doi:10.1017/S0043933915002378

How meat quality and sensory perception is influenced by feeding poultry plant extracts

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The aim of this review is to discuss aspects of poultry meat quality which are influenced by supplementing the bird's diets with plant extracts. Nutritional approaches are often more effective than direct addition of the additive to meat since the compound is preferably deposited where it is most needed. Physical qualities of broiler meat, including pH and colour, is of major importance, since broiler chicken meat is nowadays usually consumed as cut up pieces or processed products. Sensory and proximate meat quality should be taken into consideration because this allows manufacturers to identify, understand and respond to consumer preferences more effectively. Lipids including cholesterol are an important component of meat and contribute to several desirable sensory characteristics of meat and meat products. Amongst meat products, poultry meat is considered to be more prone to the development of oxidative rancidity compared to red meat. This is explained by the higher content of phospholipids in poultry meat. The available literature is limited regarding changes in meat quality due to the effect of medicinal plants, especially in poultry, however this review will summarise the results of the investigations that have been published to date.

Keywords: meat; quality; spices; herbs; poultry

Introduction

The use of nutritional strategies to improve the quality of meat is a relatively new approach that has emerged at the interface of animal and food science. Nutritional approaches are often more effective than direct addition of the additive to meat since the compound is preferably deposited where it is most needed (Govaris *et al.,* 2004; Dhama *et al.,* 2015). As in other animal species, the physical quality of broiler meat is of major importance, since broiler chicken meat is usually consumed as cut up pieces or

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Received for publication June 27, 2015
Accepted for publication July 25, 2015

https://doi.org/10.1017/S0043933915002378 Published online by Cambridge University Press

processed products rather than as whole carcasses. Physical quality refers to several meat properties, including pH and colour. Meat quality is closely related to the decrease in muscle pH *post mortem*. Rapid *post mortem* decline in pH results in pale, soft and exudative (PSE) meat with reduced water-holding capacity (Owens *et al.,* 2000; Džinić *et al.,* 2008; Puvača and Stanaćev, 2011). The variations in colour of broiler breast meat fillets are significantly correlated with muscle pH and extremes in colour variations (Džinić *et al.,* 2007a; Khalafalla *et al.,* 2011). Low ultimate pH results in 'acidic meat' with similar defects to those of PSE meat (Barbut, 1997), while high ultimate pH leads to dark, firm and dry (DFD) meat with dark colour and poor storage quality (Allen *et al.,* 1997; Laudadio and Tufarelli, 2011). Beside physical meat quality, economic importance is related to sensory and chemical characteristics of meat which should not be forgotten.

Three sensory quality characteristics colour, texture, and flavour are the main attributes affecting meat consumer acceptance, and lipid peroxidation is the primary cause of these quality deteriorations in meat and meat products (Kostadinović *et al.,* 2015). Antioxidants are natural or synthetic substances used to prevent lipid oxidation, and are typically present in many plant extracts. The aim of this review is to present main parameters of poultry meat quality influenced by medicinal herbs.

Sensory characteristic of poultry meat quality

Sensory analysis is one of the oldest means of meat quality control which allows producers to identify, understand and respond to consumer preferences more effectively (Saha *et al.,* 2009; Matitaputty *et al.,* 2015), and increasing choice in the marketplace (Ponte *et al.*, 2004). In the consumer research published by Puvača *et al.* (2015a), sensory quality of meat has high scores for smell, juiciness and overall impression, demonstrating that the addition of spices including garlic, black pepper and hot red pepper in the diet did not have an adverse effect on meat quality. Conversely, when Džinić *et al.* (2013) evaluated the sensory quality of breast chicken meat with the addition of 2% of garlic powder in feed, they saw a characteristic taste and pungent smell of garlic transferred to meat. This characteristic flavour can be both non-beneficial and beneficial, depending of consumer's affinities and demands. In the same investigation, the addition of garlic led to excellent meat quality regarding the juiciness and tenderness of breast meat. Similar results were obtained by Pavelková *et al.* (2013) using oregano essential oil in broiler diets, which resulted in improved sensory meat quality, which negated previously published influences of this phytobiotic in altering of taste, juiciness and tenderness of chicken meat. The addition of 30 mg/kg of *Macleaya cordata* plant extracts (Zdunczyk *et al.,* 2010), which is from same alkaloid family as black pepper, resulted in an intense smell for breast meat without any atypical smell. The study of Waskar *et al.* (2011) reported that supplementation with polyherbal products in poultry diets was effective in improving overall meat quality attributes such as fillet and tender yield, sensory characteristics, organoleptic cooking parameters, overall palatability and consumer acceptability of meat. Plant products, such as garlic, black pepper and hot red pepper, did not have any residual or adverse effects on eating and cooking quality of meat, and can be regarded as safe for usage (Džinić *et al.,* 2009; Puvača *et al.,* 2015a).

