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# Influence of different sources of fat on lipid index of muscle and fat tissue of pigs

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**Abstract:** Of the total meat production in Serbia, pork makes up more than one half. This meat is often associated with cardiovascular diseases due to its high contents of fat and saturated fatty acids. The aim of this study was to determine the effect of various sources of fat in pig feeds on lipid indices of fat and muscle tissue of pigs from the point of view of consumer health needs. A total of 30 Yorkshire × Landrace crossbred pigs were divided into three experimental groups of 10 individuals and fed a complete finisher mixture for fattening pigs, with standard raw materials and chemical composition but with differing sources of fat. The results obtained show fat sources in pig feed significantly influenced the lipid indices, and the differences were more pronounced in fat than in muscle tissue of pigs.

## 1. Introduction

Pig production is an important part not only of agricultural production but also of the agricultural service industries as suppliers of necessary equipment, raw materials, and preventive and protective materials [1]. The rapid development of pig breeding has led to an increase in the reproductive efficiency of sows and carcass quality, but the meat content of carcasses has almost reached a physiological maximum. The market requires quality meat with a favorable meat:fat ratio, so the goal of each meat industry is based on the production of meat that fulfills quality criteria. Production and consumption are in a causal relationship, and so high consumption causes high production and *vice versa*. The same relationship exists between demand and price, with a low price, of course, increasing consumption [2].

Pigs have a short reproductive cycle that lasts about six months. In intensive sowing, during the production cycle, in one year from one sow, 36 fattening animals can be produced, of which about 1500 kg of meat can be obtained. Pork is accepted as consumable by many cultural groups and is often further processed. In the culinary industry, it is more widely used than other meat species, while beef production has been suppressed, as its market price is lower. The total production of pigs is unevenly distributed worldwide and very differently across the continents, which is conditioned by a number of factors, such as climatic conditions, surface, structure and quality of arable land, development of agro-industrial complex and the like. The continent that stands out for pig production is Asia.

Pig production in Serbia is the most important branch of animal production, both from the socio-economic and from the biological and zootechnical points of view [3]. Pigs in Serbia are the most common meat animal, and production is characterized by the growing participation of large farms (capacity 10,000 to 20,000 pigs per year), while small producers are slowly disappearing. The quality



of pigs in Serbia has improved significantly and can be said to be slowly approaching the world standard. What permanently burdens the production of pigs and pork in the world, but is much more pronounced in Serbia, are the large fluctuations in the price of live pigs. This is the result of major disorders in the supply and demand of pigs, but also the enormous variation in the price of the basic pig feed, corn [1]. In 2019, there were almost 3 million pigs in Serbia. According to the Statistical Yearbook of Serbia, the annual production of pork is about 250,000 tons. In Serbia, pigs are the most commonly slaughtered animal, and therefore, this type of meat is the most common on the table of average consumers [4]. Consumption of pork in Serbia is at the level of the European average, around 43 kg per capita per year. Meat consumption has fallen to today's levels as a result of the decline in living standards over the past twenty years [1].

The basic task of raising livestock is achieving high production of quality meat with minimal food consumption and with as low as possible production costs. The needs of pigs for nutrients and energy are expressed as the need for life sustainability and production. The need for fat in pigs is considered to be relatively small, up to 2%. Lack of essential fatty acids can lead to severe disorders, and a lipid amount of up to 6% in the feed accelerates its utilization.

Fats have multiple relevancies in human nutrition, both for food acceptability and for application in the technological processes of food production. Their energy significance is based on the fact that one gram of fat has an energy value of 9 kcal (37 kJ), which is much more than the energy value (4 kcal per g (17 kJ)) of proteins and carbohydrates [5, 6]. In human diets, fat is particularly important as the carrier of fat soluble vitamins (A, D, E and K) and support for their absorption in the digestive tract. Human organs do not have the ability to synthesize two polyunsaturated fatty acids (PUFA), i.e., linoleic acid (LA; C18: 2 n-6) and alpha-linoleic acid (ALA; C18: 3 n-3). The lack of these essential fatty acids can cause disease in humans.

