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Review
(Derleme)

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Et Kalitesi ve Hayvan Besleme arasındaki İlişkiler

Relationship Between Meat Quality and Animal Nutrition

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Keywords:
Meat quality, red meat, broiler, fatty acids, nutrigenomics.

ABSTRACT

The present review asessessed meat quality taking into account complex and multivariate qualities including meat production. Production conditions; however, consist of management system, breeding, genotype, feeding, holding and stunning before slaughtering, method of slaughter, cooling and storing conditions. Meat quality changes depending on many factors such as feed, level of feeding, weaning age, castration, slautering age, etc. Today, animal nutritionists have developed new nutrition strategies to improve meat quality by changing the feed composition of poultry and small/large ruminant. Also, animal nutrition can affect gene expression in the animal via epigenetic effects varying the differentiation and proliferation of adipose cells. Scientists can use different feedstuffs to modulate the expression of target genes and increase meat quality.

Anahtar Kelimeler:
Et kalitesi, kırmızı et, kanatlı eti, yağ asitleri, nutrigenomikler

ÖZ

Et kalitesi, etin üretim koşullarının da dahil edildiği kompleks ve çok değişkenli özellikleri dikkate alınarak bu derlemede incelenmiştir. Üretim koşullarını ise yönetim sistemi, yetiştirme, genotip, besleme, kesim öncesi bekletme ve bayıltma, kesim yöntemi, soğutma ve depolama koşulları oluşturmaktadır. Et kalitesi yem, besleme kalitesi, sütten kesim yaşı, kastrasyon, kesim yaşı, vb. pek çok faktöre bağlı olarak değişir. Günümüzde, hayvan besleme bilim insanları hem kanatlı hem de küçük ve büyükbaş hayvanlardan elde edilen etlerinin besin madde kompozisyonunu değiştirerek et kalitesini iyileştirmeye yönelik besleme stratejileri geliştirmiştir. Ayrıca, hayvan beslenmesi, yağ hücrelerinin farklılaşmasını ve çoğalmasını değiştiren epigenetik etkilerle hayvandaki gen ekspresyonunu etkileyebilir. Bilim insanları, hedef genlerin ifadesini değiştirmek ve et kalitesini artırmak için farklı yemleri kullanabilirler.

Introduction

Despite significant differences in digestive physiology in cattle, sheep, and poultry, the carcass composition of all of them can be regulated by feeding. This is mainly possible by the amount and combination of ration given to the animals.

Feeds contain protein, energy, vitamins, and mineral matters at different rates, which are defined as nutrients. Animal nutrition scientists meet the nutrient requirements of livestock animals to provide their living and optimum yield by rations brought together with various feeds. It is known that for centuries, the nutrient composition of meat, milk, and eggs, the most important protein sources of human nutrition, has also been affected by changes in rations.

In recent years, animal nutrition scientists have made manipulations in the compositions of foods of animal origin by following the demand of the consumers. Especially in the past decade, many applications have been developed which will make egg nutrient composition more useful in terms of human nutrition. Eggs had enriched with omega-3 fatty acid (n-3 FA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), Vitamin E, carotenes, and selenium to form eggs by lowering the cholesterol content, and they are being available for human consumption can be given as an example (Açıkgöz and Soycan Önenç, 2006).

However, it is not as easy as in eggs to regulate the composition of nutrients of meat according to consumer preferences. Especially the nutrients in feeds are taken by ruminants feeds are changed by the microorganisms of the rumen. During this change, rumen microorganism synthesize Vitamin B groups and fatty ac, ds such as conjugate linoleic acids (CLA). Therefore, meat is a food rich in protein, mineral substances and group B vitamins, and its digestibility varies between 91% and 100%.

