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KEYNOTE

Pig meat-health: a possible binomial?

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SUMMARY

Meat and meat products are important sources of essential nutrients for humans, but recent epidemiological studies have associated red meat and processed meat consumption with an increased risk of cardiovascular disease and colorectal cancer due to saturated fatty acids, added salt, oxidative products, N-Nitroso compounds that develop during processing steps, and oxidative capacity of HEME-Iron. Moreover, the International Agency for Research on Cancer has recently defined red meat as probably carcinogenic and cured meat as carcinogenic. This has created considerable alarm among consumers, a significant reduction in consumption of these products and a remarkable negative impact on the market. Europe, with about 150 million of pigs and a yearly production of about 22 million tons carcass weight, is the second biggest producer of pork in the world, and the Mediterranean area of Europe is known around the world for the high quality of processed pig meat products. Therefore, it seems very important to develop new strategies of production and processing that can improve the healthful features of pork and derived products. The paper focuses on some of these strategies.

Additional keywords

Pork.
Fatty acid composition.
Oxidative stability.
Human health.
n-6/n-3 ratio.

Carne suina e salute: un binomio possibile?

SOMMARIO

La carne e i prodotti carnei sono fonte importante di nutrienti essenziali per l'organismo, ma recenti studi epidemiologici hanno associato il consumo di carne rossa e di carne trasformata ad un incremento del rischio di comparsa di malattie cardiocircolatorie e del cancro al colon. Ciò a causa della presenza di acidi grassi saturi, di sale aggiunto, di prodotti dell'ossidazione, di nitroso derivati che si formano durante le fasi di trasformazione, e della capacità ossidativa del ferro-EME. Recentemente l'International Agency for Research on Cancer (IARC) ha definito le carni rosse come probabilmente cancerogene e i salumi come cancerogeni. Ciò ha creato un notevole allarmismo nei consumatori, una significativa riduzione dei consumi di questi prodotti e un grosso impatto negativo sul mercato. L'Europa, con circa 150 milioni di suini e una produzione annuale di circa 22 milioni di tonnellate di carcasse, è il secondo produttore mondiale di carne suina, e l'area Mediterranea è conosciuta in tutto il mondo per la produzione di salumi di alto pregio. Appare pertanto di notevole importanza studiare nuove strategie produttive e di trasformazione atte a migliorare le caratteristiche salutistiche della carne suina. Nella relazione verranno prese in esame alcune di queste strategie.

Parole chiave aggiuntive

Carne suina.
Composizione acidica.
Stabilità ossidativa.
Salute.
Rapporto n-6/n-3.

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INTRODUCTION

Meat and meat products have a high nutritional value due to their good levels of protein content (20-35%) providing all essential well balanced amino acids, of fat soluble (A, D, E, K) and B6 and B12 vitamins, of long chain n-3 polyunsaturated fatty acid (PUFA), readily absorbable iron, selenium, zinc (Mourouti et al., 2015) and, especially in ruminant meat, an appreciable conjugated linolenic acid (CLA) level (Chin et al. 1992). For long time meat consumption has been positively associated with human health, but in the recent years it is frequently associated with a negative health image and a low meat intake, especially red and processed meat, is recommended to reduce the risk of cancer and metabolic syndrome (Biesalski, 2005; WCRF/AIRC, 2009). Nevertheless, due to the rapid economic development, in the last decades the consumption of meat in Europe has gradually increased **(Table I)** and therefore it is necessary adopt strategies to improve quality of meat and meat products making them healthier for consumers. Indeed, one of the key goals of nutritional research focuses on the modification of fatty acid composition of meat and on the improvement of the oxidative stability of lipids.

MEAT AND HEALTH

Since meat and meat products are important sources of essential nutrients for humans and also a major source of fat in the diet, there is an increasing interest in modifying the fatty acid (FA) composition of meat lipids in order to improve nutritional value of meat (Enser et al. 2000).

Diets high in saturated fatty acid (SFA) contribute to increase LDL-cholesterol level, which is positively related to the occurrence of heart diseases (Nieto & Ros, 2012) and it has been hypothesized to increase the risk of colorectal cancer (CRC) (Lin et al. 2004). In the last few decades several epidemiological studies have associated red meat and processed meat consumption with an increased risk of cardiovascular diseases (CVD) (Kontogianni et al. 2008) and CRC (Cross et al. 2007). Mechanisms by which meat and meat components could promote the cancer were investigated by meta-analyses (Larsson & Wolk, 2006) and the main hypothesized mechanisms involve the excess of fat, protein and iron (Corpet, 2011). In particular, different works have confirmed that Heme-Iron content and nitroso compounds are the most relevant causes of CVD and CRC, because are the major responsible for fat peroxidation and N-nitroso pathway, the latter mostly in cured meat (Pierre et al. 2006). Moreover, type, time and temperature of cooking can generate polycyclic aromatic hydrocarbons and heterocyclic amines which are carcinogens (Sugimura et al. 2004).

