

Physiochemical Properties and Meat Quality Parameters of Wild Boar Meat: A Review

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ABSTRACT

Wild boar meat has well balanced with nutrients and comprised with unique sensory attributes and meat quality parameters, however, limited information and studies have been performed on nutritional quality and meat quality parameters. The proximate composition of wild boar meat, mainly protein and fat contents were ranged at 21.6-24.11% and 2.27-2.62% respectively. The composition of fatty acids in wild boar has obtained higher values for unsaturated fatty acids particularly mono unsaturated fatty acids; nonetheless, investigation on availability of essential amino acids was scarce. Wild boar meat was darker colour, less tender and pH ranged at 5.44-5.71. Further, sophisticated studies will promote the consumption rate of wild boar meat among consumers that ultimately provide an opportunity to industries to enhance their production.

Keywords— Meat Quality Parameters, Proximate Composition, Sensory Attributes, Wild Boar Meat

I. INTRODUCTION

Wild animal's meat is easily accessible in rural part of every country with the cheap price (Rao, 2002; Saadoun and Cabrera, 2008); however, slaughtering of wildlife resources is considered to be guilty of an offence in most of the countries. Moreover, wild meat is balanced with all required nutrients, particularly, a good protein source and recommended as a healthy (Hoffman and Wiklund, 2006; Soriano et al., 2006) and safe food (Strazdina et al., 2014; Russo et al., 2017). Currently, some developed countries have initiated farms to raise wild animals while provision of the same natural environment. The main objective of this project is to providing wild meat and meat products to local consumers without against rules and regulations. Therefore, the importance of wild meat consumption is

gradually increasing in the worldwide, among these; wild boar meat is getting more attention by the consumers.

Consumers has initiated to forecast towards the identification of food sources which could be obtained from the natural environment because researchers have proved that nutritional level of wild products are as equivalent as products produced from intensive farming systems. As the consequence, the consumption rate of meat originated from wild animals has shown phenomenal growth in the recent years, especially in developed countries. Accordingly, wild boar meat also plays a significant role in the contribution among other types of meat including venison, beaver, etc. Wild boar (*Sus scrofa scrofa*) is an omnivorous animal which consumes 90-95 % of plant originated foods and rest of the part derived from animal originated foods (Genov, 1981; Pinna et al., 2007). The foremost characteristic of wild meat other than nutritional value is unique sensory attributes such as smell, taste and texture, therefore, it widely attracts by consumers. (Soriano et al., 2006; Vergara et al., 2003; Szymańko et al., 2007)

Moreover, consumer acceptability is one of the principal problems faced by meat industries when they tend to provide customer satisfaction by their meat products. Banovic et al. (2009) mentioned that generally, consumers choose meat products mainly based on two parameters: the outlook of the product (appearance, colour and odour) and changes in meat quality parameters after heat treatment (firmness, juiciness, taste and flavor). Müller et al. (2000) have proven that although, the European wild boar meat has provided an ideal standard with respect to carcass composition and an excellence meat quality characteristic; those were not selected for commercially important meat traits while comparing with Meishan, Pietrain and their cross swine breeds. The reason behind this was lack of knowledge on identification of significance value on wild boar meat

quality and lack of standardization in evaluation of meat quality parameters. Therefore, detail study on proximate composition and meat quality attributes of wild boar meat should be carried out in order to aware the consumers.

Furthermore, inclusion of meat of wild animals, including wild boar meat in diet is extensively auspicious for human health because polyunsaturated fatty acids are mostly abundant while it has lower content of SFA (Medeiros et al., 2002), lower caloric value (Szymański et al., 2007) and higher in protein content (21-25%) (Skobrák et al., 2011). Moreover, trace minerals such as iron, zinc, copper, manganese, etc are enough available in wild meat, therefore, it is considered as an excellent source of minerals (Skobrák et al., 2011). According to Daszkiewicz et al. (2007); Fajardo et al. (2008); Jukna and Valaitienė (2012) have stated that wild meat commands a high price than other types of meat due to the presence of outstanding nutritional properties, health aspects and mainly the animals are not treated with any kind of hormones or steroids. However, limited information and studies have been performed on nutritional quality and meat quality parameters. Therefore, the review was written in an attempt to gather existing information available on wild boar meat and to compare with previous studies. This would be facilitated to identify integral characteristics of wild boar meat which could be applied in development of novel food products and also to identify potentials where future studies are needed.