The attention of the professional and scientific communities today is focused on finding an adequate means of controlling cardiovascular diseases in humans. Research focuses on controlling the qualitative relationship between saturated and unsaturated fatty acids in fats. The class of n-3 PUFA is derived from ALA, the main source of which is fish oil, while the class of n-6 PUFA is derived from LA, which is mainly found in vegetable oils [7]. The desaturation and chain elongation of ALA and LA, by which their PUFA derivatives are formed, are catalyzed by the same enzyme (desaturase). This creates competition for this enzyme among these essential fatty acids, so increasing the concentration of LA can inhibit the conversion of ALA into its derivatives, and *vice versa*, intaking predominantly ALA and/or eicosapentaenoic acid can reduce the production of LA derivatives and arachidonic acid. These dis-balances can impair the ratio of n-6:n-3 fatty acids in the body [8, 9]. Research shows an important role is played by the interaction of these two groups of dietary PUFA (n-6 derived from LA and n-3 derived from ALA) in the development of cardiovascular diseases in humans. Contemporary human diets have undesirable ratios of n-6:n-3, often exceeding 25:1, although this ratio should be 4:1 [5, 10]. The nutritional value of fat and its importance for human health is most often expressed through the n-6:n-3 ratio, but recently, lipid indices have been used that are directly related to the fatty acid composition of the tissue. Calculating the atherogenic (AI) and thrombogenic index (TI) indicates the potential for cardiovascular disease, and for the purpose of protecting consumers against hypercholesterolemia, a condition that can cause atherosclerosis, the hypocholesterolemic/hypersterolemic index (h/H) is calculated.

As animal nutrition can affect the ratio of n-6:n-3 fatty acids in pigs, lipid indices can also be affected. The fatty acid profile of feeds is directly reflected in the fatty acid profile of the animal tissues [11]. The aim of this study was to determine the effect of various sources of fat in pig feeds on fatty acid composition and lipid indices of fatty and muscle tissue from the pigs, in terms of consumer health needs.

## 2. Materials and Methods

For the purposes of this study, 30 Yorkshire × Landrace crossbred pigs were used with a starting weight of 60 kg. The pigs were divided into three experimental groups of 10 individuals and fed with a complete finisher mixture for fattening pigs, with standard raw materials and chemical composition. The feed for the pig groups differed in that the experimental group E-I had sunflower seed in the feed, the second experimental group E-II had a linseed preparation at the recommended 2.5% level in the feed (Vitalan 85-15; Vitalac, France), and feed for the third experimental group E-III had soybean grits. Vitalan 85-15 contained 85% extruded linseed and 16% wheat bran.

After sacrificing the pigs, the fatty acid compositions of muscle and fat tissues were determined and used to calculate the lipid indices (AI, TI, h/H) according to the following formulas:

$$AI = [(C12:0) + (4 \times C14:0) + (C16:0)] / [\Sigma n6 + \Sigma n3 + \Sigma MUFA]$$

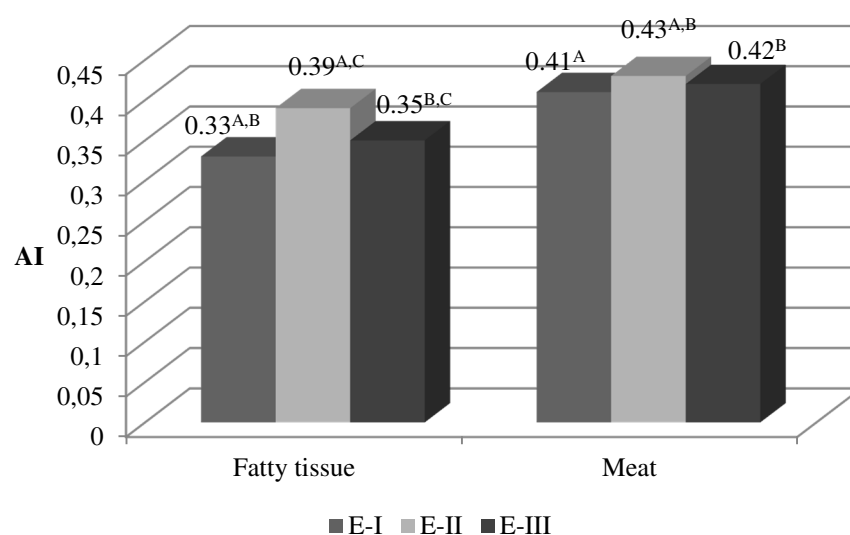
$$TI = [(C14:0) + (C16:0) + (C18:0)] / [0.5 \times \Sigma MUFA + (0.5 \times \Sigma n6) + (3 \times \Sigma n3) + (\Sigma n3 / \Sigma n6)]$$