Meat has great importance in human nutrition, especially during the growth stages. Growth occurs as a because of cell proliferation and development. The building block of a cell is protein. Therefore, the living organism needs protein to make new cells. This requirement is met by the foods they consume depending on their nutrition habits. Most of the proteins found in the meat structure can be converted to human body proteins. Therefore, the digestibility and biological value of the protein in meat is higher than that of vegetable proteins (Özkan and Açıkgöz, 2007). When compared to the protein content of red meat, poultry and fish meat, it can be reported that they contain the same amount of protein. However, skinless poultry meat, and fish contain less saturated fat and cholesterol in comparison to red meat (Hu, 2005). The fat within the meat structure provides a distinctive taste, flavor, juiciness, and allows it to be consumed appetite. Moreover, the fat of the meat increases the secretion of fluids within the digestive system, the source of essential fatty acids, and fat-soluble vitamins (Özkan and Açıkgöz, 2007). Meat quality changes depending on many factors such as feed, feeding regime, age, slaughtering age, weaning age, castration, etc. Today, animal nutritionists have developed new nutrition strategies to improve meat quality by changing the nutrient composition of poultry and small/large ruminant (Andersen et al., 2005).

In addition, animal nutrition can affect gene expression in the animal via epigenetic effects varying the differentiation and proliferation of adipose cells. Scientists can use different feedstuffs in order to modulate the expression of target genes and increase meat quality. Therefore, it is necessary to better understand how nutrients affect the long term expression of genes involved in adipogenesis and lipogenesis (Wang et al., 2019).

Effect of nutrition on meat quality

Traditionally, the term meat quality refers to food safety, nutritional value, flavour, texture, water holding capacity, oxidative stability, color, fat content, and uniformity (Andersen et al., 2005). In other words, it includes the suitability for its edibility by consumers in terms of taste, flavor, softness, smell, and nutritiousness. Recently, quality has been assessed taking into account complex and multivariate qualities including meat production conditions. Production conditions, consist of management system, breeding, genotype, feeding, restraining and processing before slaughtering, techniques of slaughter, cooling and storing conditions (Majewska et al., 2016; Lopes et al., 2014; Andersen et al., 2005; McNivena et al., 2004).

It is aimed to achieve the highest growth rate in the course of fattening. However, this is not possible with rations based on roughage. In order to enrich the ration in terms of energy, it is necessary to increase the concentrate feed. It was reported that cattle fed with energy-rich ration have higher carcass weight and carcass fat in comparison with cattle fed with low-energy ration (Moloney et al., 2004). In fattening, to increase live weight gain (LWG) and feed conversion ratio (FCR), the increase of concentrate feed in the ratio causes fat in the carcass (French et al., 2000). Leeson and Summers (2005) stated that the nutrition rich energy based on the genotypic improvement of poultry meat proportionally activated fat storage in fattening according to the high rate of growth and protein storage of the feed.

Fat composition of meat

Studies have been carried out on marbling fat composition and its implications for human health since long time (De la Fuente et al., 2009). Health experts (World Health Organization and the Food and Agriculture Organisation) suggest to reduce the consumption of saturated fatty acids (SFA) and to increase the consumption of polyunsaturated fatty acids (PUFA), especially n-3 fatty acids consumption (Liu et al., 2017; Joy et al., 2012). Ruminant meat fat is not considered to be healthy for people due to its high SFA and low PUFA content. However, these fats are one of the major dietary sources of CLA, which is presumed to be a healthy fatty acid. CLA is a group of positional and geometric isomers of the conjugated double bond of linoleic acid (Liu et al., 2017).