II. NUTRITIONAL VALUE

Protein Content

Protein source is required to effectively perform for a number of body functions and metabolism, growth and development, and reproduction (Murphy and Allen, 2003; Sandström et al., 1989). Strazdina et al. (2013) reported that wild boar meat had the richest protein level about 21.81 – 22.92% compared with deer and beaver meat. This result was similar with the finding of paleari et al. (2003), stated that the protein content of wild boar meat was 21.9%. Skobrák et al. (2011) stated there was no significant ($p < 0.05$) difference between protein content (21.81%) of wild boar meat with respect to different management systems. Similar finding was observed by Szymański et al. (2007) in wild boar meat (21.6%) from Poland. Wild boar meat has shown higher amount of protein content about 23.03% compared with other ruminant animals including cattle and sheep, however, slightly lower than commercially pork (24.11%) Jukna and Valaitienė (2012).

Amino acids profile

Investigation and interpretation on availability of amino acids in wild boar meat was scarce. Nevertheless, few studies have focused and reported amino acids profile in wild boar meat originated from different geographical

locations. (Strazdina et al., 2013) investigated the total content of essential amino acids in wild boar meat and stated that it contained approximately 24.14 g/100 g. However, the investigation has further mentioned that the sum of essential amino acids composition of beaver meat was more than double of wild boar meat and beaver meat was well-balanced in essential amino acids profile than wild boar meat. Further studies have to be performed to brief the amino acids profile in wild boar meat.

Fat Content

Fat content and composition of fatty acids in wild boar meat were deeply analyzed and reported in detail by a plenty of previous studies. Based upon that Strazdina et al. (2013) have stated the fat content of hunted wild boar meat was 2.82% obtained from Latvia, Europe. Further, Skobrák et al. (2011) mentioned that significant difference ($p < 0.05$) was observed for fat content in wild boar meat collected from Hungary with regards to different management systems. Hence, the lowest fat content was detected in extensive farming system about 4.27% while the highest fat content was shown in semi-intensive farming system (14.12%). Jukna and Valaitienė (2012) have obtained 2.27% of intramuscular fat in wild boar meat which was equivalent to roe meat (2.28%). Further, the fat content of *Sus scrofa ferus* from *musculus longissimus lumborum* was 2.62% obtained by Szymański et al. (2007). Zomborszky et al. (1996) reported the wild meat had the fattest meat with 5.3%, so, the study has shown a drastic difference in the total fat content wild boar meat than other previous findings. The dramatic difference in the total fat content might be increased due to high availability of feeding materials, individual variations and genetic factors. Moreover, the percentage of fat content was obtained higher values in adults than in young animals when analyzed physio-chemical properties of longissimus muscle in wild boar by Dannenberger et al. (1996).

Fatty acids Profile

Strazdina et al., 2013 mentioned the total percentage of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were 34.79, 35.63 and 17.25% individually. The fatty acids profile of wild boar meat is known to contain less quantity of especially PUFA than pork (Berrisch-Hempfen, 1995). The total fatty acid contents including SFA, MUFA and PUFA in Chorizo sausages prepared from wild boar meat were 30.2, 49.2 and 20.6% respectively, whereas, total content of SFA, MUFA and PUFA in Saucisson sausages were 32.4, 53.5 and 14.1% correspondingly (Soriano et al., 2006). According to the study of Ramanzin et al. (2010), the composition of fatty acids from animals farming conditions has amalgamated with some factors including the effect of age at either slaughtering or hunting age, sex and hunting season, however, seasonal variation in nutritional level and feed availability were not considered. Further, variation of SFA, MUFA and

PUFA of wild boar with respect to age and type of muscles is shown in Table 1.

Table 1: Table 1 Fatty acid profiles of hunted wild boar meat from different anatomical locations (Source: Quaresma et al., 2011; Razmaite et al., 2012)

Type of muscle	Age	SFA	MUFA	PUFA
<i>M. psoas</i> from wild boars hunted in Portugal	Adult Males	34.7	38.9	25.4
	Adult Females	34.2	42.6	22.5
	Young animals	33.3	42.2	23.8
<i>M. longissimus dorsi</i> from wild boars hunted in Lithuania	Males (n=27)	38.88 ±0.81	43.65 ±1.00	17.39± 1.18
	Females (n=22)	36.30 ±0.92	44.26 ±1.15	18.91± 1.35
	Males (n=16)	43.40 ±1.20	45.31 ±1.14	11.35 ±0.88
Subcutaneous fat	Females (n=19)	40.19 ±1.01	46.69 ±0.96	11.45 ±0.74

Moreover, Russo et al. (2017) reported age is greatly influenced the fatty composition in wild boar meat, accordingly, higher percentage of palmitic acid (C16:0), and caproic acid (C6:0) were obtained in young and sub-adult animals respectively. Additionally, hunting season was the most influencing factor on the fatty acid profile of meat due to no restriction on the diet; nonetheless, sex and hunting age have little impact on fatty acid composition (Russo et al., 2017).

