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Review article

Consumer health maintenance related to goat meat fatty acids composition and distribution as influenced by some non genetic factors

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Meat health related issues as perceived by the consumers has become motivators for liking and purchasing of meat products in developed world with a high incidence of cardiovascular disease. Apart from the genetics of the animal desirable goat meat quality production is affected by various known non genetic factors of which could be manipulated to modify the composition and distribution of fatty acids and other biochemical and physical meat quality properties. Knowledge of these as individual factors and/or their combined influence is essential for efficient and desirable meat production which is safe for human consumption. There has been an observed distinctive association of individual levels of non genetic factors such as diet, castration and muscle type with composition and distribution of fatty acids in goat meat which corroborates results reported for other species of animals worldwide.

1. Introduction

Modern consumers are increasingly concerned about production of safe meat with no undesirable effects on their health (Andersen et al 2005). Past decade has been characterized by rapid changes in consumer trends pertaining to meat consumption which has forced meat producers need to meet consumer demands and preferences. Consumer preference for meat quality has been difficult to define however some studies have shown that consumers perception on meat is related to its fat content and composition of fatty acids. Fats and fatty acids have become important because of their effects on human health (Alonso et al 2009) and fatty acids profiles have long been studied for their implication on health maintenance (De la Fuente et al 2009). In developed countries consumer interest in fatty acids composition and distribution has doubled over the years (Nuernberg et al 2003) hence the production of safe and desirable meat quality has become a primary focus for both producers and researchers (Newcom et al 2004).

Goats suit the above scenario because it produces relatively lean meat which is suitable for health conscious consumers (Mushi et al 2010). However its suffice to say the composition and distribution of these fatty acids has their presence based on the influence of some known non genetic factors. The role of individual non genetic factors has been the subject of an extensive number of studies for example, diet (Banon et al 2006), production system/practice (Scollan et al 2005), age (Attah et al 2006), nutrition (Demirel et al 2006), genotype (Madruga et al 2008), slaughter weight (Kadim et al 2004), castration (Kabede et al 2008), rearing systems (Rodriguez et al 2008), chronological age (Warren et al 2007) and muscle location (Arguello et al 2005). The list non exhaustible and the present review attempt to highlight the influence of non genetic factors on fat composition in goat meat and their relation to health meat consumption.

2. Fat, cholesterol and health

The suitability of meat for human consumption is determined by cholesterol content associated with coronary heart disease (Brzostowski et al 2008). Consumers are interested in goat meat as a source of relatively lean meat especially in developed countries with a high incidence of cardiovascular disease (Banskalieva et al 2000). In developed countries fatty acids composition and total amount of saturated fatty acids have been identified as dietary risk factors related to various cancers and especially coronary heart disease (Pascual et al 2007).Compared to meat from other ruminants' species goats' meat has low cholesterol concentration of 48.76 to 56.63 mg/100g (Hasik et al 1999). Due to the relationship between high fat diets and heart diseases, consumer interest in the fat content and fatty acids composition of foods has grown in recent years (Scollan et al 2006). The concentration of essential unsaturated fatty acids is of primary importance from the perspective of a healthy diet since they help to prevent or control hypercholesterolemia considered a key risk factor of coronary heart disease (Pfeuffer 2001). The thrombotic tendency of blood depends largely upon the balance between antithrombogenic (C20:3n- 6 C20:5n-3) and thrombogenic (C20:4n-6) fatty acids (Enser et al 1996). High dietary levels of long chain saturated fatty acids (SFA) increase plasma cholesterol level compared with high levels of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (Grundy and Denke 1990). Increase in the ratio saturated fatty acids to unsaturated fatty acids could have negative health implications from the consumers stand point of view (Department of Health 1994). Higher intake of C20:4n-6 is not desirable from human health point of view as it can lead to insulin resistance, higher accumulation of storage adipose tissue and in vivo platelet aggregation (Banskalieva et al 2000). A higher dietary intake of long chain saturated fatty acids except stearic acid has been associated with increase in plasma cholesterol levels and hence poses a higher risk for atherosclerosis (Aro et al 1997). Stearic acid is partially converted to oleic acid in vivo and has not been shown to elevate blood cholesterol (Valsta et al 2005). Oleic acid is considered hypolipidaemic as it reduces cholesterol in plasma and triglycerides (Lee et al 1998) and lipaemia by reducing both the cholesterol raising low density lipoprotein and triglycerides (Rao et al 2003). It is due to this fact that stearic acid and all unsaturated fatty acids have been classified as desirable fatty acids for human health (Russo et al 1999). High proportion of linoleic acid is beneficial for human health due to diminish thrombotic tendency in blood and risk of suffering coronary disease (Caneque et al 2003; Webb et al 2005). However index of polyunsaturated to saturated used has some limitation because not all saturated fatty acids increase cholesterol the positive effects of monounsaturated fatty acids like oleic acid is not considered when this index is used (De la Fuente et al 2009). Consumers are advised to increase their overall intake of monounsaturated fatty acids and polyunsaturated fatty acids as these fatty acids help to decrease low density lipoprotein-cholesterol. Nutritionists now recommend not only limiting fat intake but also consuming large amounts of PUFA, especially those of n-3 rather than n-6 PUFA (Simopoulos 2002). However Demirel et al 2006 it is difficult to simultaneously attain desirable ratios for both PUFA: SFA, n-6:n-3 in meat from ruminants. Recommended PUFA: SFA ratio by Department of Health of England (HMSO 1994) of at least 0.45 that excludes C18:0.The PUFA should have a high content of conjugated acid isomers.

