How to cite: Soycan Önenç, S., Özdogan, M., Effects of Some Vitamin, Mineral, Esantial Oils Used in Animal Nutrition on Meat Quality, J. Anim. Prod., 2021, 62 (1): 77-83, https://doi.org/10.29185/hayuretim.777160

Rewiews
(Derleme)

J. Anim. Prod., 2021, 62 (1): 77-83
https://doi.org/10.29185/hayuretim.777160

Effects of Some Vitamin, Mineral, Esantial Oils Used in Animal Nutrition on Meat Quality

Hayvan Beslemede Kullanılan Bazı Vitamin, Mineral ve Uçucu Yağların Et Kalitesine Etkileri

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Alınış (Received): 05.08.2020 Kabul tarihi (Accepted): 21.12.2020

Keywords: Feed additive, meat quality, vitamin, mineral, essential oil.

ABSTRACT

With the increase in industrial animal husbandry, animal yield (for example, meat yield) has been accepted as the most important indicator. The quality of product has been ignored. Recently the quality of animal products as meat quality as has been questioned as conscious consumers have increased. In addition, animal nutritionist focused on research to improve both the quantity and quality of animal products. Feed additives are used in poultry and ruminant nutrition to improve performance and quality of animal products.

Today, probiotics, prebiotics, organic acids, vitamin-mineral premixes and essential oils are feed additives commonly used in animal nutrition. It has been demonstrated through studies that these have a positive effect on the quality of poultry and ruminant meat. In this review, the effects of some vitamins, minerals and essential oils used in animal nutrition on meat quality are emphasized.

Anahtar Kelimeler: Yem katkı maddesi, et kalitesi, vitamin, mineral, uçucu yağ.

ÖZ

Endüstriyel hayvancılığın artmasıyla birlikte hayvansal verim (örneğin, et verimi) en önemli gösterge kabul edilmiştir. Ürün kalitesi ise geri planda kalmıştır. Son yıllarda, bilinçli tüketicilerin artmasıyla et kalitesi gibi, hayvansal ürünlerin kalitesi sorgulanmaya başlanmıştır. Bununla birlikte hayvan beslemeciler hem hayvansal ürün miktarını hem de kalitesini iyileştirmeye yönelik araştırmalara ağırlık vermişlerdir. Hayvansal ürün miktarı ve kalitesini iyileştirmek için, kanatlı ve ruminant beslemede yem katkı maddeleri kullanılmaktadır.

Günümüzde, probiyotikler, prebiyotikler, organik asitler, vitamin-mineral premiksleri ve uçucu yağlar hayvan beslemede sıklıkla kullanılan yem katkı maddeleridir. Bunların kanatlı ve ruminant etlerinin kalitesini de olumlu yönde etkilediği yapılan çalışmalarla ortaya konmuştur. Bu derlemede, hayvan beslede kullanılan bazı vitamin, mineral ve uçucu yağların et kalitesi üzerine etkileri üzerinde durulmuştur.

INTRODUCTION

Feed additives are ingredients added to animal rations, feed or water to improve feed quality, promote growth, break down anti-nutritional factors, absorb toxins, alleviate nutritional deficiencies, affect animal production, performance or welfare, coccidiostatic or histomonostatic effects and reduce energy (Mendel et al. 2017).

Feed additives used by the poultry and ruminant industries include organic acids, essential oils, vitamins, minerals, plant metabolites, amino acids, herbs, non-digestible oligosaccharides, and the food industry or other natural by-products. However, the contributions used are not limited to these. Meat quality is a critical point it determines the acceptability and continued interest in the product by consumers. Consumers often expect the meat to be nutritious, healthy, fresh, weak, soft, juicy and tasty (Hoffman and Wiklund, 2006). Meat is an excellent source of high quality protein for humans. It is also an important source of iron (Fe), zinc (Zn), potassium (K), selenium (Se) and B vitamins, especially vitamin B12 (Wyness et al., 2011).