Ratio of SFA/PUFA and ω -6/ ω -3

A higher ratio of PUFA/SFA and lower ω -6/ ω -3 enriched meat products contribute to balance the fatty acid in consumer's intake and also prevent from an increased risk of obesity, hypercholesterolemia and some cancers (Wood et al., 2008). The total content of omega 6 and omega 3 in hunted wild boar meat from Latvia, Europe were 13.89 and 2.89 respectively (Strazdina et al., 2013). Linolenic acid was highly contributed to omega 6 fatty acids than others (Strazdina et al., 2013). However, according to the world Health Organization (WHO), the ratio of ω -6/ ω -3 should be lower than 4. Wood et al. (2004) reported that the most abundant polyunsaturated fatty acid in wild boar meat is linolenic acid, thus causes high biological value for wild meat. Russo et al. (2017) stated the hunting month has a massive impact on PUFA/SFA ($p=0.05$) and ω -6/ ω -3 ($p=0.01$), however both values were widely deviated from recommended level by Wood et al. (2004).

Mineral content

The mineral content of wild boar meat was 1.15% (Strazdina et al., 2013). Among these minerals, iron, zinc and copper were 3.44 mg/kg, 3.73 mg/kg and 0.07mg/kg respectively. The similar finding was observed by Jukna and Valaitienė (2012), the ash content was 1.12% and

also significant difference was observed between different animals species such as cattle, sheep and commercial pig ($p<0.001$). Strazdina et al., 2011 have analyzed the presence of macro and micro minerals in wild boar meat under different management systems and also compared with commercial pork (Table 2). The equal amount of calcium and phosphorous levels were observed in both extensive and intensive management systems (18.38 g/kg and 27.98 g/kg; 2500 mg/kg and 2500 mg/kg correspondingly). No significant differences were observed for manganese and iodine in the wild boar compared with previous studies on commercial pork.

Table 2 Element content of wild boar meat

(Source: Skobrák et al., 2011)

Elements	Management Systems		
	Extensive (n = 06)	Semi intensive (n = 30)	Intensive (n = 30)
Ca (mg/kg)	55.77±3.78	189.30±38.35	83.16±8.53
P (mg/kg)	2501±51.19	2009±66.43	2500±81.23
Mg (mg/kg)	250.80±4.99	187.60±9.46	259.70±8.85
Fe (mg/kg)	44.25±5.10	39.83±3.52	55.66±3.83
I (mg/kg)	0.071±0.008	0.107±0.019	0.111±0.009
Se (mg/kg)	0.130±0.013	0.047±0.006	0.075±0.005
Mn (mg/kg)	0.220±0.038	0.569±0.119	0.517±0.052
Cu (mg/kg)	1.922±0.169	1.325±0.110	2.174±0.092
Zn (mg/kg)	52.17±6.99	37.87±3.23	50.28±3.62

III. MEAT QUALITY PARAMETERS

The meat quality parameters and also sensory attributes of meat is governed by the physical, chemical and morphological composition of the meat and by subsequent post-mortem processes amalgamated with the technology applied for an effective storage (Hofbauer et al., 2006).

Colour

The colour values of lightness (L^*), redness (a^*) and yellowness (b^*) of wild boar meat gathered from different climatic conditions in Lithuania and observed 36 hours after slaughtering were 46.14, 19.38 and 9.12 respectively (Jukna and Valaitienė, 2012). As results revealed, wild boar meat has intense lightness value than other colour parameters. Borilova et al. (2016) have distinguished the colour values for shoulder and leg from wild boar meat obtained from Czech Republic, based on that leg part has shown comparatively higher values for L^* , a^* and b^* . Nonetheless, L^* and a^* were did not significantly change with the different storage temperatures but b^* has increased at the end of the storage period (21 days). Despite, Szmańko et al. (2007) stated that Poland wild boar meat was characterized by lower L^* , but with higher values of a^* and b^* colour parameters compared with polish large white breeds. Marchiori and Flicio (2003) have reported the similar findings in wild boar meat collected from Brazil.

