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ANIMAL PRODUCTION

Dietary lipid sources on the fatty acid profile of swine fat: a review

Stephan Alexander da Silva Alencar[1] **Charles Kiefer**[1*]

[1]Programa de Pós-graduação em Ciência Animal, Universidade Federal de Mato Grosso do Sul (UFMS), 79070-900, Campo Grande, MS, Brasil. E-mail: charles.kiefer@ufms.br. *Corresponding author.

ABSTRACT: *Swine production has focused its efforts to reduce the amount and improve the quality of fat deposited on carcass. Due to the association of the lipid profile with cardiovascular diseases, researches have been developed to understand how the deposition occurs and to improve the fatty acid profile of swine fat. Among the factors that affect the fat composition, race, sex, and diet, the third one has the greatest impact. Lipid inclusion seems to be a promising way to modulate the lipid profile of fat in pig carcass, with an effect on saturated, monounsaturated and polyunsaturated fatty acids. The effect is greater in that fatty acid with the highest concentration in the source used. Soybean oil can double the value of linoleic acid, a by-product of olive oil increases oleic acid by 4%, and flaxseed oil has the ability to increase α-linolenic acid from less than 1% to over 18% in total fatty acids. In addition to the source, the duration and concentration influence the modulation of the fatty acid profile.*
Key words: *lipid profile, omega 3, omega 6.*

Fontes lipídicas da dieta no perfil de ácidos graxos da gordura suína: revisão

RESUMO: *A cadeia produtiva de suínos tem concentrado esforços para reduzir a quantidade e melhorar a qualidade da gordura depositada na carcaça. Devido a associação do perfil lipídico com doenças cardiovasculares, pesquisas têm sido desenvolvidas para entender como ocorre a deposição e para melhorar o perfil de ácidos graxos na carcaça. Dentre os fatores que afetam a composição dessa gordura estão a raça, o sexo e a dieta dos suínos, sendo que este último é o de maior impacto. A inclusão de ingredientes lipídicos parece uma promissora forma de modular o perfil lipídico da gordura na carcaça dos suínos, sendo observado efeito nos ácidos graxos saturados, monoinsaturados e poli-insaturados. O efeito é maior naquele ácido graxo de maior concentração na fonte utilizada. O óleo de soja pode dobrar o valor do ácido linoleico. Um subproduto do óleo de oliva incrementa em 4% o ácido oleico. E o óleo de linhaça tem a capacidade de aumentar o α-linolênico de menos de 1% para mais de 18% no total de ácidos graxos. Além da fonte, o período e a concentração influenciam na modulação do perfil de ácidos graxos.*
Palavras-chave: *perfil lipídico, ômega 3, ômega 6.*

INTRODUCTION

Pork is a highly popular food for many people owing to its excellent nutritional qualities. However, consumers usually do not choose their food solely for its nutrients and other characteristics are also taken into account, such as whether the product is visually appealing, chemically and biologically safe to eat, free from artificial preservatives or food additives, and healthy (JATURASITHA et al., 2016).

Fats are one of the few components of meat that can be modified in both quantity and composition. Therefore, research studies that focus on the association of fats with diseases as well as methods to reduce their harmful effects on human health are very necessary, and there are currently many producers that seek for new sales opportunities (MAPIYE et al., 2012). Lately, special attention has been given to the fatty acid composition of the fat in pork as it is associated with human health (AHMED et al., 2016). Studies on lipid profile changes in fats in general, and in pork in particular, tend to focus on two main areas: identification of the factors that can alter the lipid profile and worsen or improve the quality of the processed meat, and ways to transfer a healthier lipid profile to consumers.

With regard to the factors capable of influencing the fatty acid content of fats and pork, researchers have focused on the breed, sex, and diet of the animals, with the one found to have the

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greatest impact being the diet (JUÁREZ et al., 2016). However, there still needs to be further studies carried out on the use of different lipid sources in feed for improving the fatty acid profile of farmed animals. In this context, this review article presents an overview of established information on fat deposition in the swine carcass, the impact of fats on human health, and how dietary lipid supplementation can contribute to changes in the fatty acid profile of farmed pigs.