Vitamins and meat quality relationships

Generally, meat quality is evaluated in terms of the color, smell, hardness and aroma of the meat. The meat color is an important factor in evaluating lean meat and the color of fresh red meat is caused by oxymyoglobin. The 80-90% of the color of the well blood-drawn meat originates from myoglobin. The change of the meat color from red to brown is caused by the oxidation of oxymyoglobin to metmyoglobin (Fausstman et al., 1998).

The most important approach accepted in recent years is to use feed additives with different antioxidant properties to slow the oxidation of color pigments and lipids. The main task of these feed additives is to reduce the oxidation of fresh meat myoglobin after cutting and to delay the formation of metmyoglobin (Fausstman et al., 1998). In addition to the protection of meat from oxymyoglobin and the delay of lipid oxidation are essential in terms of the protection of meat color longer. To improve the meat color, it becomes widespread to added vitamin E, vitamin D3, selenium and essential oils into the ration. The addition of α- tocopherol (Arnold et al., 1993) and β-carotene (Muramoto et al., 2003) into the ration led to a delay in metmyoglobin formation in the meat of fattening bull. However, meadow plants contain a high level of tocopherols and carotenoids. The color stability of longissimus muscle containing 187 μg β-carotene/g is higher than those containing 0.026 μg β-carotene/g (Muramoto et al., 2003). Therefore, it could be said that grazing at meadows in the finishing period of fattening is a method that can be applied to protect meat color stability.

In a previous study conducted, it was reported that α-tocopherol and β-carotene contents in fattening cattle grazing on meadows were higher and that fatty acid composition of meat was appropriate as food, yet peroxidizable lipid concentration of meat was high and color stability of meat was low (Muramoto et al., 2005). In cattle feeding with rich polyunsaturated fatty acid (PUFA), if the antioxidant level is insufficient, it first triggers the oxidation of plasma lipids, then lipid oxidation induces free radical formation and myoglobin oxidation in muscles (Scollan et al., 2006). While lipid oxidation in meat causes deterioration of the taste, it also causes the the meat colour to darken with the oxidation of myoglobin (Fausstman et al., 2010).

The active provitamin of vitamin A is β-carotene and is synthesized in plant tissues. The transformation rate of β-carotene into vitamin A is 2:1 in chicks, 6:1 in sheep, and 8:1 in cattle. Therefore, the rate of transformation of β-carotene into vitamin A is taken into account while calculating the need for vitamins of animals. The need for vitamins varies according to animal species (Taşkın et al., 2010). The effects of vitamin A and β-carotene on meat quality are variable. Oka et al. (1998) reported a negative relationship between serum vitamin A concentrations and marbling deposition. The addition of a low amount of vitamin A was associated with a decrease in the rate of unsaturated fats and an increase in intramuscular fat hardness (Siebert et al. 2006).

Vitamin A addition into cattle rations reduces lipid and pigment oxidation, at the same time it also increases the tenderness of meat (Wang et al., 2007). It was also reported that vitamin A has an effect on marbling and that the effect of the high level of vitamin A in addition to marbling changes according to age. In a study conducted by Oka et al. (1998), it was stated that vitamin A's addition to 15-month-old cattle increased the marbling score without leading to subcutaneous adiposity, yet it was also reported that the similar conditions did not occur in 21-23-month-old Cattles. Studies have shown that neither β-carotene addition nor vitamin A restriction affects carcass characteristics. Hovewer, beta-carotene supplements affected intramuscular fats to a limited extent. In addition, higher levels of β-carotene supplementation did not affect intramuscular fat content or muscle color much, although they slightly reduced intramuscular fat content and promoted muscle tenderness (Jin et al. 2015). Moreover, in the studies, it was also reported that retinoic acid, a form of vitamin A, regulated the growth hormone gene expression (Dikeman, 2007).

It was also reported that vitamin A revealed a regulating effect on the growth hormone synthesis system, and affected marbling development indirectly. In a previous study, it was determined that the growth hormone directly reduced the score of marbling (Dalke et al., 1992). Carotenoids play important roles as provitamin A, as antioxidants, and in cellular differentiation, growth, reproduction, gene expression, immune function, and adipocyte functions (Jin et al. 2015). In a study on gene expression of vitamin A reported that addition of vitamin A to cattle during the finishing period increased fatty acid binding protein (FABP) 5 and stimulated the activation of peroxisome proliferator activated receptor (PPAR). Accordingly, lipid oxidation and adipocyte hypertrophy increased while marbling decreased (Wang et al., 2016).