The fat in beef meat is found as membrane lipids (as phospholipids), as intermuscular fat (between the muscles, INTMF), as intramuscular fat (IMF, fat within muscles), and as subcutaneous fat (SF). IMF content in lean beef meat is usually 2-5%. This value is considered as low-fat in many countries (Scollan et al., 2006). IMF and fatty acid composition of IMF are taken as basic quality control criteria in the sensorial properties of the meat and especially in its health assessment. Chemically, the IMF includes the sum of phospholipids, triglycerides, and cholesterol. In the muscles of mammalian and avian species, triglycerides are not primarily stored within intramuscular adipocytes (approximately 80% at least) but are found in cytoplasmic myofibrils in droplets near the mitochondria (5% to 20% of total triglycerides). Lipids stored as droplets within the fibers in red muscles; whereas in white muscle lipids are stored in adipocytes, mainly in myosepta (Hocquette et al., 2010) for beef, the average value of CLA is originated from intramuscular, intermuscular, and subcutaneous (Aldai et al., 2007). Generally, the IMF content positively affects sensory qualities, including taste, juiciness, and tenderness of red meat or fish meat, at the same time low-fat content leads to a decrease in flavor (Hocquette et al., 2010).

Marbling is a term used in the red meat industry and refers to the image of the IMF in the form of streaks or white flecks among bundles of muscle fiber. In white meat, this is not regarded as a physicochemical characteristic of meat. Under the microscope, marbling fat appears as specific adipose storage, embedded in the connective tissue matrix of adiposity close to the blood capillaries. Among poultry, chicken and turkey have especially low IMF levels (<1% in breast meat). As in mammals and poultry, great differences in IMF are observed among fish species depending on the ability of the muscle to store energy as fat (Hocquette et al., 2010). Marbling fat is a significant criterion for the juiciness, flavor, and tenderness of the meat (Scollan et al., 2006; Pannier et al., 2014).

The increase in the case of adiposity is a sign of the distribution of subcutaneous fat on the carcass and the marbling fat in meat (French et al., 2000). In the fattening period, it is usually aimed to apply a feeding program that will maximize protein storage by limiting the fat storage of animals. In the studies conducted for the determination of the effect of feeding on adiposity, it was reported that unwilted grass silage ration, when compared to wilted grass silage/dry grass and/or no silage-included rations increased adiposity (Muir et al., 1998). In another study, it was found out that rations containing starch promoted adiposity more than rations containing digestible crude cellulose (Melton, 1990). Moreover, in the same study, it was reported that rations containing corn gluten, corn industry by-products caused more adiposity than those containing barley.

In feeding conditions with rations containing grass silage, in which the protein requirements of animals are met, the increase of grass silage caused adiposity in the carcass (Steen and Robson, 1995). However, Keane and Allen (1998) reported that after feeding with only silage at the beginning of fattening period, feeding with silage and *ad libitum* concentrate feed at 135 days of fattening period caused less fat accumulation in the carcass.

The type of fatty tissues and the lipid profile in the animal body is affected by time (age, physiological period, season, etc.), genetic and innumerable environmental factors (Borys et al., 2012). Intensively fattened lambs were reported to contain a high proportion of stearic acid and PUFA in the IMF, at the same time the semi-intensive fattened ones had a more favorable fatty acids profile. Generally, those with low body weight (20-30 kg) were found to have a more favorable intermuscular fatty acids profile than those with a high body (30-40 kg) weight (Borys et al., 2012).

The effect of the energy level of the ration causes an increase in INTMF accumulation, at the same time it leads to a decrease in heat resistant connective tissue. This positively affects the tenderness, juiciness, and flavor positively of the meat (Larick and Turner, 1990). It was also reported that feeding followed by more than a 30 days period of feeding with concentrate feed increased the tenderness of meat (Harison et al., 1978) and that the highest tenderness and muscle tissue development was achieved under the conditions of 50-100 days of feeding with concentrate feed (Larick and Turner, 1990).

