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Factors effecting growth, properties and quality of beef meat

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ABSTRACT

Nowadays consumers are highly interested in the quality of the products they eat, especially when this refers to meat. Consumption of meat from ruminant animals and its derivatives is on the increase, particularly in Pakistan. Current analysis is a review of the different factors that affect meat quality in ruminants. Some factors throughout the entire meat chain are analyzed, or rather, from those that producers underscore to improve the quality of their products to those related with consumers´ habits and beliefs. Most of the papers reviewed have been developed by researchers involved in the meat quality in collaboration with Pakistani or international groups.

Key Words:
Beef meat, Quality of beef, Growth factor of beef meat, factor effecting beef

Introduction

Protein has an important role in body functioning of a human life. It is needed in human body for repair and maintenance in the form of energy, hormones, enzymes, antibodies, storage and transportation of molecules. Proteins are most abundant substance in our body after water. There are two sources of protein in human diet; one is plant protein while other one is animal protein. Both have same importance as both sources provide essential amino acids. Animal source has been part of human diet since a long, although it usage pattern has been changed variously along with the evolution of human race. In earlier ancient times, animal meat was gained from hunting of wild animals (Larsen 2003), but with the change in time it shifted from wild to domesticated animals. Major domesticated animals used for meat are cattle, buffalo, pig, camel, sheep andgoat, which are first documented to be domesticated 10500 (Bullongino et al. 2012), 7000 (Yang et al. 2008), 9000 (Giuffra et al. 2000), 5000 (Epstein1971), 9500 and 10000 years ago (Zeder 2008) respectively. Meat of bovine is termed as Beef, while meat of sheep and goat as Mutton. Beef has a major role in meat industry of the world 3rdin consumption after pork and poultry. Around 60022 thousand metric ton meat production while 58164 thousand metric ton totalconsumption was reportedlastyear (USDA 2016). India, Brazil and Australia has greater role in worlds beef export. Per 100g beef (lean) provides 70.0 water, 485 kJ energy, 1.8 fatty acids, vitamins,1.2 minerals and sterols along with 22.3 proteins (FAO 2007). Beef meat is of a great importance for human health as it contains conjugated linoleic acids which can decrease the

chances of cancer development, bone density loss, atherosclerosis, diabetes and many other chronic diseases (McGuire et al.2000). Also it improves immune response and prevents heart attack. Beef contains 7.6 microgram/100g selenium which is an important component of immune system and various metabolic pathways including thyroid hormone metabolism (Brown et al.2001). Beef meat can be used in fresh, dried and freeze form. Recently, a lot of focus on quality and quantity has provided the world with better nutrition in a better economic framework. As the world population increases, there is also increase in meat demand globally so market globalization has made itessential for increased production and processing of beef products. Beef is processed, stored and transported on scientific basis to ensure its natural flavor, juiciness and tenderness keeping in view the ethnic value, demand and purchasing power of consumer (Hugas et al. 2002). Beef quality can vary along with variation in processing, storage and transportation methods along with breed, nutrition, health status at slaughter and husbandry conditions (Hoving-Bolink et al. 1998). Production systems of beef cattle like intensive production system, extensive production system and conventional production system also has impact on quality and composition of meat & carcass (Keane et al. 1998). This review has been designed to summarize the research conducted regarding the factors which can affect meat quality, its composition and growth regarding the human health perspective.