Fatty acids in pigs

Carbohydrates, proteins, and lipids provide energy for the maintenance of the body and tissue growth. As pigs mature, an increasing proportion of the energy is stored as fat in the animal's body, especially when energy intake exceeds requirements, and is mobilized for oxidation when dietary energy is limiting (MAPIYE et al., 2012). Fats are deposited in different places in the body but can be divided into three main categories: visceral fat, subcutaneous fat, and muscle-associated fat. The last of these three types can be further divided into inter- and intramuscular fat, also known as marbling. According to the animal's growth stages, fat deposition occurs first in the viscera, then subcutaneously and intermuscularly, and finally intramuscularly (DAVIES & PRYOR, 1977).

Subcutaneous swine fat can be separated into three individual layers. The outer layer develops first and has the highest proportion of unsaturated fatty acids of the three layers. By contrast, the middle and inner layers develop later but at a faster rate. Moreover, the middle layer has the most lipogenic activity of the three layers, resulting in a higher deposition of saturated fatty acids (APPLE et al., 2009b).

The types define the amount of each type of fatty acid in swine fats and amounts contained in the feed that the animal had consumed as well as by those produced endogenously through *de novo* synthesis from precursors such as carbohydrates and proteins. When absorbed precursors are not being used for protein synthesis or oxidized for the production of adenosine triphosphate, their carbon skeletons are funneled into *de novo* fatty acid synthesis and energy storage instead. The product of the fatty acid synthesis pathway is palmitic acid, which can be further extended to stearic acid, both of which can be converted to monounsaturated fatty acids by the enzyme Δ^9-desaturase to form palmitoleic and oleic acids (MAPIYE et al., 2012). Under low-fat diets, the endogenous synthesis of palmitic, stearic, and oleic acids occurs at a ratio of 1.6:1.0:3.0, respectively (DURAN-MONTGÉ et al., 2010).

With regard to fatty acids obtained from feed, the digestion of the fat-containing feed in the small intestine leads to the breakdown of the triglycerides, the components of which eventually form micelles that are then absorbed. From there, the fatty acids are distributed throughout the animal's body and can be used or stored in tissues without changing their shape (WOODS et al., 2009).

Although, saturated and monounsaturated fatty acids can be obtained from feed, they are not considered essential because they can be synthesized endogenously by the animal. By contrast, the polyunsaturated fatty acids linoleic acid (C18:2*n*-6) and α-linolenic acid (C18:3*n*-3) are considered nutritionally essential because they can only be obtained through a balanced diet (WOOD et al., 2008). Mammals are unable to synthesize these essential fatty acids because they lack the enzymes needed for placing a double bond at the omega 3 or 6 positions (CALDER et al., 2004).

Linoleic and α-linolenic acids are also precursors of the long-chain omega 6 and omega 3 polyunsaturated fatty acids that are synthesized *via* elongation and desaturation (MAPIYE et al., 2012). In mammals, the desaturation and elongation processes occur primarily in the liver (CALDER et al., 2004). In the omega 6 pathway, linoleic acid is the precursor from which arachidonic acid (C20:4*n*-6) is eventually formed through the activity of various enzymes. In the omega 3 pathway, α-linolenic acid is converted to eicosapentaenoic acid (EPA; C20:5*n*-3) and docosahexaenoic acid (DHA; C22:6*n*-3) (SKIBA et al., 2015). It has been found that oleic, palmitic, stearic, and linoleic acids are the predominant fatty acids in pork fat, with the monounsaturated fatty acids being the highest in concentration, followed by the saturated fatty acids and finally the polyunsaturated fatty acids (APPLE et al., 2009a; JUÁREZ et al., 2016).