Conjugated linoleic acids are thought to be responsible for several health promoting effects such as anti-carcinogenesis, immunomodulation and anti-obesity (Enser 2000). Williams (2000) observed that conjugated linoleic the naturally occurring fatty acids in ruminant derived food to which various beneficial health effects are attributed. Research has concentrated on increasing the amount of unsaturated fatty acids notably polyunsaturated fatty acids of n-3 series and conjugated linoleic acid in beef (Givens et al 2006).The inclusion of pasture in the diets of steers increase the proportion of conjugated linoleic acids (De La Fuente et al 2009). In addition to above mentioned conjugated linoleic acid exhibited antioxidants properties inhibiting the discoloration of meat during storage (Du et al 2000). Clear evidence of an enhanced proportion of conjugated linoleic acids in pasture fed animals compared with concentrate fed animals (Realini et al 2004). The enzyme responsible for conversion of saturated fatty acids into mono unsaturated fatty acids is desaturase which the main task is to convert stearate into oleate (St John et al 1991). The enzyme also converts vaccenic acid (18:1 Trans 11) into conjugated lionoleic acid (Schmid et al 2006). The desaturase activity is sensitive to a variety of dietary and environmental factors (Ntambi 1999). There are several considerations regarding the nutritional value of fats and the effects of fatty acids balance on health to meat consumers (Ding et al 2010). One is that there should be a high concentration of what are termed as desirable fatty acids which are C18:0 and other unsaturated fatty acids (Banskalieva et al 2000). Consumers should take not that not all fatty acids have adverse implications on consumer health. The other is saturated fatty acids which may be harmful to health as they tend to elevate low density lipoprotein-cholesterol levels. The adverse effect of saturated fatty acids on human plasma cholesterol levels makes it is imperative to consider biochemical processes and products that affect levels and composition of ruminant intramuscular fat (Barton et al 2007).

Bonamone and Grundy 1988 suggested that only C16:0 increases blood cholesterol whereas C18:0 has no effect and C18:1 cholesterol content. Because these fatty acids represents the majority of fatty acids the ratio of (C18:0+C18:1)/C16:0 could perhaps better describe possible health effects of different types of lipids. Although PUFA may have beneficial effects on blood cholesterol there is concerned that some meats may have an excessively high ratio of n-6; n-3 PUFA (James et al 1992). Desirable fatty acids are believed to reduce the absorption rate of dietary cholesterol and bile acids as well as to influence lipoprotein synthesis (Bartnikowska 1993). Desirable fatty acids could range from 76.63% to 77.68% in goat meat or 61.3% to 79.8% same muscle in other goat breeds (Matsuoka et al 1997; Park and Washington 1993). A particular important role in promoting health has been associated with polyunsaturated fatty acids being an essential and key food ingredient (Leibesender 1996; Hasik et al 1999). However little is known about the fatty acid composition of goat meat and only a few investigation have been done on fatty acid composition of lipids in some goat muscles (Sauvant et al 1979; Nitsan et al 1987; Potchoiba et al 1990; Park and Washington 1993;; Johnson et al 1995; Matsuoka et al 1997). The fatty acid composition of goat meat lipids has received little research attention relative to that given to other meat animals (Banskalieva et al 2000). Publications addressing the fatty acids composition of some fat depots in goats (Duncan et al 1976; Sauvant et al 1979; Bas et al 1982; Casey and van Niekerk 1985; Hamminga et al 1996; Rojas et al 1994). Special attention is currently paid to manipulation of dietary fatty acids because of the impact of fatty acids intake on human health (Wood et al 2004). It is however important to note the role that the health risk factor of animal derived lipids has often been over emphasized although it is evident that these lipids provide physiologically functional and potentially health beneficial fatty acids (Razminowicz et al 2006).