Adiposity in poultry occurs usually in the form of abdominal and internal organ adiposity. There are studies regarding the reduction of adiposity by lowering the calorie/protein values of rations at a low level (Bartov and Plavnik, 1998). When poultry carcasses were investigated, studies are revealing that fat of drumstick is higher than that of breast meat (Boskovic et al., 2010; Shahin and Elazeem, 2005). There is also a study reporting that there is a difference in carcass fat of broilers with the same ration at intensive production and free-range systems, and the lean carcasses are produced with fed at free-range systems (Boskovic et al., 2010). On the other hand, it was also reported that gender affected the carcass adiposity and that in broilers fed with the same rations, carcasses of female broilers were more fat than the male ones Topal and Ozdogan, 2013). Because the level of oil in the ration affects the adiposity of the carcass, it is known that there are also studies conducted to determine the effect of different oil sources and levels on broiler carcass (breast and thigh meat) composition (Ozdogan and Akşit, 2003). It was reported that oil addition into the ration or the increase in the protein level of ration increased the carcass yield. On the other hand, water and fat proportions in the carcass changed inversely correlated, and the ration containing low-protein and oil additive decreased the level of water of the carcass (Marion and Woodroof, 1966).

The concentration of leptin with insulin-like growth factor (IGF-1) and insulin in fed and fasted cows were positively correlated with body condition score. The serum concentration of leptin was significantly associated with carcass composition (marbling, back fat depth, and kidney, pelvic, heart fat) and quality grade in *Bos Taurus* steers and heifers (Roh et al., 2016).

Modifications to change the CLA content of meat

CLA occurs as a by-product during biohydrogenation of linoleic acid or by the action of *trans*-vaccenic acid (C18: 1 *trans*-11) Δ9 desaturase in the body (Liu et al., 2017). Physiologically, *Cis*-9, *trans*-11 and *trans*-10, cis-12 are the major isomers. It was reported that these isomers form 80-90% and 3-5% of the total CLA, respectively, in products obtained from ruminants (Koknaroglu, 2007). In the studies carried out it was reported that CLA inhibits cancer, atherosclerosis, and diabetes, affects the immune system and bone composition, reduces body fat content (Liu et al., 2017; Joy et al., 2012). It is recommended that *cis*-9, *trans*-11 CLA which is not possible with general dietary habits should be consumed more than 400 mg/day to see the biological effects (Koknaroglu, 2007).

In recent years, increasing the proportion of PUFA, especially n-3 FA and CLA, by lowering the proportion of SFA in animal products has been a new feeding strategy applied in animal nutrition (Liu et al., 2017; Ozdogan et al., 2017; SoycanOnenc et al., 2015; Cho et al., 2013; Scollan et al., 2006; Leeson and Summers, 2005; Piasentier, 2003; Sirri et al., 2003).

Modifications to poultry

Meats form monogastric animals are poor sources of CLA (0.1-0.2% of total fatty acids). Chicken meat is an ideal candidate for CLA enrichment by feeding rich CLA because CLA will not be further saturated before absorption and its deposition in tissues is relatively highly efficient (Liu et al., 2017). Hovewer, it is not economical and productive (fattening performance) to feed with CLA-rich diets. In a previous study, the addition of CLA addition at different levels into poultry rations decreased the content of monounsaturated fatty acid (oleic and palmitoleic acids) content in the thigh and breast meat, although it increased CLA content paralel to the amount added (Sirri et al., 2003).

Many studies have proposed that CLA feeding can decline fat deposition and increase lean meat content. These modifications might be explained by its activity on lipoprotein lipase to increase lipolysis. Generally, many results for meat fatty acid profiles from broilers fed CLA show increased SFA and decreased unsaturated fatty acid (USFA). It is supposed that these changes result from due to the inhibition of the Δ9-desaturase activity of the liver. The other factor of change is the lack of conversion of C18:0 to C18:1. Another possible mechanism was that CLA can be used as a substrate for Δ6-desaturase which converts linoleic acid to arachidonic acid. Therefore, it results from a high content of linoleic acid in broiler meat (Cho et al., 2013). Recently, Liu et al. (2017) reported that dietary CLA significantly increased the CLA and SFA content, and decreased the monounsaturated fatty acid (MUFA) in breast and drumstick muscle. Also, dietary CLA may decrease the lipid peroxidation level in the breast and drumstick muscles of broiler chickens perhaps through increasing the γ-glutamyl cysteine synthetase activity to induce glutathione synthesis and changing the fatty acid composition to increase oxidative stability.