It was stated that vitamin D addition into rations had an effect on the tenderness of the meat, and increased the level of calcium in muscles and blood (Dikeman, 2007). It reveals this effect by the synthesis and activity of calmodulin protein. The increasing calmodulin causes excessive accumulation of calcium in muscles, and thus calpain level increases at the post-slaughter period (Boleman et al., 2004).

High levels of calcium, accelerating proteolytic degradation by increasing the activity of the calpain enzyme in the meat, also effect muscle pH and meat color positively. In a study conducted, it was reported that vitamin D3 addition improved color stability of cattle meat and that it revealed high stability to protein oxidation and low stability to lipid oxidation (Hansen et al., 2012). It was also reported that the administration of vitamin D3 at the pre-slaughter period increased the tenderness of meat (Montgomery et al., 2002), activated residue calpain at the post-slaughter period by increasing calcium concentration and increased tenderness by accelerating postmortem glycolysis (Lawrence et al., 2006). However, vitamin D3 at high levels causes toxic effects and has a negative impact on feed consumption.

It is well known that in grazing cattle, the meat color is darker than normal, and the fatty tissue is a typical yellow color because of the β-carotene. The main reason for the formation of undesirable color and odor in red and white meats is that the fats and proteins in the meat are oxidized. This also causes the shelf life to shorten.

The use of polyunsaturated fatty acid at high levels, and especially n-3 fatty acids in the ration in order to reduce the fat level in meat decreases the oxidative stability of meat (Juárez et al., 2012). In poultry, the muscle tissue can be easily enriched with α-tocopherol added to the feed and antioxidant content can be increased. However, the content of the oxidizable substrate (PUFA) in feed and tissues is important for the achievable level of enrichment. The researchers calculated the α-tocopherol levels required to prevent oxidative processes in the tissues. In a study (Cortinas et al. 2003), increasing the amount of PUFA added to the feed has been reported to reduce the accumulation of α-tocopherol in the thigh meat. The addition of antioxidants such as vitamin E and Se into the ration solves the oxidative stability of meat successfully (Juárez et al., 2012). Especially the addition of retinol, vitamin C, manganese (Mn), and Se into the ration increased the antioxidant capacity of meats, and thus low lipid peroxide levels of meats were determined (Buckley et al., 1995). In a study conducted, the addition of Vitamin E into the ration in intensive fattening affected the meat color of the cattle positively, and also lengthened the shelf life (Hill and Williams, 2001). It was reported that at the same time vitamin E addition to ration in lamb fattening decreased the 12th-day value of thiobarbituric acid reactive substances (TBARS), it was not effective on color (Atay et al., 2009).

Vitamin E content of green roughages and especially of alfalfa is 5-10 times higher than crops (Fausstman et al., 1998). Pasture consumed by cattle is known to supply vitamin E requirements, in addition to other natural antioxidants (De la Fuente et al., 2009). Vitamin E amount in feedstuff, however, changes depending upon the species of feed, its vegetation period, and the time of storage. On the other hand, it is informed that the feed being rich in unsaturated fatty acids, leads to insufficiency in vitamin E (Dagdas and Yıldız, 2004). Harvest and drying causes a significant loss in vitamin E. The germs of legume grains are also rich in vitamin E. Therefore, it would be appropriate to include by-products containing germs in rations. De la Fuente et al. (2009) reported that beef from extensive systems had the lowest n-6/n-3 PUFA ratio and the highest concentration of vitamin E (3.91 mg a-tocopherol/kg muscle).