Fatty acids in human diet

Because of the higher human consumption of red meat in recent years and hence increase in the animal fat and energy density of the human diet, particularly in developed countries, there is concern that there will be a higher incidence of chronic human diseases linked to this type of diet, especially cardiovascular disorders, leading to a significant global health problem (BHUPATHIRAJU & TUCKER, 2011). For a long time, it was believed that the amount of dietary fat was unique in triggering heart disease (MUNRO & COTRAN, 1988) because the high fat intake would raise the levels of cholesterol in the blood plasma. Cholesterol is a natural and essential component in humans, as it acts mainly to keep the cell membrane barrier in place. In the bloodstream, the transport of cholesterol and other lipids throughout the body is carried out by lipoprotein complexes composed of apolipoproteins and lipids (HALS et al., 2017).

It is known that high levels of high-density lipoprotein (HDL) are inversely correlated with cardiovascular diseases, having the potential to protect against atherosclerosis by transporting cholesterol molecules from the tissues to the liver, where they are converted to bile acids and subsequently excreted (SHAEFER & LEVY, 1985). The HDL-transported cholesterol is; therefore, considered the "good cholesterol." By contrast, the low-density lipoproteins (LDL) or very low-density lipoproteins transport cholesterol molecules to the arteries, where they can accumulate in the artery walls and thereby increase the risk of cardiovascular disease (HALS et al., 2017).

However, the association of fats with cholesterol; and consequently, with an increased risk of cardiovascular diseases, has been proven to be wrong. Studies have indicated that total fat intake does not have a significant effect on the occurrence of cardiovascular diseases and their consequent mortality rate (SKEAFF & MILLER, 2009). Proof of this stems from the study of populations such as the Inuit, who have a low prevalence of cardiovascular diseases despite subsisting mainly on high-fat diets (HU et al., 2018).

From the paradigm that the total fat consumed is not fully responsible for negative effects on human health, it was observed that the saturated fats were the type of fats that should be avoided, as their high intake increases the total cholesterol and LDL levels and triglyceride: HDL ratio in the blood, causing atherosclerosis (MICHA & MOZAFFARIAN, 2010; BHUPATHIRAJU & TUCKER, 2011).

Previously, there were conflicting findings among studies that had investigated the association between saturated fatty acids and an increased risk of cardiovascular diseases (HAMMAD et al., 2016). However, these disagreements were due to the fact that the studies were conducted in different countries with populations that differed in their consumption of individual fatty acids. For example, the consumption of myristic and lauric acids is higher in some regions, whereas that of palmitic acid is more prevalent in other places (FATTORE et al., 2014).

Thus, it was observed that not all fatty acids belonging to the same group are the same, and each fatty acid that makes up a particular group of saturated fatty acids has a different effect on cardiovascular disease risk. For example, stearic acid (C18:0) has no effect on blood plasma triglyceride and LDL levels or the triglycerides: HDL ratio, whereas myristic acid (C14:0), lauric acid (C12:0), and palmitic acid (C16:0), increase the plasma levels of LDL (SIRI-TARINO et al., 2010) and triglycerides (MICHA & MOZAFFARIAN, 2010).

Although, stearic acid has no effect on some of these parameters, a positive association has been found between consumption of the four main saturated fatty acids (i.e., lauric, myristic, palmitic, and stearic acids) and mortality from cardiovascular diseases (KROMHOUT et al., 1995). Conversely, other studies have indicated that only palmitic acid is associated with an increased risk of cardiovascular disease and the effects of the other fatty acids are not significant (KLEBER et al., 2018).

Interest in the effects of monounsaturated fatty acids on cardiovascular disease has increased owing to their possible cardioprotective effect (HAMMAD et al., 2016). For example, the Mediterranean diet is considered highly beneficial for the prevention of cardiovascular diseases, being associated with cardioprotective activity because its main lipid source is olive oil, which is rich in monounsaturated fatty acids (SALAS-SALVADÓ et al., 2018).