Modifications to ruminant

Grains feed are rich in linoleic acid (C18:2), but lower in linolenic acid (C18:3). Meadows, however, are rich in linolenic acid, but poor in linoleic acid. Therefore, the amount of CLA in meats of farm animals fed with rations high in grain proportion is lower than those grazing at meadows and pastures. In other words, the source of high CLA amount in the meat of ruminants grazing at meadows is linolenic acid. Hence, Piasentier (2003) reported that the CLA amount was found higher in the meats of lambs grazing at the meadow.

Rumen bacteria are capable of converting α-linoleic acid directly into stearic and palmitic acid. This situation allows the linoleic acid amount of ruminant meats to be affected greatly with the addition of polyunsaturated fatty acids at a high rate into rations (Wachira et al., 2002). The addition of linseed into the rations of lambs increased C18:3 level in meat significantly. Lamb rations containing oil seed and rapeseed meal led to an increase in long-chain fatty acids as 2.4 fold for C18:3, 3.5 fold for C20:5 and 1.8 fold for C22:5 (Borys et al., 2012). C18:3 in carcasses of grazing lambs was at the higher level in comparison to lambs fed with rations including concentrate feeds. Pasture plays a key role in improving FA composition. However, not all forages have the same effect, depending on maturity, variety, and preservation of the forage. Green forage is a good source of n-3 PUFA, although it varies according to maturity and forage species. Hay making processes lead to a loss of FA precursors of CLA, reducing total FA by over 50%, with a higher loss of linolenic acid. The most of losses are showed up in wilting prior ensiling (Joy et al., 2012).

The oil addition into rations is to inhibit the microbial (especially cellulolytic) activity in rumens. Casutt et al. (2000) reported that using vegetable oils or oil seeds (sunflower or safflower) rich in linoleic acid is more effective in increasing the amount of CLA in animal products. In the rumen, USFA in feeds is saturated by the bacteria via biohydrogenation (Wachira et al., 2002). The first step of hydrogenation in the rumen is *cis*-12 in double-bound converted to *trans*-11 with the isomerization, and so conjugated di and trienoic fatty acid were formed. The second step is *cis*-9 in double bond converted to *trans*-11 (vaccenic acid) fatty acid in the reduction reaction. The third step is the exposure of the *trans*-11 double bond to hydrogenation and its conversion to stearic acid. The second way of CLA synthesis is by desaturating transvaccenic acid in the adipocytes and mammary glands with the enzyme Δ9-desaturase (Wachira et al., 2002).

When oils rich in linoleic acids are added into the ration so that it does not affect the microbial activity of the rumen, the added linoleic acid amount in the rumen and thus the ratio of its byproduct CLA and vaccenic acid also increases. Even though vegetable oils added into the ration provide polyunsaturated fatty acids which are a source for bacterial isomerizationand/or biohydrogenation in the rumen, they affect the amount of CLA of meat. Moreover, if ration oil in the rumen is resistant to isomerization and/or hydrogenation, no CLA is produced either in the rumen or in the muscles (Scollan et al., 2006). One of the ways of increasing the CLA amount in red meat is the addition of fish oil into the ration. Fish oil contains C20 and C22 polyunsaturated fatty acids, and these oils are not converted into CLA or vaccenic acid in the hydrogenation in the rumen. Therefore, the addition of fish oil into the ration inhibits the last step of hydrogenation and the transformation of linoleic acid into stearic acid (Koknaroglu, 2007). The transformation of vaccenic acid, which does not undergo hydrogenation, into CLA with the effect of the ∆9-desaturase enzyme increases the amount of CLA (Wachira et al., 2002). When Enser et al. (1999) added fish oil into the ration, they reported that the CLA amount in the *longissimus lumborum* of Charolais cattle increased.