Breed

Beef animals have beenclassified generally into two groups: one is used for reproduction and milk purpose, called as maternal breed group while the other one is used as meat production due to it higher growth rate, called as terminal breed group. Breed has very important impact on growth of animal as well as its meat properties. Each breed has its own different fat and protein ratio.Soji et al.(2016) studied the effect of genotype and age in several South African classification systems of beef animals. These classification systems were based upon sex, fatness, conformation, age, and bruising.Different beef breeds like Simmental, Angus, Fleckvieh, Bonsmara, and Non-descript were used in each system and it was observe that different breeds in same age group and sameclassification system had difference in meat pH, color, thawing, tenderness and quality. Meyer (1994) estimated the direct and maternal factors on growth of beef Australian cattle and found that breed and genetics are strongly correlated with growth rate as it has impact on animal's birth weight, weaning weight and final mature body weight of Angus and Zebu crossed cattle breed. So it is established that breed of animal or genetic makeup of animal has impact on growth of animal and its meat composition. In another study Vieira et al. (2007)found that effect of breed on meat composition was found very significant. Three different breeds including Limousine, Brown Swiss and Asturiana de los Valles were used and it was observed that breed affected a lot on intramuscular fat, juiciness, carcass weight and dressing percentage parameters. Sanudo et al.(2004) suggested that there is significant effect of breed on insoluble collagen, resulting in difference oftoughness and shearing force of meat. Some other resultsby Schenkel et al. (2004) indicate breed effect on feed efficiency, meat composition and body growth. According to Monsón et al. (2005) breed also has impact on beef flavor and tenderness, resulting effect on preference by consumers.But some researchers have observed no significant effect of breed on sensorial characters of meat. Campo et al. (1999) reported that overall there was no difference on flavor, juiciness and tenderness of seven European beef breeds slaughtered at same aging times.

Sex

Gender has great impact on physical and sensorial characters of beef meat. Both sexes at same age and same external environment may have different characters regarding carcass composition. Carcass composition may vary according to the physiological stage of animal which is mainly influenced by sex. Zhang et al.(2010) found that sex also has effect on fatty acid profile as well as physiochemical properties of meat. Meat from male beef animal has a specific boar taint in it, which is due to presence of high aldosterone.

Table 1. Comparison of fatty acid compositions of intramuscular fat from Qinchuan cattle of different genders (%)

Table # 1

Parameter	Females (n=6)	Castrated males (n=6)	Intact males (n=6)
Water (g/100g)	71.30±0.18B	71.92±0.62B	74.69±0.54A
Protein (g/100g)	22.39±0.26b	22.99±0.54a	23.88±0.51a
Ether extract (g/100g)	4.00±0.48A	4.15±0.60A	1.89±0.15B
Ash content (g/100g)	1.18±0.18b	1.83±0.23a	1.89±0.16a
Hydroxyproline (mg/g)	0.57±0.04bB	0.66±0.03bAB	0.77±0.03aA
Shear force values (kg)	3.73±0.33b	4.01±0.40b	5.27±0.34a
pH	4.54±0.15b	4.63±0.37b	5.52±0.12a
Lightness	30.98±1.03a	30.94±1.38a	27.48±0.97b
Chroma	21.51±0.74	22.03±0.45	23.17±0.47
Hue	15.91±0.44	15.71±0.52	15.19±0.30
Drip losses (%)	1.87±0.19b	1.79±0.24b	2.58±0.16a
Cooking losses (%)	28.64±0.98b	29.24±0.98b	32.21±0.66a

Means ± SE. Means with different superscript letters (a, b; A, B) within the same rows differ significantly ($P<0.05$;$P<0.01$).*Source: (Zhang et al., 2010)

Some researchers have shown that male has high abnormal flavor and overall lower intensity of beef flavor (Crouse et al., 1983), while Gorriaz et al. (2002) found that male beef animals have higher flavor than that of female beef animals while still having livery taint odour. Tenderness can be measured by Warner-Braltzer and compression tests and experiments have shown that heifer has high tenderness than that of beef bulls and this can be increased due to aging affect (Hanzelková et al.2010). In a comparison of beef heifer and steer there was no adverse effecton tenderness & shear force of meat at same slaughter weight, and they almost had same tenderness (Lucero-Borja et al. 2014).Gender has effect on Yak carcass size but not on its meat composition significantly. In an experiment Yak of different breeds and both sexes were kept under same

environmental conditions. Meat color and water withholding capacity did not show variation in different sexes but carcass sizes of male were much larger than that of female animals (Zhang et al. 2016). Regarding carcass traits, meat and fat quality there is a marked difference in entire male and female animals, with average high weight gain, body condition score and intramuscular fat reported to be higher in male as compared to female animals, whereas carcass fatness, dressing percentage and percentage of lion and flank region have been reported to be higher in female animals rather than male. Some characteristics of meat like instrumental color and alpha tocopherol contents are not affected by gender (Daza et al.2014). In pork meat same findings have been reported by (Alonso et al. 2008).