pH

The pH of wild boar meat and pork from farm pigs after 36 hours of slaughtering process were 5.48 and 5.44 respectively reported by Jukna and Valaitienė (2012). Borilova et al. (2016) have identified whether pH has impact on anatomical location of muscles and also different storage temperature, accordingly, pH of shoulder meat of wild boar meat was as equal as leg meat (5.70), however, fluctuations were observed in pH values over the different storage temperature and time duration combinations. pH value of fresh meat obtained from *musculus longissimus lumborum* from the carcass of 9 months of wild boars (*Sus scrofa ferus*) and polish large white pigs were 5.71 ± 0.03 and 5.68 ± 0.12 respectively. However, different storage conditions were not significantly influenced on pH of both types of meat; especially pH of wild boar meat has not shown any changes at -18°C of storage temperature for 28 days (Szmańko et al., 2007). Therefore, the best preservation method of wild boar meat is to maintain the temperature about -18°C at the freezer for a month period. However, further study has to be performed in order to determine the shelf life of wild boar meat at the freezing condition. Wild boar meat pH value has gradually declined with respect to post mortem time duration due to the rapid conversion of glycogen into lactic acid by post mortem glycolysis process (Figure 1).

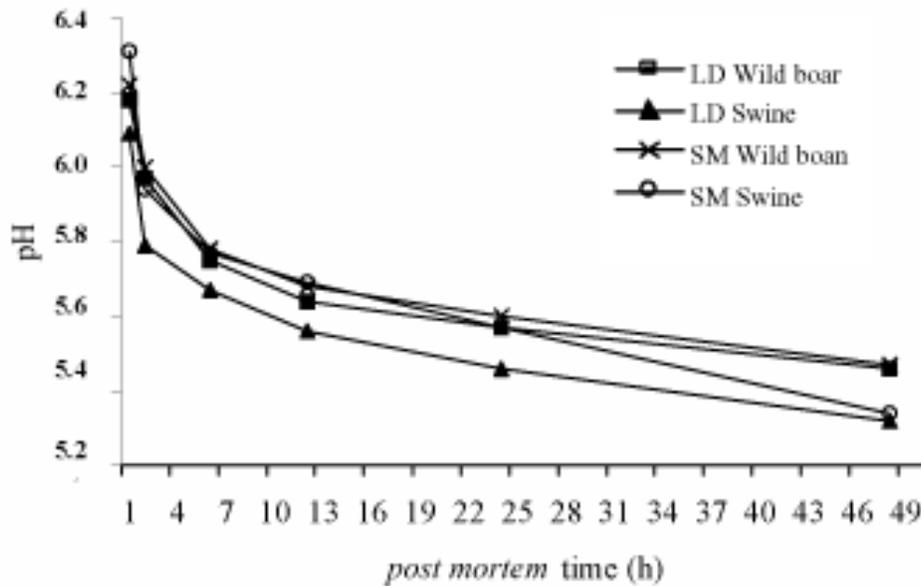


Figure 1: pH decline at various postmortem times for *Longissimus dorsi* (LD) and *Semimembraneous muscles* (SM) of wild boar and swine

(Source: Marchiori and Felício, 2003)

Texture

Fielder et al. (1998); Rahelic and pauc (1981); Sales and Kotrba (2013) proved that wild boar meat contains high amount of soft-twitch oxidative muscle fibers than domestic pigs, thus, meat ultimately gives either more tenderness or juiciness (Maltin et al., 2013) and more palatable. Tenderness of wild boar meat was 1.85 kg/cm^2 after slaughtering which is as same as tenderness of cattle meat (1.84 kg/cm^2) (Jukna and Valaitienė, 2012). Liu et al. (1996); Dransfield (1977) have proven that carcass weight of livestock has strong relationship with respect to meat texture and histology of their muscles. On the other hand, the histochemical

composition varies up to certain extent because of life style and differences in feeding pattern of wild boar meat compared with pigs (Ruusunen and Puolanne, 2004). The previous study Zochowska et al. (2005) have demonstrated that muscle meat from different anatomical locations and structure of muscle fibres could be able to impact on textural parameters with regards to different carcass weight. Accordingly, significant difference was found in textural parameters of wild boar meat especially on hardness, springiness and chewiness in *biceps femoris muscles* with respect to different carcass weight (Table 3) Zochowska et al. (2005).