3. Different muscle type/location and fatty acid composition

The content of SFA, MUFA and PUFA vary depending on anatomical region (Banskalieva et al 2000). The effects of different diets on the fatty acid composition of total lipids in different muscles have been studied (Nitsan et al 1987). Banskalieva et al 2000 observed that similar to other ruminant's diet can affect fatty acids composition of muscle lipids. Different nutritional conditions can change muscle lipid fatty acids composition in ruminants (Marmer et al 1984; Eichhorn et al 1986; Larick et al 1989; Melton 1990; Solomon et al 1991; Enser et al 1989; Mandel et al 1998). However no literature is available examining the influence of interactions between of non genetic factors such as diet, muscle type, age, live weight or breed of goats which may be essential to understand the whole issue of meat quality properties. The PUFA:SFA and (18:0+ 18:1)/ 16:0 ratios and the sum of desirable fatty acids were higher in m. longissimus dorsi of Alpine kids (Park and Washington 1993) which was in country to Potchoiba et al (1990) observation. Lipids in m. longissimus dorsi and m. biceps femoris were characterized by low proportion of saturated fatty acids (Park and Washington 1993).

4. Castration, fatty acids and meat flavor

The role of fat in meat flavor has been the subject of an extensive number of studies (Cameron and Enser, 1991: Cameron et al 2000: Mottran 1996: Nuernberg et al 2005: Teye et al 2006; Wood et al 1999, 2003). Fat content of meat varies widely depending on species, degree of fattening of the animal prior to slaughter, age and weight at slaughter and whether the animal is castrated or not (Naude and Hofmeyr, 1981: Devendra and Burns, 1983: Madruga et al, 1999). Johnson et al (1995) analyzed the effects of sex and castration on cholesterol and fatty contents of cooked goat meat. Total cholesterol content was significantly affected by slaughter age or castration these factors being independent of each other (Madruga et al 2000). Kumar et al 1983 observed that castration had no significant effect on fat content of goat meat. Johnson et al (1995) reported higher concentration of cholesterol for castrated males (98mg/100g) compared with intact males and females 94 and 100mg/100g, respectively. Oleic and linolenic fatty acids were found to be significantly affected by castration (Madruga et al 2001). The lower SFA together with the higher MUFA proportions observed in castrated male in Norwagian goats made meat from these animals nutritionally healthier than that of other animals used. Castrated goat meat contained greater unsaturated and polyunsaturated fatty acids than intact goat meat (Madruga et al 2001). Johnson et al 1995 found that fatty acids from cooked meat from intact goat had less total saturation than those from female or castrated goats. However, Enser et al (1998) suggested that the ratio n-6: n-3 PUFA for male goats is similar to that for bulls. Bas et al 1982 observed level of branched chain fatty acids (saturated C14, C15 and C16) in subcutaneous fat were higher in intact than castrated kids. Meat of young goats were juicer and tenderer than that of older animals and had a better flavor (Kirton 1970). Meat from adult male goat is generally believed by public to have a strong unattractive flavor and odour however the scientific evidence to support its presence is inconclusive (Madruga et al 2000).

A frequent complaint as goat meat coming from taste panelist is a lack of flavor often associated with a lack of tenderness which leads to a general unfavorable impression (Madruga et al 2000). Fat may contribute to the meat flavor although genetic and environmental conditions without any doubt play an important role in influencing the chemical composition of meat flavor (Divivedi 1975; Melton 1990; Mottran 1994). Species, breed, age and sex are important genetic factors on the characteristics of most meat flavors in different species (Herz and Chang 1970; Madruga 1994; Sink 1979). But not much is known about the influence of these in goat flavor formation (Madruga et al 2000). Appearance, juiceness, tenderness and overall palatability scores were higher in goats slaughtered early than advanced age (Gaili et al 1972). Tenderness reduces with age due to toughening of myofibrilar protein of meat and presence of cross bridge which set up collagen molecules and this phenomenon are universally observed in all animal tissues (Lawrie, 1992). Decrease in tenderness and juiceness with age was also reported by Schonfeldt et al (1993) and Kamble et al (1989)

Goat meat fat is a significant source of saturated fatty acids in the human diet because red meat has a relatively high ratio of saturated to unsaturated fatty acids in its lipids which are a risk factor for the development of vascular and coronary disease (Barton et al 2007). Lipids may contribute to meat flavor of cooked meat in several ways (Tikk et al 2007). Degree of unsaturation of faty acid has been reported to have significant influence on flavor attributes with high levels of unsaturated lipids contributing to desirable flavors (Mottram 1996). Lipids may undergo thermal oxidation which results in flavor active compounds that contribute directly to meat flavor (Mottran, 1991). Lipid reacts with other components within the lean tissue resulting in other flavor components (Whitfield et al 1988). Lipids act as a solvent for several aroma compounds accumulated during production processing and cooking of meat (Edmore et al 2002). Phospholipids are believed to contribute to aroma development in meat whereas triglycerides do not appear to be as important (Mottram and Edwards, 1983).

