Fatty acids profile of rabbit meat from loin and hind leg from local rabbits breed

Fatty acids are carboxylic acid with long aliphatic chain which is saturated or unsaturated. Fatty acids are very rarely branched and number of carbon atom differ from 4 to 28 in most naturally occurring fatty acids. Fatty acids occur in standalone form like in microalgae where 70% of fatty acids are in standalone form or in from of esters: triglicerydes, phospholipids and cholesteryl esters. Most common form are triglicerydes which are triple esters of glycerol, which means that three – OH groups of glycerol are bounded with COOH- group of fatty acids. This form is main component of e.g vegetable oils (which are liquid in room temperature) and fatty tissue in animal (which are solid or semi-solid). It must be stated that for human most available information are for triglicerydes as they are very important for human diet (source of energy and storage of energy), structural and metabolic function, waterproofing and thermal insulation.
We can find many different classification of fatty acids depend on their properties or biochemical/physiological role:

- By length
  - Short-chain fatty acids – with five or less carbon atoms
  - Medium-chain fatty acids – with between 6 and 12 carbon atoms
  - Long-chain fatty acids – with 13-21 carbon atoms
  - Very long-chain fatty acids – 22 and more carbon atoms
- By saturation:
  - Saturated fatty acids (SFA) – have no double bonds between carbon atoms (C=C)
  - Unsaturated fatty acids (UFA) – have one or more double bonds between carbon atoms - very often within group of this fatty acids we can find symbols – n-3 (ω-3), n-6 (ω-6) and n-9 (ω-9) – it means that after double bonds there are 3, 6 or 9 carbon atoms.
    - Monounsaturated fatty acids
    - Polyunsaturated fatty acids
- By configuration of double bonds
  - *cis* configuration – hydrogen atoms within double bond are on the same side – it may cause chain to bend, generally more double atoms less chain is bended – most naturally occurred fatty acids with double bonds are in *cis* configuration
  - *trans* configuration – hydrogen atoms within double bond are on the opposite side – this cause that chain is very similar to straight fatty acids and less ....to bend

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 1 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 1. 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
Termond White	*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
Pannon White	*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
Popielno White	*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
Moravian Blue	*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
Sl H1	*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
SL R2	*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

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 2 we presented calculated indexes commonly used for evaluation of fatty acids quality and influence on human health

Table 2. 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
Termond White	*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
Pannon White	*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
Popielno White	*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
Moravian Blue	*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
Sl H1	*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
SL R2	*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

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