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Physical characteristic of poultry meat quality

Considering the glycolytic process, the initial pH value provides a good guideline for judging physiological meat quality. Accelerated pH decline are related to a light meat colour and poor water retention, which, in the majority of cases, is seen for pH values ranging from 5.8 to 6.0 concerning exudative meat. However many other modern sensory, instrumental and biophysical methods are involved in determination of chicken meat quality (Damez and Clerjon, 2008). During recent years, deviations in meat quality which did not show typical characteristics of PSE and DFD were repeatedly reported. There was acceptable colour and increased water holding capacity (WHC) as well as pale colour and good juice retention (PFN). Of especially interest is poor WHC meat, as drip-loss means a loss in weight and texture during cooking and, therefore, economic losses and poor consumer acceptability (Fischer, 2001).

In the experiment of Puvača *et al.* (2015a), pH values ranged from 5.5 to 5.7 in breast meat and between 5.9 and 6.0 in thigh and drumsticks ($P<0.05$), while Qiao *et al.* (2001) reported pH values of lighter than-normal, normal and darker-than-normal groups of 5.81, 5.96, and 6.23, respectively, which were significantly different from each other. Puvača *et al.* (2014) recorded pH value of 5.6 in meat from chickens fed diets containing 2% garlic powder. According to Lara *et al.* (2003), meat with a pH higher than 5.8 is classified as 'normal' for quality purposes. Several researchers have demonstrated a significant relationship between raw meat colour and its pH (Allen *et al.,* 1997; 1998; Fletcher, 1999). Barbut (1993) reported that lightness (L^*) had the highest correlation of the L^*, a^*, b^* colour values with PSE conditions, and dietary addition of garlic, black pepper and hot red pepper had an influence on broiler chicken meat colour. The relationship between muscle pH, colour, and meat quality in red meat species is well established (Dutson, 1983). In poultry, however, the relative influence of pH on meat quality is not as well established as in the extremes of PSE and DFD conditions in pork and beef (Qiao *et al.,* 2001). Positive influences of plants and their extracts in chicken diets on meat quality has been observed by Savković *et al.* (2008) using a mixture of different supplements. Feeding hot red pepper showed the highest positive influence with the lowest drip-loss of breast meat after heat treatment (20.5%), while higher supplementation for thigh with drumstick quality had the most positive influence and lowest drip-loss of 27.3% (Puvača *et al.,* 2015a). Allen *et al.* (1998) reported that initial and accumulated L^* values were correlated positively with drip-loss and cooking-losses in chicken meat. Their results were in agreement with the previous findings of Barbut (1993), who observed a high correlation between L^* and cooking loss, whereas Allen *et al.* (1998) found no correlation between raw meat pH and drip-loss or cooking-losses.

Poultry meat proximate characteristics and caloric value

Gardzielewska *et al.* (2003) reported that broiler chicken feed supplemented with echinacea (*Echinacea purpurea*), garlic (*Allium sativum*) and ginger (*Zingiber officinale*) had no effect on meat moisture content. In trials by Puvača *et al.* (2015a), the highest protein content of breast (24.0 g/100 g) and thigh with drumstick (20.6 g/100 g) was observed in diets supplemented with black and hot red pepper. From this, it can be postulated that the dietary addition of black and hot red pepper led to a significant improvement in meat quality. In earlier research by Puvača *et al.* (2014), garlic powder addition to chicken diets at 2.0 g/100 g, gave significant increases in protein content (22.9 g/100 g) in breast meat compared to the control diet (21.8 g/100 g). Souza *et al.* (2011) reported that typical protein content of chicken breast meat ranged from

https://doi.org/10.1017/S0043933915002378 Published online by Cambridge University Press