5. Diet and meat fatty acids in ruminants

Feeding of the animals has proved to be important for controlling overall meat quality (Andersen et al 2005). Various studies have shown that fatty acids composition of edible tissues of cattle and sheep is influenced by diet and genotype (Wood et al 1999). Manfredini et al (1988) reported substantial effect of diet was evident for fatty acids composition in goats. Several factors can modify the composition of fatty acids among them is diet (Lawrie 2006). Different diets is responsible for much of the variation in the fatty acids composition both sheep (Rhee et al 2003) and cattle (Razminowicz et al 2006). Differences in fatty acid composition of beef from animals reared on pasture and grain based have been widely reported (French et al 2000; Nuernberg et al 2005; Steen et al 2003). Feeding regime including concentrate and roughage change fatty acid profiles due to activation of ruminal biohydragenation of dietary polyunsaturated fatty acids (Lanza et al 2006). The effects diets based on the fatty acids composition of the dietary fat with polyunsaturated fatty acids having a more negative impact on cellulytic rumen bacteria (Coppock and Wilks 1991). In the rumen most triglycerides are hydrolyzed and the unsaturated fatty acids are hydrogenated (Doreau and Chillard 1997). Increasing the proportion of n-3 fatty acids in ruminant's diets may modify the fatty acids composition of their muscle tissue indicating that all dietary fatty acids are not completely hydrogenated in the rumen (Scollan et al 2001). Unlike ruminants in which most of dietary unsaturated fatty acids are hydrogenated in the rumen (Jenkins 1993) dietary fatty acids are incorporated directly into tissue lipids in pigs (Mourof and Herier 20001; Wood et al 2003). Odd chain and branched chain fatty acid with an iso-or anteiso structure originating from lipids of rumen microorganism could be a substrate for the host animal (Bas et al 2003). Evidence is now growing that the molecular structure of dietary triacylglycerols plays an important role in the development of atheroscelosis (Patsch 1994). Triacylglycerols enriched with SFA at the sn-2 position which exhibit different metabolic behavior than triacylglycerols with SFA at sn-1 and sn-6 position (Redgrave et al 1988; Tuten et al 1993; Carnielli et al 1995). Choi et al 2000 found out that n-6/n-3 ratio was much more affected by feeding than by genetics. Intensive system in beef production displayed the highest in n-6 PUFA proportion which was attributable to the concentrate based diet (De la Fuente et al 2009).

Use of concentrate diet compared with use of milk replacer led to a higher level of unsaturated fatty acids (MUFA and PUFA) in sternal and inguinal fat (Sauvant et al 1979). The fatty acids composition of adipose tissues and muscles of young goats was shown to reflect the fatty acids composition of their milk intake (Bas et al 1987; Nitsan et al 1987) while tissue fatty acids composition of older goat's results from changes in the activity of rumen bacteria with an increase in total saturated fatty acids content. (Sauvant et al 1979). During milk feeding the fatty acid composition of adipose tissue of kids depends on the fatty of milk fat (Muller et al 1985; Kuhne et al 1986). Use of higher amounts of milk replacers or concentrate feeding of milk replacer versus and use of concentrates compared with milk or milk replacers changed the proportion of different fatty acids in internal or subcutaneous fat working with different goat breeds (Casey and van Niekerk 1985).

6. Conclusion

The review attempted to highlight the influence of individual known non genetic factors on fatty acids composition and distribution and their implication on consumer health. The non genetic factors discussed were diet, castration and muscle location/type and potentiality of manipulation of some of these to promote desirable fatty acids. Consumer preference and health awareness has been noted as an important social factor in making purchasing decisions. However the review short fall or realize the need to examine the influence of interaction of specific non genetic factors which could possibly modify the meat quality properties for health maintenance. It may be reasonably to conclude that knowledge of the relationship between or among non genetic factors on how they influence meat properties would facilitate to maximize production of desirable meat quality acceptable to consumers taking into account safety and health maintenance.

In an attempt to examine the magnitude of influence of interaction of non genetic factors in future researchers should note that interpretation of these results may be difficult because interactions could be related to sampling error. The choice of interacting non genetic factors may naturally or forced to take cognizance of heterogeneity needs of specific consumer groups which would make generalization of similar results from different environment or production system impossible. Despite the drawbacks in this endevour further understanding of meat quality properties may be achieved by examining the interaction factors.

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