Age at slaughter

Age at which animal is slaughter is very important regarding its composition and physiochemical characters. At earlier stages of life, animal growth is at much higher rate than that of late age. If animal is slaughtered at earlier stage of life then its tenderness, taste, juiciness, color and other meat quality parameters will be different as compared to later stage of life as muscle fiber, subcutaneous fat and marbling levels are different at different stages. As weight increases with increase in age of animal. Shear force value and tenderness of meat at same slaughter weight remains almost same (Lucero-Borja et al. 2014). Tenderness for the animals fed on same energy diet slaughtered at different ages around yearling and 2 year was different, with more tenderness value for yearling animals than that of 2 year old animals.So there is a lot of variation in tenderness in different age groups (Shackelford et al. 2014). Age can be estimated by incisor number of animal which may distinguish the carcass composition and meat quality (Soji and Muchenje, 2016). Shear force value decreases as there is increase in slaughter age, specifically for ribeye, shoulder clod, cold streaks and top round, but not for top sirloin butt streak. There is very small degree of marbling development at life stages of five to seventeen months so almost remain equal at these stages (Burton et al. 1993).In a study (Du Plessisand Hoffman, 2007) results showed that there was marked difference in carcass composition and live weight at different slaughter age. Thickness of back fat, omental fat and kidney fat was affected greatly by slaughter age. Animal slaughtered at thirty month of age contained more fat, dark and red color, pH towards alkaline, tougher and less tender meat as compared to slaughter age of eighteen month. So collagen contents, pH and fatness are the main factors responsible for meat quality, which vary with the age of slaughter. (Mojto et al. 2009) slaughtered cows at different ages of four year and above, depicting results having positive effect of slaughter age on meat composition and quality. Animals slaughtered at age older than four year comprised good carcass quality and muscle length of meat, also it had less water withholding capacity with high intramuscular fat and high protein contents. Sensory characters and other physiotechnological parameters were not much affected, suggesting that darkness and shear force of beef meat is increased with the increase in slaughter age of animal. In Holstein cows there is pH change and increased concentrate consumption which leads to decrease in feed efficiency, as there is increase in slaughter age. All types of fat including subcutaneous, intramuscular and intermuscular, along with carcass fatness and dressing percentage are significantly affected by slaughter age (Marti et al. 2014)

Table 2. Meat quality of Holstein animals slaughtered at 10, 12, and 14 month of age fed on highconc. diet.

Table #2

Item	**Slaughter Age**		
	10	**12**	**14**
pH	5.5	5.7a	5.6
Intramusculat fat percentage	1.6	2.2	3.0
Protein percentage	24.5	24.4	24.5
Humidity%	74.1	73.5	72.7

**Source*: (Marti *et al.* 2014)

Younger animals have lighter carcass in *color* but it is richer in lean meat proportion as compared to older animals. Older animals are heavier in weight so more dressing percentage and fat along with rib eye area is resulted (Lopez-Campo *et al.* 2012). Beef flavor intensity, juiciness, tenderess and acceptability overall is much higher in older animals. These animals are generally much fatter than younger animals(Bures and Barton, 2012).Pork meat at the slaughter age of sixteen month resulted increased cold carcass weight, live weight and killing percentage whereas its fat contents and *color* was also greater and intense as compared to animals slaughtered at age of twelve month (Franco *et al.* 2016). A biochemical substance reduced glucothione present in beef meat is not affected significantly by age of slaughter (Rakowska*et al.* 2016).

Feed and Nutrition

Feed and nutrition both have equally great influence on animal growth, meat quality and carcass composition of beef animals.Flavor, palatability, tenderness, juiciness and chemical composition of meat are some parameters which are affected by difference in diet and type of feed. Cruder protein fed to beef animal at different levels did not show much effect on dressing percentage (Hales *et al.* 2016).If calcium level in diet is decreased than recommended level, it will not help in improvement of animal's production performance, biochemical composition and carcass quality (Vergara *et al.* 2016).In case of Vitamin A, its restricted dietary levelsless than 300 microgram per liter can lead to inhibition of anti adipogenic action by inhibiting of adipocyte differentiation. Increased level of dietary zinc has been reported to result increase in marbling trait (Tanaka *et al.* 2001).Use of essential oils in beef animal's diet has no impact on fat composition, *color*, texture and water withholding capacity but has been reported to decrease lipid oxidation of beef meat at 3.5 gram per day, whereas lipid oxidation increases if supplemented at 7 gram per day to animal (Rivaroli *et al.* 2016).Feeding intensity and time spent on feeding also plays role in carcass composition manipulation. Intensive feeding as compare to extensive feeding, improves feed efficiency and daily weightgain. Carcass composition and fatty acid profile also improved in intensive feeding whereas water withholding capacity decreased.