As described above, omega 3 and omega 6 are essential fatty acids for human health as only plants have the ability to form the respective precursors linoleic and α-linolenic acids (CALDER et al., 2004). Both omega 3 and omega 6 are polyunsaturated fatty acids, the consumption of which has been shown to provide protection against cardiovascular diseases (ZHU et al., 2019) by reducing the level of LDL and the ratios of triglycerides:HDL and total cholesterol: HDL (ASCHERIO, 2002). However, omega 3 and omega 6 may have different effects on cardiovascular health, as there are indications that a high omega 6: omega 3 ratio can be responsible for the onset of cardiovascular diseases (RUSSO, 2009), whereas a ratio closer to unity (1:1) can have cardioprotective effects (HAMMAD et al., 2016).

Modification of fatty acids in pork

Pork, like other foods, is composed of a combination of fatty acids, some of which have beneficial effects while others affect human health negatively. Thus, many researchers have focused on ways to improve the composition and nutritional quality of meat (AHMED et al., 2016).

The different types of fatty acids can influence various physicochemical properties of meat, such as the firmness of the adipose tissue (toughness), shelf life (lipid and pigment oxidation), and flavor. For example, the higher the number of unsaturated fatty acids there are, the lower will be the firmness of the fat and the shelf life of the meat, which also influences the flavor. Thus, the meat processing industry values products with a greater amount of saturated fatty acids, as this characteristic contributes to the improved flavor and physicochemical properties of the products (WOOD et al., 2004).

However, there is growing concern about the role that saturated fatty acids play in the pathogenesis of coronary heart disease in humans (SIRI-TARINO et al., 2010), and their high intake is; therefore, discouraged. Aside from saturated fatty acids, pork also contains a high omega 6: omega 3 ratio (ALENCAR et al., 2017), which as mentioned above has negative effects on human health. Therefore, there is growing interest in changing this lipid profile.

As described previously, the breed, sex, and diet of the animal are some of the factors that can influence the fatty acid composition of pork carcass fats, with the dietary aspect having the greatest impact on most individual fatty acids and indices, followed by breed and sex (JUÁREZ et al., 2016). Therefore, the inclusion of specific ingredients in swine feed has been the subject of much research, especially the lipid ingredients because of their ability to change the fatty acid profile of pork fat (TURNER et al., 2014; ALENCAR et al., 2017; ALENCAR et al., 2021).

Lipid sources and fatty acids

The supplementation of oils and fats as an energy source into the diets of pigs has increased in frequency over recent years, with the aims being to reduce the caloric increment and increase the energy density of the diet and thereby prevent the negative effects of heat stress (SPENCER et al., 2005). The lipid sources consumed also influence the lipid profile of pork fat, mainly its fatty acid composition (DURAN-MONTGÉ et al., 2010). Through the use of diets containing different oils, the fatty acid compositions of adipose tissue and muscles can be altered in pigs, which is a non-ruminant species are susceptible to such changes (WOOD et al., 2008). Results can be achieved without the need for protection of the oil included into the diet, as is needed with ruminants (WOODS et al., 2009). Studies have shown alterations in several fatty acids when a lipid source is included in the diet, including changes in the sum of these fatty acids (saturated, monounsaturated, and polyunsaturated) (Table 1) and indices of fat quality for maintaining human health (TURNER et al., 2014; ALENCAR et al., 2017; ALENCAR et al., 2021).

In addition to providing fatty acids, the fats in diets can also interact with other regulatory network molecules, such as tissue-specific developmental and hormonal factors, as well as regulate gene expression. For example, changes in the expression of genes related to insulin signaling were observed in the longissimus muscle of pigs fed a fat-supplemented diet (PARK et al., 2012). In a study that compared the supplementation of pig feed with linseed oil or animal fat, the oil resulted in a lower concentration of palmitic acid in the subcutaneous fat and higher concentrations of linoleic acid, α-linolenic acid, and total omega 3 and omega 6 fatty acids (KIM et al., 2014). In another study that evaluated the muscle of pigs fed a linseed oil-supplemented diet, the lipid source increased the total polyunsaturated fatty acids and decreased the total monounsaturated and saturated fatty acids (TURNER et al., 2014).