$$h/H = [(C18:1 + C18:2 + C18:3 + C20:3 + C20:4 + C20:5 + C22:4 + C22:5 + C22:6) / (C14:0 + C16:0)]$$

Statistical data processing was done in GraphPad Prism software version 7.00 for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com). The results are presented graphically as intermediate values using Microsoft Office Excel 2010. Comparison of lipid indices among examined groups of pigs was done using one-factor analysis of variance (ANOVA). Statistical significance is shown at  $p < 0.05$ .

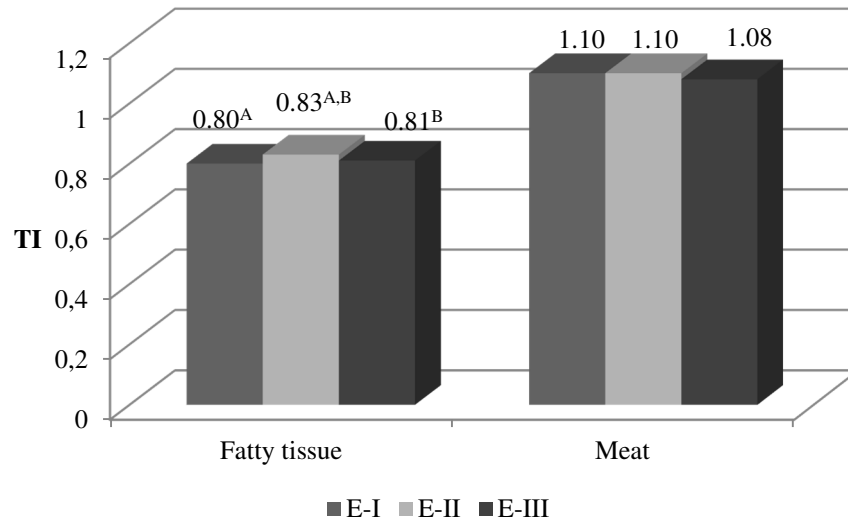
## 3. Results and Discussion

Figures 1 and 2 show AI and TI indices of fat and muscle tissue from pigs fed with different fat sources in feed. Statistically significant differences were found between the AI of fatty tissue of the examined groups of pigs ( $p < 0.05$ ). The smallest AI index was  $0.33 \pm 0.01$  in E-I, and the largest ( $0.39 \pm 0.01$ ) was in E-II pigs that were fed on linseed mixture. The AI of the meat was statistically significantly higher ( $p < 0.05$ ) in E-II ( $0.43 \pm 0.01$ ; fed with linseed mixture) than in E-I ( $0.41 \pm 0.01$ ) and E-III ( $0.41 \pm 0.01$ ) pigs.



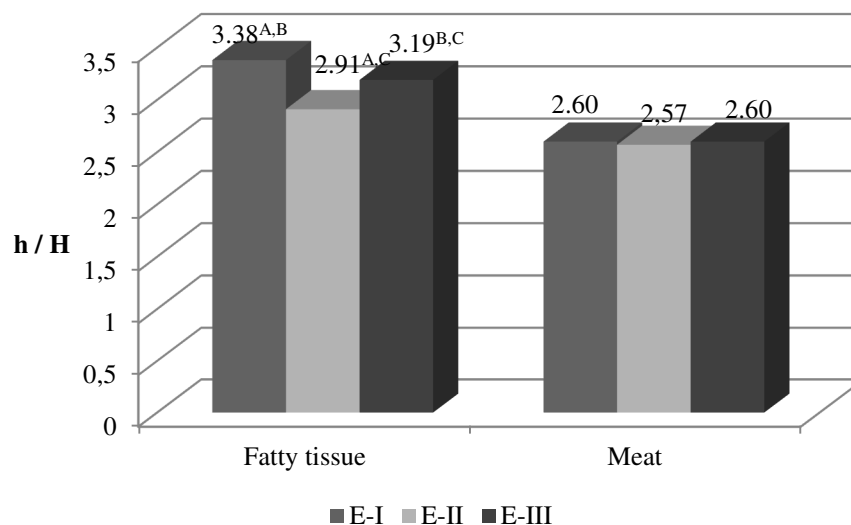
**Figure 1.** Atherogenic indices (AIs) in fatty tissue and meat from pig groups fed on mixtures with sunflower (E-I), linseed (E-II) or soybean (E-III). Bars with the same letter A, B or C differ significantly ( $P < 0.05$ ).