To reduce the risk of cancer due to the red meat and processed meat consumption, the World Center Research Fund (WCRF) and the American Institute for Cancer Research (AIRC) recommended in 2009 that "red meat intake should be no more than 500 g/week and avoid processed meat" (WCRF/AICR, 2009). Besides, in 2015 the International Agency for Research on Cancer (IARC) have classified consumption of processed meat as "carcinogenic to humans" (Group 1) and red meat as "probably carcinogenic to humans" (Group 2A) (Bouvard et al. 2015). However, it is important to notice that the real average daily intake (g/d) of total meat **(Figure 1)** (McAfee et al. 2010) showed wide differences among countries with a US consumption almost double with respect to the average in the European countries.

Table I. Evolution of meat supply in Europe (Kg per capita by year, FAO, 2016) (Evoluzione del consumo di carne in Europa (Kg pro capite per anno).

Year	Total meat	Pork	Beef	Poultry
1970	64.8	28.5	21.4	9.2
1980	80.3	38.5	22.1	13.8
1990	85.0	41.2	21.5	16.5
2000	84.0	41.5	16.2	19.6
2010	83.4	40.9	16.2	21.9
1970-2010 variation (%)	+ 28.7	+ 43.4	- 24.3	+ 138

Nevertheless, the definition of "red meat" is inconsistent within the scientific community. In European cohort studies, "red meat" is defined as fresh-meat from four-legged and domestic animal, while in some of the American cohort studies, "red meat" includes processed meat (DTU Food, 2016). However, processed meat products may include also preservatives as nitrate/nitrite, salt, sugar, and probably the different typologies of preservation contribute to increase the probability of the risk for human health. Indeed, in American studies, the association between CRC and meat intake resulted more pronounced compared to European ones (DTU Food, 2016). A different approach to define the "red meat" implies instead the amount of total Heme in meat and according to this definition, raw pork would be closer to rabbit or chicken meat, commonly considered as white meat, than to beef meat **(Table II)**. Therefore, it is necessary to define more precisely what is meant by "red meat" in order to draw correct hypothesis about the red meat cancer risk.

SOME STRATEGIES TO IMPROVE PIG MEAT QUALITY

Recently, the quality is becoming an important issue for consumers. Their main concerns relatively to pig meat are the content of fat, saturated fatty acids (SFA) and cholesterol. Therefore, it seems very important to develop new strategies of production and processing that can improve the healthful features of pork and derived products. Some of these strategies involve genetic and nutritional tools to modify the composition of the carcass and tissues as the reduction of fat depots, SFA and cholesterol, the increment of monounsaturated fatty acids (MUFA),

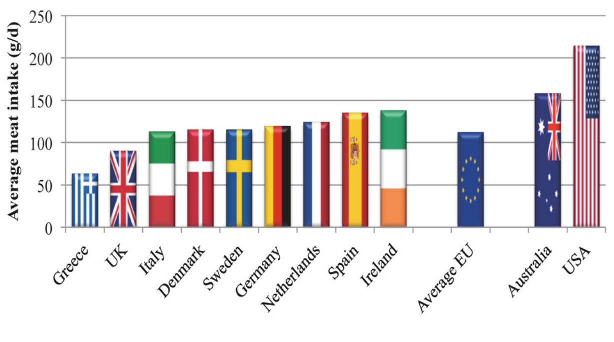

Figure 1. Average daily intake of total meat in different countries. Real average daily intake measured by the European Prospective Investigation into Cancer and Nutrition, EPIC study (Wyness et al., 2011, modified) (Consumo medio giornaliero di carne in differenti paesi. Il reale consumo medio giornaliero è stato calcolato da uno studio dell'European Prospective Investigation into Cancer and Nutrition (EPIC)).

Table II. Total and Heme Iron content of raw meat (Lombardi-Boccia et al. 2002, modified) (Contenuto totale di ferro e di ferro-EME della carne cruda).

