by Rabbit Meat Marketing Board (Organización Interprofesional para implulsar el Sector Cunícola, INTERCUN) (González-Redondo and Rodríguez-Serrano, 2012). They

organized events promoting rabbit meat consumption in three campaign: July 2008 – June 2009, July 2009 – June 2010 and July 2010 – June 2011. The campaign were divided into two promotional actions. First action was performed among medical, dietician, nurses and other specialists who encourages/prescribe diets for their patients. Second action was directed for society and included promotional events by celebrities in TV, publication of recipes in newspapers etc. Great success of this actions performed by INTERCUN ended up in increase of rabbit meat consumption. According to INTERCUN it may be necessary to perform similar actions for younger consumers especially school youth (González-Redondo and Rodríguez-Serrano, 2012). In Hungary action promoting backyard rabbit breeding were performed called "Nyúlunk a munkáért" (Szendrő, 2004)

PRODUCTS FROM RABBITS MEAT – RECIPES

Rabbit sausage

Raw materials:

• boneless rabbits meat – 4 kg

• bacon – 1 kg

• potato flour – 0,018 kg
• salt – 0,10 kg
• saltpeter – 0,004 kg
• sugar – 0,010 kg
• grinded black paper– 0,010 kg
• allspice – 0,010 kg (grind)
• boiled water, cooled – 500 ml
• natural hog casings –about 10 running meters or natural casings from rabbits intestines or artificial casings diameter 5-8 cm – about 6 running meters.

Remove bones and cut meat into small 3-5 cm piece and mix with pickling mixture (salt, saltpeter, sugar) and leave for 48h in cold place. Pickled meat should be minced in 5 mm strainer. Bacon should be cut in pieces and mince in 8 mm strainer. Mix meat and bacon, add potato flour, paper and allspice and slowly pour water into meat till it will be absorbed by meat. Taste and eventually add more spices. Tie the starting end of the casing into a knot and on the slow setting, gently support the sausage as it is piped into the casing, be careful and does not pack too tightly, also try to avoid air bubbles. Store for about 2-3 h in room temperature to dry and smoke for about 1 – 1,5 hours.

Rabbits meatballs:

Raw materials:
• Rabbits meat – small pieces-
• Salt - 1,5 %
• Winter savory 0,7%
• Olive Oil
– remove bones from meat if need/ cut into small pieces
– mince in 5 mm strainer
– mix minced meat with spices
– form meatballs and cover them with olive oils
– fry on frying pan

Meatballs can be also boiled and served with sauce.

Rabbit loin, marinated in Gravad - type marinate – recipe prepared by dr Piotr Kulawik, prof UR

Raw materials:

- Rabbit loin - 86,5%
- Salt- 5,3%
- Sugar - 4,6%
- Pepper - 1,5%
- Dill- 2,1%

Roll/ coat rabbit loin in spices, pack close and very tight into food wrap and keep for 72 hours in 4^{o}C.

Sushi from rabbit loin recipe prepared by dr Piotr Kulawik, prof UR

- Nigiri:

  Rabbit loin, marinated in Gravad – type marinate – 6g

  Boiled rice – 18g

- Maki - sushi (roll for about 10 pieces of sushi)

  - boiled rice – 230g
  - rabbit loin, marinated in Gravad – type marinate – 30g

• Wasabi – 2g

• Nori - 3 g

• Thermized cream cheese (Philadelphia type) - 20 g

• Cucumber – stripes - 15 g

Rice boiling [%]:

• Raw sushi rice - 38,2 %

• Water- 57,3%

• Vinegar- 2,3 %

• Sugar - 1,9 %

• Salt - 0,4 %

Rabbit sausage – recipe was used in preparing sausages from local rabbits breed for this brochure

Raw materials:

• rabbits meat – 4 kg

• bacon– 1 kg (this is not necessary – without bacon you will get lean sausage, sausages prepared and analysed in this project were made without bacon)

• salt – 0,08 - 0,10 kg (if we don’t add pork bacon we can limit salt to 0,04 – 0,05 kg)

• sugar – 0,01 kg

• grinded black pepper – 0,01 kg

• natural hog casings (jelita wieprzowe 28-33 mm)

– remove bones from meat if need/ cut into small pieces
– mince in 5 mm strainer
– mix minced meat with spices
– tie the starting end of the casing into a knot and on the slow setting, gently support the sausage as it is piped into the casing, be careful and does not pack too tightly, also try to avoid air bubbles
– prepare smoking sticks and place sausage leaving space between sausage loops
– traditional smoking – traditional smokehouse – logs from fruit trees – smoking time about 1 – 1,5 h (till internal temperature of sausage – 72°C)
– cooling sausage to temperature below 15°C

Literarure:

1. Cavani C., Bianchi M., Lazzaroni C., Luzi F., Minelli G., Petracci M. 2000. Influence of type rearing, slaughter age and sex on fattening rabbit: II. Meat quality. 7th World Rabbit Congress, Valencia, 4-7 July, 567-572.
2. Combes S. 2004. Nutritional value of rabbit meat : a review. INRA Prod. Anim., 17: 373-383
3. Czauderna M., Berladyn A. 2007. Meat quality and tissue fatty acid profiles in rabbits fed diets supplemented with conjugated linoleic acid. Veterinarni Medicina 52(12), 552-561
4. Dal Bosco A., Castellini C., Bianchi L., Mugnai C. 2004. Effect of dietary a-linolenic acid and vitamin E on the fatty acid composition, storage stability and sensory traits of rabbit meat. Meat Science 66(2), 407-413. https://doi.org/10.1016/S0309-1740(03)00127-X