As a matter of fact, oxymyoglobin stability in meats with high α-tocopherol concentration was determined to be high. In this regard, it was determined that the addition of vitamin E into the ration affected the meat color positively (Liu et al., 1996). By reducing free radical formation, alpha-tocopherol directly slows lipid oxidation. Alpha-tocopherol delaying the formation of lipid oxidation products increases oxymyoglobin oxidation. Vitamin E addition, especially due to its antioxidant effect both delays the oxidative degradation of meat and lengthens its shelf life. It was reported that the critical α-tocopherol concentration that will protect lipid and myoglobin at optimal levels from oxidation is 3.0-3.5 µg/g (Fausstman et al., 2010). Arnold et al. (1993) reported that in order to increase α-tocopherol concentration from 1.3 µg/g to 3.3 µg/g, rations containing 1300 IU α-tocopherol acetate should be consumed for 44 days.

Vitamin E provides lipid and color stability in cattle meat (Arnold et al., 1993), and color recovery in turkey meat (Sante and Lacourt, 1994). Ripoll et al. (2011), on the other hand, reported that vitamin E increased the shelf life of lamb meat, and Macit et al. (2003) stated that it decreased lipid oxidation and maintained color stability of lamb meat. In general, vitamin E was shown to have less effect on color stability in pork and broiler products, significantly affecting stability in cattle and lamb, and the effect on color depended on the amount of myoglobin (Guidera et al., 1997).

Recently, the use of Se and vitamin E together is emphasized. Studies showed that selenium affected oxidative stability. It also increased vitamin E level in meat. Recently, the addition of vitamin E in alpha tocopherol form in Aragonesa lambs has been shown to alter SREBF1 and PPARG transcript levels in muscle and adipose tissue, respectively (Nowacka-Woszuk, 2020). However, addition of vitamin E in ration upregulated SREBF1 expression in the longissimus thoracis of lambs (González-Calvo et al., 2014).

It was found out that the use of Mg, an inorganic source, as a feed additive enhances the sensory properties of lamb meat (Hernandez-Calva et al., 2013). In addition, studies concluded that the addition of Mg to the rations was effective on the color improvement in pork meat, increased the pH (Otten et al., 1992) and reduced the drip loss (Schaefer et al., 1993). It was also reported that magnesium (Mg) addition to lamb rations improved meat quality and increased postmortem residual glycogen content (Pethick et al., 2000). Along with Mg, Mn is also used as feed additives and exhibits magnesium-like functions (Apple et al., 2007).

In a study (Mert, 2018), it was found that the use of 80 ppm lycopene, 80 ppm lutein and 80 ppm zeaxanthin and their mixtures in poultry mixed feeds, the breast meat MDA values, the breast meat b * (yellowness) color value, and the juiciness and appearance values from the sensory characteristics positively.

Aromatic plants and meat quality relationship

In recent years, there has also been increased interest in medical and aromatic plants and the active ingredients obtained from them. Antioxidant activity of aromatic plants is related to the phenolic compounds within their structure. The most abundant of these compounds are flavonoids, phenolic acids, and phenolic terpenes. The antioxidant effect of phenolic compounds is due to their properties such as free radical clearing, compounding with metal ions (metal chelation) and inhibition or reduction of singlet oxygen formation (Soycan Önenç and Açıkgöz, 2005). It was reported that the addition of various essential oil and their mixtures at different levels into the rations had a positive effect on the meat quality of poultry, lamb, and cattle and that it improves the color of the meat by reducing metmyoglobin formation (Luciano et al., 2009). In a previous study, it was found out that the addition of essential oils blend into mixed feed provided improvement in smell, softness, taste, and flavor parameters of *Musculus longissimus dorsi* (MLD) meats of both male and female *Karya* lambs (Ozdogan et al., 2011).

In another study, it was stated that the addition of linseed (8.3% in DM ration) increased the content of omega-3 fatty acids in *Longissimus thoracis et lumborum* of lambs, at the same time the addition of aromatic spices scored higher in the sensory analysis test than in the linseed group (Realini et al., 2017).

As highlighted by Jiang and Xiong (2016), aromatic herbs and essential oils have been used in animal feed to improve the flavor of the meat. However, no research reports were found regarding the effect of the addition of a spice blend in the ration on the eating quality of lamb. Lemon albedo has been added in the formulation of meat products showing similar consumer overall acceptability to conventional products (Aleson-Carbonell et al., 2005). Karabagias et al. (2011) and Nieto et al. (2010) evaluated the impact of using thyme on meat shelf-life and detected improved odor score ratings by panelists for lamb, but samples were not tasted. Finally, Strickland et al. (2011) showed that the inclusion of garlic into the feed did not have a negative impact on the flavor of lamb and, at the high rate (3.6% on dry matter bases), made the meat more acceptable to consumers.