Table 3: Mean values of textural parameters of the QF, SM and BF muscles of wild boars of different carcass weight (Adapted from: Zochowska et al., 2005)

Carcass weight (kg)	Muscle	Hardness (N)	Cohesiveness (-)	Springiness (cm)	Chewiness (N cm)
20	QF	$33.25^{a,1} \pm 3.58$	$0.406^{a,1} \pm 0.03$	$0.99^{a,1} \pm 0.01$	$13.21^{a,1} \pm 0.7$
	SM	$36.93^{ab,1} \pm 3.3$	$0.423^{a,1} \pm 0.05$	$0.99^{a,1} \pm 0.06$	$16.15^{ab,1} \pm 1.6$
	BF	$40.76^{b,1} \pm 1.9$	$0.455^{a,1} \pm 0.04$	$0.96^{b,1} \pm 0.07$	$17.65^{b,1} \pm 3.4$
60	QF	$41.80^{a,2} \pm 2.9$	$0.430^{a,1} \pm 0.02$	$0.93^{a,1} \pm 0.11$	$16.72^{a,2} \pm 2.6$
	SM	$45.78^{a,2} \pm 3.5$	$0.461^{a,1} \pm 0.03$	$0.94^{a,1} \pm 0.08$	$19.84^{ab,1} \pm 3.0$
	BF	$53.78^{b,2} \pm 3.6$	$0.447^{a,1} \pm 0.01$	$0.09^{a,1} \pm 0.07$	$21.63^{b,1} \pm 2.5$

*QF.- m. quadriceps femoris; SM.- m. semimembranosus; BF. - m. biceps femoris.

^{a,b} No significant differences within an animal group at the 0.05 level of probability.

^{1,2} No significant differences between animal groups at the 0.05 level of probability.

Water Holding Capacity and Cooking Loss

Water holding capacity (WHC) of wild boar meat (*Sus scrofa ferus*) was $56.63 \pm 2.47\%$, showed significant differences between different storage conditions (Szymańko et al., 2007). The similar finding was observed in wild boar from Lithuania after 36 hours of slaughtering, WHC was found about 57.07%, whereas, sheep meat has shown almost the same value (57.23%), however, the highest WHC has observed in cattle meat

(62.91%) Jukna and Valaitienė (2012). WHC of 12-24 months of wild boar from both forest and farmland were similar result (Table 4) as same as Szymańko et al. (2007) findings. No significant differences in cooking loss with respect to anatomical location mainly shoulder part of wild boar meat (36.74%), nevertheless, leg has shown higher significant differences in cooking loss with the different storage conditions (Borilova et al., 2016).

Table 4: Meat quality parameters from *Longissimus dorsi* muscle in wild boar of different age and feeding area (Source: Pedrazzoli et al., 2017)

Age Feeding area	12-24 months		Older than years	
	Forest	Farmland	Forest	Farmland
pH	5.72	5.63	5.46	5.67
L*	42.42	46.7.	43.39	50.05 ^b
a*	15.72	16.53	17.68	22.33 ^b
b*	4.55	4.23	4.99	8.12 ^b
WHC (%)	56.26	55.09	53.93	51.49
Cooking loss (%)	26.35	28.79	29.57	27.94

n=8 animals per each group performed in duplicate

Flavour

Flavor is one of the principal sensory attribute and plays a major role in the food products but which is known to be influenced by antemortem and postmortem factors (Gonzalez and Ockermann, 2000). Lammers et al. (2009) have detected fifty three volatile compounds in the Tenax cartridge of frying wild boar meat. Further, production of roasty note of fried meat samples was generated by the contribution of furfurylmercaptan and another maillard product detected in the study. Moreover, the amino acids and fatty acids were recognized as the major meat aroma precursors. However, the study has failed to identify volatile compounds which responsible for the characterization of typical wild boar meat odorants.

IV. CONCLUSION

Wild boar meat has owned a number of beneficial nutritional and meat quality properties which could be able to create a stable platform for meat producers to attract consumers. Many studies have proven nutritional aspects regarding on protein, fat and fatty acids composition and micro nutrients, however, most of the researches did not give more priority to analyze essential amino acids profile. Meat quality and yield of wild boar will be significantly increased when follow proper hunting practices. Further, sophisticated studies will promote the wild boar meat among consumers that ultimately provide an opportunity to industries to enhance their production.

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