22.48 to 22.61 g/100 g. The content of protein in chicken breast meat ranges from 20.7 to 32.1%, as reported by Mohammed (2013), with energy values between 160.0 and 212.0 kcal. Puvača *et al.* (2015a) showed that the energetic value of breast meat was increased by dietary spice supplementation in feed, and ranged from 92.5 kcal to 97.5 kcal. Onibi *et al.* (2009) reported a significant influence of plant extract addition on fat content, whereby the thigh had the highest fat content (82.9 g/kg), followed by drumstick (66.9 g/kg) and the lowest was seen in breast meat (49.1 g/kg). This is akin to research that has shown fat deposition to be higher in red (leg) meat than in breast meat (Onibi, 2006; Džinić *et al.,* 2008). Breast meat fat content was affected by the interaction between sex and genetic strain, with males presenting the highest values (Souza *et al.,* 2011). On the other hand, Lonergan *et al.* (2003) reported higher fat content values in females as influenced by the interaction between sex and genetic group fed with the same plant extracts in the diet. Significantly higher ash content of chicken meat was reported by Mohammed (2013). Regarding the energy value of chicken meat, it can be observed that the addition of plant extracts to chicken feed had a significant influence on altering the caloric value of meat.

Cholesterol in poultry meat

The available literature is limited regarding changes in muscle cholesterol due to the effect of cholesterol-reducing agents such as medicinal plants, especially in poultry. Konjufca *et al.* (1997) reported that cholesterol concentrations were higher in thigh than breast meat when chickens were fed diets supplemented with garlic powder. A possible explanation for this could be that cholesterol is usually associated with adipose tissue, which is more abundant in the thigh than in the breast meat. Moreover, thigh meat has a greater content of slow-twitch fibres than breast meat which has many more large mitochondria, hence the metabolic rate is much faster in comparison to fast-twitch fibres.

In field experiments, supplementation with garlic powder significantly decreased cholesterol levels in breast meat (60.5 and 41.4 mg/100 g), thigh with drumstick (52.9 and 46.4 mg/100 g), skin (122.3 and 97.5 mg/100 g) and liver (502.9 and 474.0 mg/100 g). Other researchers have confirmed the positive influence of dietary garlic powder on the reduction of cholesterol levels in meat (Džinić *et al.,* 2009; Stanaćev *et al.,* 2012) and blood (Shahriari *et al.,* 2009; Issa and Abo Omar, 2012; Puvača *et al.,* 2015b). Under the influence of black pepper, cholesterol level in breast meat (54.3 and 40.1 mg/100 g), thigh with drumstick (37.8 and 30.7 mg/100 g), skin (122.2 and 100.6 mg/100 g) and liver (493.6 and 393.2 mg/100 g) can be significantly reduced ($P<0.05$) compared to control and garlic treatments, but with no significant differences compared to hot red pepper supplementation (Puvača *et al.,* 2015b). These positive effects of black and hot red pepper can be attributed to antioxidative activity (Nabil Alloui *et al.,* 2014). In addition, black pepper constituents include essential oils (α- and β-pinene, limonene, and β-caryophyllene), piperine, eugenol, the enzyme lipase, and minerals (Singletary, 2010). Puvača *et al.* (2015b) confirmed that black pepper lowers cholesterol levels in tissues of chicken, while others (Shahverdi *et al.,* 2013; Abou-Elkhair *et al.,* 2014) have confirmed lowering effects of cholesterol in the blood and serum of chickens.

Al-Kassie *et al.* (2011) reported that black pepper supplemented at levels of 0.50, 0.75 and 1.0% in broiler diets depressed cholesterol, Hb, RBC and H/L ratio concentration. The best effect on cholesterol when measured in the study of Puvača *et al.* (2015b) was observed with dietary hot red pepper and spice mixtures. Hot red pepper in amount of 1.0 g/100 g, reduced cholesterol content in breast meat (41.2 mg/100 g), thigh with drumstick

https://doi.org/10.1017/S0043933915002378 Published online by Cambridge University Press

(24.7 mg/100 g), skin (87.4 mg/100 g) and liver (263.1 mg/100 g). Trials conducted by Al-Kassie *et al.* (2012) using hot red and black pepper separately and in combination showed similar benefits, whereby addition of these supplements led to a reduction in cholesterol, RBC, WBC and H/L blood ratio concentrations. Shahverdi *et al.* (2013) revealed that the inclusion of hot red pepper in broilers diet decreased cholesterol, triglyceride, glucose concentrations and H/L ratio concentration in broiler blood plasma, what is in accordance with other findings. The advantage of hot red pepper in broiler nutrition is that the birds can consume the active component capsaicin without any adverse effects on feed intake, as birds are insensitive to the irritant effects via capsaicinon sensory neurons and lack vanilloid receptors for capsaicin.