Results have been observed both for the fat in the evaluated muscle and for subcutaneous or visceral fats. However, in terms of the number of fatty acids affected and their concentration, the results for subcutaneous fat are generally higher than those for meat fat, regardless of the diet used (ALENCAR et al., 2017). One reason why meat fat is less affected by the addition of a dietary lipid source is due to the higher amount of membrane polar lipids in meat cells than in subcutaneous fat cells (BEE et al., 2002). This requires a constant saturated fatty acid: polyunsaturated fatty acid ratio in order to maintain membrane fluidity for allowing the passage of compounds into and out of the cells (BEE et al., 2002).

Some studies have not reported significant differences in the saturated fatty acids when lipid sources are included in swine diets (JATURASITHA et al., 2002; ALONSO et al., 2012). This is because, unlike polyunsaturated fatty acids, saturated fatty acids can be synthesized *in vivo* by pigs and; is therefore, less influenced by dietary fat (JUÁREZ et al., 2016).

Saturated and monounsaturated fatty acids of 16 and 18 carbons are the main products synthesized in animals, and the interconversions between them limit the impact of dietary fat additions (WOOD et al., 2008). In a study by ALONSO et al. (2012), the supplementation of diets with animal fat in two concentrations (1% and 3%) or soybean oil was not enough to change the concentration of saturated fatty acids.

Table 1 – Results of main lipid sources inclusion in pork fatty acids.

Comparison	Period	---------------------------Effect of fatty acids-----------------------		Reference
		Increase	Decrease	
		Canola Oil		
Control diet	42 days	C18:2, C18:3n3, C20:5, PUFA, n6, n3	C16:1, C18:1n9, C22:6, MUFA	VEHOVSKÝ et al. (2019)
Animal fat (1.1%)	68 days	C18:3n3, C20:3n3, C20:5n3	C16:0, C16:1,	GJERLAUG-ENGER et al. (2015)
Control diet	98 days	C16:1; C18:1n9, MUFA	C16:0; C18:0; C18:2n6; C18:3n3; C20:5n3; C22:6n3; PUFA; n6; n3	ALMEIDA et al. (2021)
Soybean oil (4.0%)	28 days	C16:1; C18:1n9, C18:3n6; C20:5n3; MUFA; n3	C18:2n6; PUFA; n6	OKROUHLÁ et al. (2018)
		Soybean Oil		
Control diet	42 days	C18:2, C18:3n3, C20:5, C22:6, PUFA, n6, n3	C16:1, C18:1n9, MUFA	VEHOVSKÝ et al. (2019)
Control diet	90 days	C18:2n6, C18:3n3, C20:5, PUFA	C16:0, C16:1, C18:0, C18:1n9, SFA, MUFA	ALENCAR et al. (2021)
Control diet	30 days	C18:2n6, C18:3n3, C20:5, C22:6n3, PUFA	C16:0, C16:1, C18:0, C18:1n9, SFA, MUFA	ALENCAR et al. (2017)
Control diet	98 days	C16:1; C18:1n9, MUFA	C18:2n6; C18:3n3; C20:5n3; C22:6n3; PUFA; n6; n3	ALMEIDA et al. (2021)
		Linseed Oil		
Control diet	70 days	C18:3n3, PUFA, n3	-	BRESTENSKÝ et al. (2016)
Soybean oil (1.5%)	-	C16:1, C18:3n3, n3	-	JIANG et al. (2017)
Control diet	-	UFA, n-3	SFA	CERVEK et al. (2011)
Soybean oil (5.0%)	28 days	C18:2n6, C18:3n3, n6, n3	C16:0	KIM et al. (2014)
		Animal Fat		
Corn oil (4%)	-	-	C18:2	KOUBA & MOUROT (1999)
Control diet	56 days	C18:1n9; C18:3n6	C16:0	WEBER et al. (2006)
Control diet	44 days	C14:0	C12:0; C18:3n6; C20:4n6	ALONSO et al. (2012)
Control diet	-	C20:3n6; C20:4n6	C16:0; SFA	APPLE et al (2009)a
		Fish Oil		
Control diet	98 days	C16:0; C18:0; C16:1; C20:5n3; C22:6n3; SFA; n3	C18:2n6; C18:3n3; PUFA; n6	ALMEIDA et al. (2021)
Linseed oil (5.0%)	47 days	C18:1n9; C20:5n3; C22:5n3; C22:6n3	C14:0; C16:1; C18:2n6; C18:3n3; C20:4n6	SKIBA et al. (2014)
Control diet	-	C18:3n3; C20:5n3; C22:5n3; C22:6n3	C16:0; SFA	HALLENSTVEDT et al. (2010)
Control diet	80 days	C14:0; C20:5n3; C22:6n3; n3	C18:2n6; PUFA; n6	JATURASITHA et al. (2009)