It was reported that the addition of oregano essential oil delayed lipid oxidation (MDA formation), and revealed a strong antioxidant effect (Simitzis et al., 2008). It was found out that monensin and propolis extract addition in fattening cattle did not affect the chemical composition (moisture, crude protein, ash, total lipid, and total cholesterol) of *Musculus Longissimus (ML)*, but that propolis extract increased the linoleic acid level (Valero et al., 2011).

In poultry feeding, studies have been carried out to improve meat quality by using different feed additives, aromatic plants, and their excretes. Among these, studies conducted with myrtle (*Myrtus communis L.*) leaf (Yeşilbağ et al., 2013), onion extract and powder (An et al., 2015), aromatic plants and their oils (Yeşilbağ et al., 2009; Simsek et al., 2007) and vitamins (Imik et al., 2009) are summarized in Table 1.

Table 1. Effects of some feed additives on meat quality of broilers
Tablo 1. *Bazı yem katkı maddelerinin piliç etinin kalitesi üzerine etkileri*

Feed additives	Level	Color	Odour	Firmness	Flavour	Appearance	Overall rating level
Pimpinella anisum (in feed)	100 mg/kg		7/10	6.8/10	7.3/10	6.5/10	6.9/10
	200 mg/kg		6.9/10*	6.8/10	7.2/10	6.7/10	6.9/10
	400 mg/kg		6.7/10*	7.2/10*	7.7/10	7.0/10	7.2/10*
	100 mg/kg		7.1/10	7.1/10*	7.2/10	7.1/10	7.1/10*
Oregano (in feed)	200 mg/kg		6.9/10	7.010*	7.1/10	6.6/10	6.9/10*
	400 mg/kg		6.8/10	7.3/10*	7.6/10*	7.1/10	7.2/10*
	100 mg/kg	6.9/10	7.4/10	6.7/10	7.0/10	7.2/10	6.8/10
Essential oil mixture (in feed)	200 mg/kg	7.4/10	7.9/10	7.3/10	7.7/10	7.6/10	7.4/10
	400 mg/kg	7.2/10	7.4/10	7.6/10	7.9/10	7.7/10	7.6/10
	0 g/kg	3.5	7.6	6.7	7.6	-	7.3
Rosemary, dry (in feed)	5.7 g/kg	3.4	7.4	6.7	7.1	-	7.2
	8.6 g/kg	2.3	6.8	6.7	6.8	-	7.1
	11.5 g/kg	3.0	6.7	5.55	5.55	-	5.8
	100 mg/kg	3.5	7.6	6.0	6.8	-	7.1
Rosemary extract	150 mg/kg	2.75	7.35	6.55	6.5	-	6.9
	200 mg/kg	3.1	7.0	6.75	6.0	-	6.5
Vitamin E	200 mg/kg	3.6	7.2	6.60	7.1	-	7.1
	0		5.71	6.07	5.96		6.21
	500 mg/kg		6.35	6.57	6.00		6.35
Myritus communis extract	1000 mg/kg		6.32	6.57	6.46		6.46
	2000 mg/kg		6.53	6.10	6.50		6.68
	5000 mg/kg		6.14	5.67	6.50		6.53

CONCLUSION

Meat quality is a criterion that conscious consumers emphasize and determine their consumption preferences. Enrichment of poultry and red meat with substances that improve human health is an interesting topic in animal production. Meat quality or producing meat that meets desired qualities has been an area in which animal breeders work. Due to changing consumer behavior, the importance of this issue is increasing day by day. It is known to have some vitamins, minerals and essential oils to improve or maintain meat quality. In addition to improving the vitamin and mineral values of meat, there have been many studies to improve the color and aroma of meat. It is noteworthy that some vitamins, minerals and essential oils have been used more intensely in order to produce the desired meat quality in intensive livestock. In animal nutrition, efforts to improve meat quality of new feed additives will remain important in the future.

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