Lipid oxidation of poultry meat

According to Kostadinović *et al.* (2015), the liver is an organ with a central metabolic role in the organism, often referred to as 'the main laboratory' since it performs detoxification and antioxidation tasks, and hence is the prime target for the study of the metabolism of xenobiotic and other toxic substances. Antioxidant enzymes counteract excessive formation and deleterious effects of reactive oxygen metabolites. For example, superoxide dismutase (SOD) catalyses the conversion of superoxide anion radical to H_2O_2, catalase reduction of H_2O_2 to water, while glutathione peroxidase (GSHPx) acts in conjunction with other enzymes to reduce H_2O_2 and to terminate lipid peroxidation (Halliwell and Chirico, 1993). This reduces the oxidative damage of fats in meat, extends shelf life and increases meat safety.

Lipids are an important component of meat and contribute to desirable sensory characteristics of meat. Lipids enhance the flavour and aroma profile of meat and increase tenderness and juiciness (Gorelik *et al.,* 2008). However, it is generally accepted that lipid oxidation is the primary process responsible for quality deterioration of meat during storage. Many investigations have shown that plant flavinoids have the capacity for powerful antioxidant activity by scavenging free radicals and terminating oxidative reactions. Kostadinović *et al.* (2015) reported that concentrations of the oxidative indicator malondialdehyde (MDA) were significantly lower and GSHPx activity was higher in the group supplemented with *Artemisia absinthium* than in the unsupplemented group, and found less lipid peroxidation in the blood and plasma of broiler chickens fed the supplemented diet.

All meat and fish products are prone to oxidation. Amongst meat products, poultry meat is considered to be more prone to the development of oxidative rancidity compared to red meat, due to the higher content of phospholipids in poultry meat. It has been demonstrated that meat oxidation starts by a peroxidation of the phospholipid fraction. The lowest level of MDA in breast meat (0.05 mg/kg), thigh with drumstick (0.12 mg/kg) and liver (0.13 mg/kg) was observed in treatment with addition of 1.0 g/100 g of black pepper, while the highest was observed in the control group (Puvača *et al.,* 2015b). Lipid oxidation reduces meat quality by a number of ways, including off-flavours, higher drip loss and colour changes. During lipid oxidation, poly-unsaturated fatty acids are degraded to volatile short-chain oxidation products, which cause bad odours (Jensen *et al.*, 1998), and affect the ability of the membranes to hold water, contributing to drip loss (Weber and Antipatis, 2001).

Results of thiobarbituric value (TBARS) methods showed that supplementation with lemon balm and the combination of hawthorn and yarrow in broiler diets caused a reduction in lipid oxidation in the thigh muscle (Marcinčáková *et al.,* 2011). Luna *et al.* (2010) added thymol and carvacrol to broiler diets at levels of 150 mg/kg for 42 days

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and reported positive effects on the oxidative stability during the storage of red meat. Similar positive effects of medicinal plants and aromatic herbs on shelf life were observed by Šperňáková *et al.* (2007) using rosemary powder and by Govaris *et al.* (2004) with oregano powder.

Conclusions

It can be concluded that the dietary addition of plants and their extracts to broiler diets can have significant influence in improvement of sensory, physical and proximate composition of meat. Meat from chickens fed with such supplementary compounds has higher energetic values which are of practical importance for human nutrition. Many plant extracts act as powerful antioxidants in the alteration of chicken meat quality and safety; lowering cholesterol and decreasing lipid-oxidation processes. Spices, herbs and aromatic plants can be used as very effective natural supplements, and there is evidence that, apart from improving meat quality, they can provide an alternative to antibiotic growth promoters. Moreover, the technological as well as nutritional and sensory quality of chicken meat can be reached with proven feed supplements, because not all plant-derived additives may have beneficial effects on meat quality.

Acknowledgments

This paper is a part of the project III 46012 which is financed by Ministry of Education, Science and Technological development of the Republic of Serbia.

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