Species	Total iron (mg/100g)	Heme iron (mg/100g)	Heme iron (%)
Lamb	2.23	1.68	75.3
Horse	2.21	1.75	79.2
Beef	2.09	1.82	87.1
Chicken	0.59	0.22	37.3
Rabbit	0.45	0.25	55.6
Pork	0.42	0.26	61.9

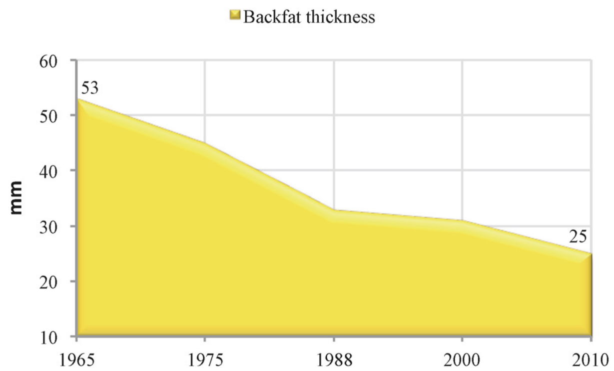

Figure 2. Backfat thickness variation in Italian heavy pig between 1965 and 2010 (Ceci & Guizzardi, 1978; Lo Fiego et al. 2010) (Variazione dello spessore del lardo dorsale nel suino pesante italiano tra il 1965 e il 2010).

PUFA n-3 series and conjugated linoleic acid (CLA), and the increment of oxidative stability by dietary antioxidant supplementation as vitamins E, C and Flavonoid. On the other hand the development of healthier meat products is possible by the reformulation of ingredients reducing the content of fat, sodium and nitrites, incorporating bioactive peptides and pro/prebiotics bacteria, vitamins antioxidants, Se, Ca and increasing eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), α-linolenic acid (ALA) and CLA. Moreover, to minimize the losses of bioactive compounds and the formation of harmful substances as biogenic amines, nitrosamines, thiobarbituric acid reactive substances (TBARs), is necessary to optimize processing technologies, storage and distribution conditions.

In order to meet the nutritional recommendations to reduce fat and SFA meat intake, pig production industries adopted strategies able to reduce the fat content of carcasses. In the Italian heavy pig production, the backfat thickness has been reduced of about 50% in the last fifty years **(Figure 2)**. In the pig as in other monogastric animals, it is possible to modify the lipid FA composition changing the dietary source of lipids. Bertol et al. (2013), comparing three different dietary oil sources, verified that the best n-6/n-3 ratio was obtained with flax oil. Similar results were obtained in studies that showed the ability of extruded linseed to increase only the n-3 class of the PUFA (Enser et al. 2000).

Our preliminary study confirmed that diets with extruded linseed affected the FA composition of backfat and LD muscle of pigs. Indeed, in the backfat only the final amount of n-3 displayed statistical differences ($P<0.001$) comparing the control group (C, 1.1%) with the linseed and vitamin E group (LE, 4.0%) and Linseed and polyphenols group (LP, 3.4%), while for SFA, MUFA, PUFA and n-6 no statistical differences were observed **(Figure 3A)**. An even more significant variation was found in the n-6/n-3 ratio in the backfat and LD muscle **(Figure 3B)**. The ratio decreased from the higher values of the C group (12.6 and 15.4 in backfat and LD muscle respectively), to the values of 3.1 and 5 in the LE group and 3.4 and 4.8 in the LP group (Lo Fiego et al. 2016, data not published). LE and LP showed the recommended value of n-6/n-3 ratio suggested by World Health Organization and FAO. However, obtaining high amount for the healthy FA fractions (MUFA, PUFA, n-3), is as important as their protection. A previous study has shown the positive impact of the addition of vitamin E in animal feed (Lo Fiego et al., 2001): the α-tocopherol promotes the lipids protection, leading to a lower development of TBARs. Lo Fiego et al. (2001) compared the FA oxidative stability in *Longissimus thoracis* (LT) of pigs fed with meal containing 20 (control) or 500 mg vitamin E/kg. The dietary vitamin E integration demonstrated its effectiveness starting from the fifth day of storage when the vit. E group displayed a significantly lower content of TBARs comparing to the control group **(Figure 4)**. According to our results, it is possible to modify the FA composition of pig meat by using particular source of lipid together with the vitamin E, a natural antioxidant, administrated through the diet. This allowed the production of healthier fresh pork meat and consequently pork meat could be considered as a new good source of n-3 FA.