5. Dal Bosco A., Castellini C., Mugnai C. 2002. Rearing rabbits on a wire net floor or straw litter: behaviour, growth and meat qualitative traits. Livest. Prod. Sci. 75 (2), 149-156

6. Dalle Zotte A. 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Review. Liv. Prod. Sci., 75, 11-32.

7. Dalle Zotte A. 2004. Dietary advantages: rabbit must tame consumers. Viandes et Produits Carnés, 23, 161-167.

8. Dalle Zotte A., Cossu M.E., Parigi Bini R. 2000. Effect of the dietary enrichment with animal fat and vitamin E on rabbit meat shelf life and sensory properties. In Proc. 46th ICoMST, 2000 August-September, Buenos Aires, Argentina, 4.II-P8

9. Dalle Zotte, A., Szendrő, Z. (2011). The role of rabbit meat as functional food. Meat Science, 88, 319 – 331.

10. FAOSTAT. 2012. Rabbit meat production in the EU

11. Failla S., Contò M., Ballico S., Concetti S., Negretti P.: Performances and meat quality of Leprino Viterbese breed rabbit, bred with three different housing system. 50th Int. Congr. Meat Sci. Technol.,Helsinki, Finland, 8-13 august 2004, pp. 1260-1263.

12. Gašperlin L., Polak T., Rajar A., Skvarèa M., Iender B. 2006. Effect of genotype, age at slaughter and sex on chemical composition and sensory profile of rabbit meat. World Rabbit Sci., 14, 157-166.

13. González-Redondo P., Rodríguez-Serrano T.M. Promotion of rabbit meat consumption in Spain; Proceedings of the 10th World

Rabbit Congress; Sharm El-Sheikh, Egypt. 3–6 September 2012; pp. 955–959.

14. Hernández P., Cesari V., Pla M. 2007. Effect of the dietary fat on fatty acid composition and oxidative stability of rabbit meat. In Proc. 53rd International Congress of Meat Science and Technology, 2007 August, Beijing, China, 367-370.

15. Hernández P., Cesari V., Blasco A. 2008. Effect of genetic rabbit lines on lipid content, lipolytic activities and fatty acid composition of hind leg meat and perirenal fat. Meat Sci., 78, 485-491.

16. Kling J. 2007. Situation of rabbit production in Hungary in 2006. In: Proc. 18th Hung. Conf. Rabbit Prod., Kaposvár.

17. Kling J. 2008. Situation of rabbit production in Hungary in 2007. In proc.: 20. Nyúltenyésztési Tudományos Nap, Kaposvár, 2008. 87-91.

18. Kowalska D: 2006. Wartość dietetyczna mięsa króliczego. Wiad. Zoot., XLIV, 3, 72-77.

19. Kowalska D. 2013. Historia udomowienia dzikiego królika.Wiadomości Zoot., R. LI, 1: 41–50

20. Krupiński J., Martyniuk E., Krawczyk J., Baran L., Bielański P., Bobak L., Calik J., Chełmińska A., Kawęcka A., Kowalska D., Majewska A., Obrzut J., Pasternak M., Piórkowska M., Polak G., Puchała M., Sikora J., Sosin-Bzducha E., Szyndler-Nedza M., Tomczyk-Wrona I. 2017. 15th anniversary of coordination of animal genetic resources conservation programmes at the National Research

Institute of Animal Production(in Polish). Przegląd Hodowlany, 4, pp. 30-36

21. Leiber F., Meier J.S., Burger B., Wettstein H.R., Kreuzer M., Hatt J.M., Clauss M. 2008 Significance of coprophagy for the fatty acid profile in body tissues of rabbits fed different diets. Lipids 43(9), 853-65. doi: 10.1007/s11745-008-3210-5.

22. Maj D., Bieniek J., Łapa P. 2008. Jakość mięsa królików rasy białej nowozelandzkiej i kalifornijskiej oraz ich mieszańców. Med. Wet., 64 (3), 351-353.

23. Maria G.A., Liste G., Villarroel M., Buil T., Sañudo C., Olleta J.L., López M. 2004. Effect of transport time and season on aspects od rabbit meat quality. 50th Int. Congr. Meat Sci. Technol., Helsinki, Finland, 8-13, 221-224.

24. Petracci M., Soglia F., Leroy F. 2018 . Rabbit meat in need of a hat-trick: from tradition to innovation (and back). Meat Science, *146*, 93- 100. https://doi.org/10.1016/j.meatsci.2018.08.003

25. Ramírez J.A., Oliver M.A., Pla M ., Guerrero L ., Ariño B ., Blasco A. , Pascual M., Gil M . 2004. Effect of selection for growth rate on biochemical, quality and texture characteristics of meat from rabbits. Meat Science 67, 617-624

26. Salvini S., Parpinel M., Gnagnarella P., Maisonneuve P., Turrini A. 1998. In: Banca dati di composizione degli alimenti per studi epidemiologici in Italia. Istituto Europeo di Oncologia, Milano, Italy, 1998, p. 958.

27. Szendrő, Zs., 2004 – A világ nyúltenyésztése. http://www.kaposvar.pate.hu/szeregys/kisallat/Avilag_nyultenyesztese.pdf.

28. Szkucik, K., Pyz-Łukasik, R. (2006). Wartość pH tkanki mięśniowej królików. Ann. Univ. MariaeCurie-Skłodowska Sect. DD, 61, 13, 115–118.

29. Tůmová E., Skřivanová V., Skřivan M., Marounek M., LaštovkováJ., Kubošková M., Knížek J. 1996. The effect of genotype on the growth, digestibility of nutrients and meat quality of broiler rabbits. Sci. Agric. Bohem., 27: 39-48.

30. USDA (2014). USDA National Nutrient Database for Standard Reference, Release 26. (http://ndb.nal.usda.gov)

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