[1]SFA = Saturated fatty acids; MUFA = Monounsaturated fatty acids; PUFA = Polyunsaturated fatty acids; UFA = Unsaturated fatty acids; n6 = Omega 6; n3 = Omega 3.

Despite this, the inclusion of fats in the diet can reduce *de novo* fatty acid synthesis (DURAN-MONTGÉ et al., 2010). This is mainly observed when the fat is rich in polyunsaturated fatty acids (JUMP et al., 2005) and when there are high concentrations of linoleic acid that lead to a reduction in Δ^9-desaturase expression and thereby a decrease in the concentration of oleic acid (KOUBA et al., 2003).

By contrast, monounsaturated fatty acids can be increased through dietary fat supplementation. The inclusion of a by-product of the olive oil industry into the diet increased the concentration of oleic acid in the body from 32.6% to 36.7%. The increase in this type of fatty acid has some advantages over that of polyunsaturated fatty acids, owing to the lower possibility of the sensory and physicochemical qualities of the fresh meat or processed products being altered (MAS et al., 2010).

The variability of polyunsaturated fatty acids is high, being influenced by several factors, including diet (JUÁREZ et al., 2016). Like all animals, pigs lack the Δ^{12}- and Δ^{15}-desaturase enzymes that are only present in plants. Thus, the animals cannot synthesize polyunsaturated fatty acids, such as linoleic and α-linolenic acids (CALDER et al., 2004).

In order for there to be an increase in the concentration of these fatty acids in pork fat, there must be a dietary supply. Significant results have been achieved using diets supplemented with a high level of linoleic acid, which is a common fatty acid in grains and oilseeds (WOOD et al., 2008). The inclusion of 6.8% soybean oil in swine feed increased the concentration of linoleic acid from 14.81% to 22.60% in the subcutaneous fat and from 9.82% to 14.11% in the meat (ALENCAR et al., 2017).

Depending on the fat source supplied, the estimated deposition rates of the two essential fatty acids are approximately 65% to 73% for linoleic acid and 63% to 64% for α-linolenic acid (DURAN-MONTGÉ et al., 2010). Up to 82% of the α-linolenic acid supplied in feed is deposited directly into the carcass, whereas the remainder is oxidized or converted into other fatty acids (SKIBA et al., 2015).

In one study, dietary supplementation with 5.43% soybean oil for 90 days increased the linoleic acid content by an average of 113% and that of α-linolenic acid by approximately 251%. This difference is due to the fact that in animals fed basal diets without additional soybean oil, the concentrations of linoleic acid are approximately 14.5% and 9.09% and those of α-linolenic acid are 0.63% and 0.26% in subcutaneous fat and meat fat, respectively. Thus, when a lipid source is included in the diet, the impact on α-linolenic acid is much greater than that on linoleic acid. This is why it is possible to observe a reduction; and consequently, an improvement, in the omega 6: omega 3 ratio in swine fat even with the dietary inclusion of linoleic acid-rich lipid sources, such as soybean oil (ALENCAR et al., 2021).