CONCLUSIONS

On the basis of the available data, the association between cancer risk and consumption of red and processed meat is convincing even if the mechanisms involved are still not completely clarified. For example, the hypothesis about the red meat cancer risk depends on the definition of “red meat”, which remain questionable. In the last decades, an increased general consumer awareness of this problem resulted in a raised demand of healthier meat and meat products: on the one hand the reduction of fat, cholesterol, sodium and nitrite and on the other hand an improved of FA composition.

Regarding the FA composition in pork meat, it is easily and directly influenced by diet. Nowadays, the pig dietary supplementation with the n-3 PUFA, protecting them from peroxidation by complementary supplementation with vitamin E or others natural antioxidants, results in a pig meat that fit with human nutritional needs.

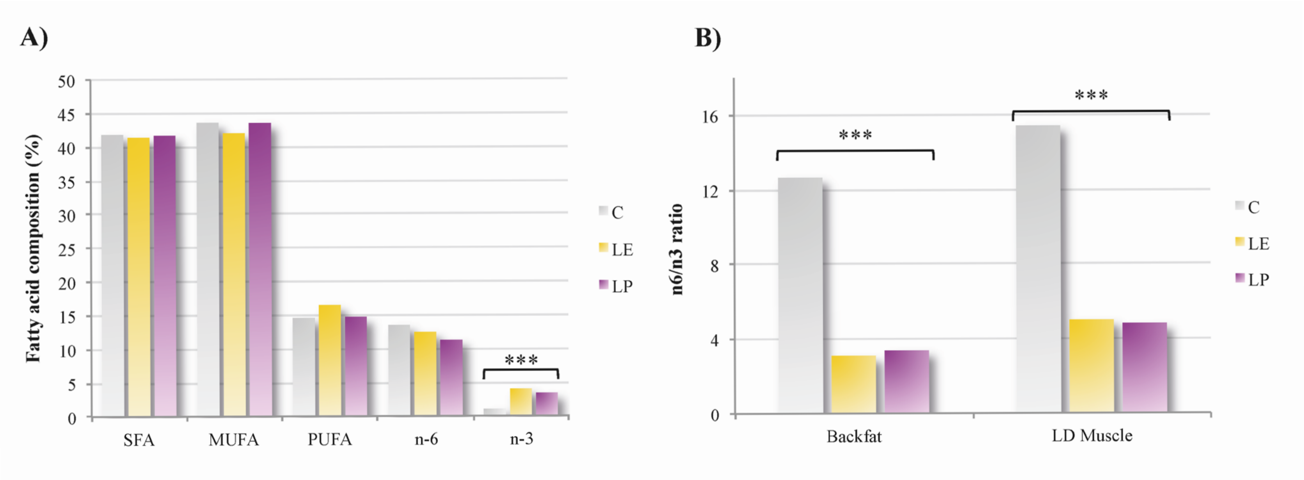

Figure 3. Effect of the different diets on FA composition of lipids. A) % of total FA of backfat; B) n-6/n-3 ratio of backfat and *Longissimus dorsi* (LD) muscle; *** P< 0.001 (Lo Fiego et al. 2016, data not published) (Effetto di diverse diete sulla composizione acidica dei lipidi. A) % di acidi grassi nel lardo dorsale; B) rapporto n-6/n-3 nel lardo dorsale e nel muscolo *Longissimus dorsi* (LD); *** P< 0.001).

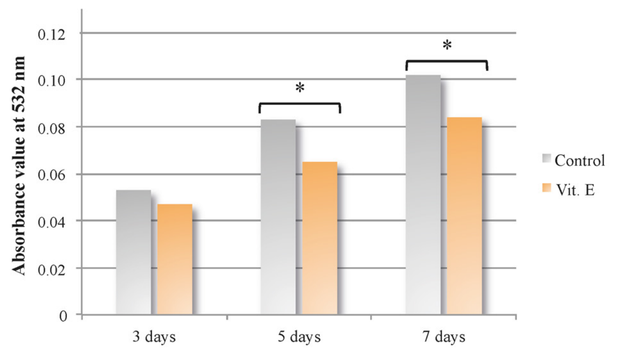

Figure 4. Effect of dietary Vitamin E supplementation on TBARs content of *Longissimus dorsi* muscle at different times post mortem. TBARs were expressed in units of absorbance at 532 nm; *P ≤ 0.05 (Lo Fiego et al. 2001) (Effetto dell'aggiunta della Vitamina E nella dieta sul contenuto di TBARs del muscolo *Longissimus dorsi* a diversi tempi post mortem. I valori di TBARs sono stati espressi in unità di assorbanza a 532 nm; * P≤ 0.05).

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