There are variable effects on collagen solubility and tenderness of meat but no significant influence flavor, shear force and juiciness of intensive fed animals (Sami *et al.* 2004).Time spent on feeding when increased it resulted in deposition of subcutaneous and intramuscular fat and decrease in water withholding capacity without improvement in grade quality of meat. Oliec acid accounts for desirable flavor which tends to be more with increase in time spent on feeding (Duckett *et al.*1993). Residual feed intake has been correlated positively with greater dry matter intake and feed conversion ratio. So more residual feed intake is, more growth of the animals is resulted. Color b* parameter in animals with high residual feed intake showed increased intensity as compared to lower residual feed intake animals. As there was no increase in shear force, tenderness and flavor with high residual feed intake, so it is not related with the beef meat quality (Baker *et al.* 2006).Animal fed on concentrate for finishing has been reported to be having increased carcass conformation, carcass weight, fatness and finishing quality. Fat contents are twice greater as compared to pasture fed animals. In pasture fed animals the muscle color is much darker and fat is yellowish, whereas Warner-Bratzler value of shear force is lower after ageing of meat. Conjugated linoleic acid and omega-3 fatty acid also found to be more in pasture finished animals(Realini *et al.* 2004). (Nuernberg *et al.* 2005) and (Yang *et al.* 2002) also reported increased level of these polyunsaturated fatty acids in grass based feeding system as compared to concentrate feeding system. Lipid stability in both systems does not vary and remains almost same but supplement of vitamin E reduced it in grass fed animals. Supplementation of vitamin E also effected meat color and meat appeared more red in color in concentrate feeding animals as compared to grass fed.

Miscellaneous

There are lot of other factors which can affect growth of beef animal and its carcass composition. Pre-slaughter handling, bleeding, aging, cooking, transportation, lairage time, rigor temperature, social dominance, and consumer preferences are some of the key factors including in this category.

1. Pre-slaughter handling

Handling of animal before slaughter is very critical point to be considered when we talk about meat quality. Mishandling of animalcauses stress in animal which deteriorates meat quality and effects meat composition. Catecholaminesare chemical compound which are released in animal in state of stress and are responsible for depletion of glycogen in muscle (O'Neill *et al.* 2006). Bonsmara and Nguni breeds of beef showed greater interaction between catecholamine and meat quality. Warner- Bratzler shear force value, *color*, cooking and pH have been reperted to be interacted with stress and catecholamine (Muchenje *et al.* 2008). Angus breed showed daviation from these results, having zero correlation. So there is a variation in response but there is always an effect of pre-slaughter handling on meat composition. Pre-slaughter mishandling can also cause non-pH mediated impacts on quality of meat (Ferguson and Warner,2008) by effecting its organoleptic quality and making it prone to faster spoilage. (Ferguson *et al.* 2014) also reported undesirable effect of pre-slaughter stress on animal welfare and as result meat quality deterioration.

2. Bleeding

Slaughtering beef animals can be done by various methods. These may includeAfrican traditional method, Islamic method (Halal), Jewish method (Kosher) and Sikh method (Jhakta). All of these methods require efficient bleeding to give better quality meat. As meat is a very good nutritious source for growth of microbes, so it efficient bleeding is not carried out it will cause bacterial growth in meat consequently affecting its quality and making it more prone to spoilage. In modern day technique of slaughter, stunning is done to avoid any inconvenience from the animal during slaughter. Stunning results in blood splashes development in meat while degrading its quality. Best method for achieving maximum blood loss and meat quality is Islamic method(Aghwan *et al.*2016)if it is implemented in recommended guidelines.

3. Aging

Aging of meat means storage of meat for some time after slaughter. Aging has been reported to increase the overall meat quality. (Colle et al. 2015) demonstrated the effect of aging on two diffent types of muscles in beef animals and results by consumer panel clearly indicated aged meat to be tenderer, whereas aging causes decreasecolor content of meat.

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Cover Letter

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