It was reported that the vaccenic acid amount in the duodenum increased with the increase of green fodder from 12% to 36% in the ration. Biohydrogenation responsible for CLA formation from linoleic acid in the rumen is catalyzed with linoleic acid isomerase enzyme synthesized by *Butyrivibrio fibrisolvens* bacteria (Koknaroglu, 2007). Therefore, the CLA absorption amount is determined by the linoleic acid amount taken with the ration, *Butyrivibrio fibrisolvens* population and the activity of this population. French et al. (2000) reported that although linoleic acid amount taken with feeds was the same, the CLA amount increased due to the increase in the amount of forage in the ration. This is due to the fact that the increased amount of forage constitutes the favorable conditions for the development of the *Butyrivibrio fibrisolvens* bacteria. With the increase of forage amount, biohydrogenation and pH of the rumen increased. Due to animals with low-level pH rumens being fed with high-level concentrate feed, biohydrogenation and lipolysis decreased. Another reason for the regression of biohydrogenation due to concentrate feed consumption is the shortening of the retention time of the feeds in the rumen. Thus, the contact time of oils within the structure of feeds with bacteria in the rumen is shortened (Koknaroglu, 2007). It was reported that the CLA amount in the duodenum increased with the increasing forage amount in sheep fed with rations including different proportions of intensive feed.

Effect on sensory properties

Feeding with grains rich in polyunsaturated fatty acids and roughages changed the taste and tenderness of the meat significantly. It was reported that in lamb fattening with concentrate feed, the smell and tenderness of the meat was less in comparison to traditional fattening (Priolo et al., 2002). In another study, it was reported that concentrate feed and traditional feeding affected C17:0, C18:0, C18:1 c11, C18:1 c9, C18:2 c9c12, C18:2 c9t11 fatty acids, and total CLA contents significantly. Thus, the muscle fatty acid of *Chios* (*Sakız*) lambs changed based on feeding (SoycanOnenc et al., 2015). In a recent study, it was determined that the levels of olive cake increased the water-holding capacity of meat. Furthermore, although the levels of olive cake were shown to decrease total n-3 and total SFA, they also increased total n-6, n-6/n-3 ratio, total MUFA, and total PUFA were not different (Ozdogan et al., 2017).

Although studies are reporting that there is no effect of feeding manipulation on meat quality characteristics such as thaw loss, cooking loss, pH24, L* (light), a* (red), b*(yellow), and C*(chroma) values (Soycan Onenc et al., 2015). There are also conducted studies revealing that these parameters changed based on feeding manipulation (Rodriguez et al., 2008).

Nutrigenomics and meat quality

Nutrigenomics, one of the fastest-growing areas of research in recent years, includes studies to determine the effect of ration components on the functioning of the genome in terms of gene expression forms and epigenetic modifications such as DNA methylation and histone modifications (Nowacka-Woszuk, 2020). Nutrigenomic studies in farm animals carried out especially for meat production and health protection. Meat production worldwide has recently concentrated on improving meat quality in terms of fatty acid profile and marbling (Nowacka-Woszuk, 2020).

Leidera et al. (2018) reported that muscle fatty acid composition may control or be controlled by transcription factors, which will affect expression of genes involved in the lipid metabolism (in Table 1). Fatty acids affect on the nucleus by binding to certain nuclear receptors or transcription factors and regulating their activity, thus playing a central role in regulating the expression of genes involved in fatty acid up take by muscle cells. The PUFA-rich ration is important in modifying the fatty acid component in beef to regulate SCD1 expression in the muscle of cattle (Leidera et al. 2018). Herdmann et al. (2010) reported that the increase in n-3 PUFA content in the ration caused less SCD1 expression and thus less CLA c9, t11-C18: 2, and oleic acid in muscle. Teixeira et al. (2017) reported that expression levels of Lipoprotein lipase (LPL) and fatty acid binding protein 4 (FABP4) genes in muscles of Nellero bulls fed the ground corn have been determined to be higher than the angus bulls. Increased expression in these genes may be duetolow PUFA and high stearic acid in ration. Similarly, high energy grain rations to finishing cattle significantly up regulates SCD1 expression in adipose tissues and increases adipose deposition (Duckett et al., 2009).