The average TI of fatty tissue from pigs fed with added linseed ( $0.83 \pm 0.02$ ) was statistically significantly higher ( $p < 0.05$ ) than the average TI of fatty tissue from E-I ( $0.81 \pm 0.01$ ) and E-III ( $0.81 \pm 0.01$ ) pigs (Figure 2). No statistically significant differences were found between the average TI of muscle tissue from the pig groups (TIs ranged from 1.08 to 1.10).



**Figure 2.** Thrombogenic indices (TIs) in fatty tissue and meat from pig groups fed on mixtures with sunflower (E-I), linseed (E-II) or soybean (E-III). Bars with the same letter A or B differ significantly ( $P < 0.05$ ).

A statistically significant difference ( $p < 0.05$ ) between the h/H index was found in the fat tissue of all three examined pig groups. This index ranged from  $2.91 \pm 0.04$  (E-II) to  $3.38 \pm 0.06$  (E-I). The h/H index of pig muscle tissue ranged from  $2.57 \pm 0.06$  (E-II) to  $2.60 \pm 0.03$  (E-I and E-III). The differences between the average values of h/H of muscle tissue from pigs fed with different fat sources were not statistically significant.



**Figure 3.** The ratio of hypocholesterolemic/hypercholesterolemic fatty acids (h/H) in fatty tissue and meat in from pig groups fed on mixtures with sunflower (E-I), linseed (E-II) or soybean (E-III). Bars with the same letter A, B or C differ significantly ( $P < 0.05$ ).

Small AI or TI indicates nutritionally more valuable food, or that the food could lower the risk of cardiovascular diseases associated with fat intake [12]. High h/H indices indicate the higher nutritive value of fat. Previous studies on this topic showed the use of linseed (i.e. flaxseed) in pig nutrition significantly affects the n-6:n-3 ratio. Thus, the ratio of n-6:n-3 in the muscle tissue from pigs fed with added linseed was 13.67, 32.40 and 17.84 (E-II, E-I and E-III pigs, respectively) [13]. The n-6:n-3 ratio in the fatty tissue from pigs feed with added linseed was 10.23, 27.30 and 17.74 (E-II, E-I and E-III pigs, respectively) [13]. This raises the question of whether lipid indices are more relevant indicators of the nutritional value of fat in food.

According to literature data, age and provenance in broilers does not significantly affect lipid indices of breast and thigh meat. The AI of breast meat was 0.46-0.54, TI was 0.99-1.10, and h/H index was 1.81-2.18. The same indices were 0.40-0.46 (AI), 0.96-1.08 (TI) and 2.22-2.57 in thigh meat [14]. In muscle tissue of pigs, AI was 0.47, TI was 1.06 and h/H ratio was 2.19, in pig fat tissue, AI was 0.48, TI was 1.14 and h/H ratio was 2.26, while in pig liver, AI was 0.30, TI was 0.94 and h/H ratio was 3.40. AI and TI in the liver have lower values than in fat and muscle tissue, while the h/H ratio is higher in liver, which is beneficial for consumer health [15]. Muscle tissue of different breeds of cattle had AI of 1.85, and 1.62, TI of 3.95 and 3.63 and h/H ratio of 0.52 and 0.62 [16]. In groups of sheep with different fat sources in their diets, AIs were 0.92 and 0.77, and TIs were 2.14 and 1.64 [17]. Fish AI was 0.43-0.46, TI was 0.32-0.36 and h/H index was 2.30-2.59, depending on the season [18]. Other low AI and TI and high h/H indices were also reported by other authors [19, 20].

#### 4. Conclusion

Different sources of fat in pig feed significantly affect the lipid indices, and these differences are more pronounced in fat than muscle tissue of the pig.

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