Many studies have emphasized the enrichment of pork with omega 3 fatty acids, owing to the positive effects on human health (KOUBA et al., 2003; HAAK et al., 2008; JUÁREZ et al., 2010; KIM et al. 2014; TURNER et al., 2014). Researchers have used flaxseed, which contains a large amount of oil rich in α-linolenic acid, to successfully increase the content of omega 3 polyunsaturated fatty acids in adipose tissue and meat fat (CORINO et al., 2014). Despite this, it was reported that meat alone would not have a sufficient concentration of polyunsaturated fatty acids to be considered an omega 3-enriched product, and a sufficient amount of subcutaneous fat must be retained during the preparation of the cuts to obtain the minimum concentration (TURNER et al., 2014). Dietary supplementation with 15% flaxseed for 12 weeks was able to increase the concentration of α-linolenic acid to 18.6% and reduce the omega 6:omega 3 ratio to 0.68 (JUÁREZ et al., 2010).

It was surmised that another benefit of increasing the α-linolenic acid content in pork fat is that it should lead to higher concentrations of long-chain omega 3 fatty acids (EPA and DHA). However, contrary to what is expected, the increase in α-linolenic acid did not lead to increases in these two fatty acids and instead only increased the concentration of EPA and with contrasting results between studies (JUÁREZ et al., 2010; CORINO et al., 2014).

Possible reasons for this are that the conversion of α-linolenic acid to EPA and DHA requires the enzymatic activities of elongase and desaturase, and there is competition with omega 6 polyunsaturated fatty acids (WOODS et al., 2009). Another reason could be that Δ^6-desaturase prefers 18-carbon polyunsaturated fatty acids over long-chain ones (PORTOLESI et al., 2007).

Another way to achieve this effect would be by using fish oil, which is rich in EPA and DHA. Using 6% fish oil, it was possible to increase the concentrations of EPA and DHA fatty acids by 522.73% and 628.57%, respectively (HAAK et al., 2008). The disadvantage of this type of supplementation is the fishy odor that is transferred to the meat, which can lead to consumers rejecting the product (WOOD et al., 2008).

In addition to the oil source, the duration and level of supplementation are important factors that will determine what the impact will be on the lipid profile of pig fats. JUÁREZ et al. (2010) evaluated three levels of flaxseed supplementation (5%, 10%, and 15%) for four periods (0, 4, 8, and 12 weeks before slaughter) and observed a linear effect for most of the fatty acids evaluated, and even a quadratic effect for α-linolenic acid, indicating that supplementation does not increase the fatty acid concentration indefinitely.

CONCLUSION

According to the literature, the fatty acid profile of pork fat is formed by both *de novo* synthesis and the ingestion of fatty acids through the diet. Because of these two pathways, the fatty acid composition of the meat fat may be different between swine carcasses. Among the factors that can alter the fatty acid composition of pork fat, the diet has the greatest effect. Researchers have observed that; although, the inclusion of lipids in the diets of these animals changes the profile of fatty acids in the carcass fat, the fatty acid that will be increased will depend on the fat source used, where those in greater proportion in the diet will be more availability in the pork carcass. Compared with the effects of other lipid sources, the inclusion of soybean oil into the diet increased the linoleic acid content the most, whereas the addition of linseed oil increased the α-linolenic acid level and that of fish oil increased the levels of EPA and DHA. The effects also depend on the duration and level of lipid inclusion. In summary, the fatty acid composition of pork fat does indeed influence human health, with a higher risk of cardiovascular diseases being associated with a higher consumption of saturated fatty acids and an unbalanced omega 6: omega 3 ratio.

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DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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