Oliveira et al. (2014) observed that LPL and FABP 4 expression levels correlate positively with stearic acid. However, acetyl CoA carboxylase alpha (ACACA), stearoyl-CoA desaturase (SCD1), and SREBF1 genes also positively correlated with LPL and FABP4 (Teixeira et al.2017). Nakamura et al.(2014) showed that high levels of PUFA repress SREBF1 content by inhibiting proteolytic activation and decreasing mRNA stability. The long-chain n-3 PUFA such as docosahexaenoic acid and eicosapentaenoic acid are nuclear repressors of SREBF1 through in hibition of transcription and by increasing mRNA turn over (Rodríguez-Cruz and Serna, 2017). The concentration of *de novo* fatty acid synthesis products is reduced due to the decreased expression of ACACA and FASN in the muscle. As a result, lipogenesis decrease (Hiller et al., 2011).

The expression of SCD1 in muscle tissue is directly related to mechanisms involving the break down of triglycerides by lipoprotein lipasea nd transport of fatty acid molecules to adipocytes via FABP4 pathway (Jurie et al., 2007). LPL and the FABP4 genes have complementary function and a strong positive correlation was determined between the expression levels of both genes. Besides, the FABP 4 gene was determined to have a positive correlation with PPARG (Teixeira et al.,2017).

Table 1. Fatty acids and grains effects on expression of genes in ruminants associated with lipid metabolism (Leidera et al., 2018).

Tablo 1. *Ruminantlarla ilişkili lipid metabolizmasında genlerin ekspresyonuna tahılların ve yağ asitlerin etkileri*

Content	Effects	References
PUFA	Upregulate PPARA and PPARG	Rodríguez-CruzandSerna (2017)
PUFA	Downregulate SREBF1	Nakamura et al.(2014)
n-3 PUFA	Downregulate SREBF1, ACACA, FASN, SCD1	Herdmann et al. (2010), Hiller et al. (2011), Rodríguez-CruzandSerna (2017)
C16:0 and C18:0	Upregulate PPARA and PPARG	Bionaz et al. (2012)
C17:0, C17:1 and C18:0	Upregulate LPL and FABP4	Oliveira et al. (2014)
t10,c12-C18:2	Downregulate SREBF1 and SCD1	Teixeira et al. (2017)
C18:0 and α-C18:3	Downregulate PPARA and SCD1	Oliveira et al. (2014)
C 16:1	Upregulates ACC, SCD1	Duckett et al., (2009)
Groundcorn	upregulate LPL and FABP4	Teixeira et al. (2017)

PUFA = poly unsaturated fatty acids; PPARA = peroxisome proliferator-activated receptor α; PPARG = peroxisome proliferator-activated receptor gamma; SREBF1= sterol regulatory element-binding protein-1c; SCD1=stearoyl-CoA desaturase; ACACA = acetyl-CoA carboxylaseα; FASN =fatty acid synthase; LPL = lipoprotein lipase; FABP4 =fattyacid-binding protein 4; MUFA=mono unsaturated fatty acids.

Conclusion

From the literature, it is evident that animal nutrition has demonstrated effects beyond its roles of building blocks of the meat: from a beter meat yield to meat quality as healthy human nutrition. Adequate dietary provision of nutrients is necessary for sustaining profitable and healthy animal production and protecting the animal health in all species.

Studies have been conducted on the fat of ruminant and poultry meat composition such as fatty acids ratio and omega-3 fatty acids and CLA, and its implications for human health for a long time. In addition, the effect of animal nutrition on epigenetic mechanisms is still poorly understood in farm animals. The main mechanisms on regulate of genes expression are as DNA methylation, histone modifications, and noncoding RNA interactions. Detailed research is needed to determine the effects of rations on these mechanisms in the future.

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