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Effects of age on slaughter performance and meat quality of Binlangjang male buffalo

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ABSTRACT

Twelve representative buffalo were selected from 22 suckling calves, 41 weaned calves, 57 reserve bulls and 20 adult bulls for slaughter. The study aims to assess the effect of age on dressing percentage, meat percentage and carcass meat yield and physico-chemical properties of longissimus dorsi and biceps femoris, and to evaluate the correlation between live weight and marbling, backfat thickness, rib eye area. The results showed that the slaughter performance and meat quality of Binlangjang male buffalo showed an obvious change with age. The dressing percentage decreased from 54.93% to 51.22% with the increase of age, while meat percentage and carcass meat yield increased gradually with age, which were 34.58–38.59%, 62.95–75.34%; Marbling, backfat thickness and rib eye area increased with age, and there was significant difference between the situation before 3 months and after 12 months of age ($P < 0.05$). The moisture content was maximum at birth, which then gradually decreased, but the difference was insignificant ($P > 0.05$). The levels of fat, protein, cholesterol and inosine acid were significantly different before 3 months of age from those after 12 months ($P < 0.05$). Cholesterol content was negatively correlated with age, the minimum was 80.25 mg/100 g; Inosine acid content increased with age, reaching 133.11 mg/100 g. Marbling, backfat thickness, rib eye area had a high correlation with live weight, with correlation coefficients respectively at 0.9096, 0.9291, 0.9551. Based on the prediction model of live weight, Buffaloes was suitable for slaughtering for superior slaughter performance and meat quality after 24 months of age.

1. Introduction

Traditionally, consumers and culturists regard as rough, poor taste, smell of mutton of buffalo meat and low slaughter performance. The slaughtered buffalos are basically obsolete cows or 10-year-old bulls without fattening, leading to consumers' cognitive error in buffalo meat quality and slaughter performance. Studies found that buffalo meat at the appropriate age of slaughter is more tender and fresh than beef, rich in high protein, high essential amino acids, with low intramuscular fat, low saturated fatty acids, low cholesterol and triglycerides, plus ω-6 and ω-3 closely related to human health (Neath et al., 2007; Iqbal et al., 2007; Uriyapongson, 2013; Arganosa, 1973; Ross, 1975; Joksimovic and Oqnjanovic, 1977; Baruah et al., 1990; Anjaneyulu et al., 1990, 1994; Bhat and Lakshmanan, 1998; Sharma, 1999; Kondaiah, 2002; Di et al., 2003; Manafiazar et al., 2007; Rosalina et al., 2007, 2008; Rao et al., 2009; Choi and Kim, 2009; Kandeepan et al., 2009; Nurainia et al., 2013; Qiu, 1985; Wu et al., 2010; Yang, 2011; Yin et al., 2013; Tao et al., 2014). Kandeepan et al. reported that average dressing percentage of buffalo was 55.40–59.00% (Kandeepan et al., 2009) in modern farming mode, with breeding cost lower than that of other buffalo. Age is an important factor affecting meat quality (Tang, 2010; Daya and Pant, 2017; Sharma et al., 2017). Borghese studied meat quality of Mediterranean Italian buffalo at 20, 28, and 36 weeks of age, and found that the meat organoleptic quality and physico-chemical scores

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were higher after those at 36 weeks of age; Kashif also examined physiochemical and organoleptic quality of longissimus dorsi of buffaloes aged 1.5 years, 1.5–2 years, and over 2 years which were randomly sampled from the local meat market in Pakistan, regarding that quality of buffalo over 2 years old was better (Borghese et al., 1978; Awan et al., 2014; Herrera-France et al., 2017). Therefore, buffalo can be developed into a high-quality meat resource (see Table 1).

As the only river buffalo in China, Binlangjang buffaloes are mainly distributed in the southwest of China. Cows are used for milk production, while the bulls can gradually develop for table purpose to solve the current issue of high price and short supply of beef. At present, the study on slaughter performance and meat quality of Binlangjang male buffalo of different ages is limited or incomplete. In this study, continuous slaughter method and laboratory analysis were adopted in systematic, in-depth research of meat performance and meat quality of Binlangjang male buffalo of different ages. The purpose is to evaluate the effects of age on dressing percentage, meat percentage and carcass meat yield and physico-chemical properties of longissimus dorsi and biceps femoris, and to evaluate the correlation between live weight and marbling, backfat thickness, rib eye area. Appropriate slaughtering age will be determined to provide the basis for giving play to meat value of Binlangjang male buffalo, which plays an important role in improving economic efficiency (see Table 2).

Binlangjang buffaloes are the only river buffaloes in China identified by the Chinese Commission on Animal Genetic Resources in 2008. Having been raised in Tengchong County in the upper reaches of Binlangjiang in western Yunnan for over 500 years, the cows are used for milk production (Miao et al., 2008), while the bulls are used for meat production after fattening (see Table 3).

The 12 buffalo in good body condition and representative of the group were randomly selected for continuous slaughter test from 63 male calves (22 suckling male calves and 41 weaned male calves), 57 reserve bulls and 20 adult bulls in the Bafule Binlangjang buffalo core field of Tengchong. The buffalo were 53.57 ± 19.22 kg (5, 36, 66 days), 109.7 ± 32.05 kg (144, 154, 179 days), 232.5 ± 29.65 kg (373, 547 days) and 390.17 ± 78.49 kg (735, 969, 1114 days) in weight and age, each group with 3 buffalo. The dressing percentage, meat percentage and carcass meat yield and the physical properties and chemical compositions of longissimus dorsi and biceps femoris were measured.

The test buffalo after weighing and 24 h of water and food fasting were placed in a clean plastic sheeting, with the head and hind legs fixed with a rope, to be rinsed with water before electric shock. Bovine jugular vein blood after quiet. Blood was collected and weighed. Then the skin was peeled off, with genitals, head, hoof, tail and internal organs removed and weighed. The digestive system was removed from the abdominal cavity and weighed, and further weighed after the contents were removed. At the same time, two samples of biceps femoris and longissimus dorsi (between 12 and 13th rib) on the left side of the carcass were taken. For one of them, backfat thickness and rib eye area of longissimus dorsi (between 12 and 13th rib), pH, marbling score, water holding capacity, flesh color and muscle fiber diameter were measured on the spot. The other was frozen at −20 °C and taken to the laboratory for the determination of the shear force and chemical composition.

The rib eye area was determined by graph paper. Marbling score evaluation was conducted based on the American NPPC standard reference map. Longissimus dorsi pH was measured by LEICHI BJ-260, pH meter at 45 min after the slaughter. Flesh color was measured by DY-300 portable colorimeter, while shear force was measured by NY/T1180-2006TAPlus texture analyzer, moisture was determined by drying under ambient pressure, the result was necessary to reach constant weight. Then, samples were ground using a blender and dry ice to obtain a homogenous powder (AOAC, 1990). Ether extract was obtained by diethyl ether extraction in Soxhlet extractor. Crud potein content was determined using the Kjeldahl apparatus, and protein was computed using a fixed conversion factor of 6.25 g of protein/g of N. Ash content was determined by incineration (550 ± 20 °C) in a muffle furnace. Inosinic acid and cholesterol were determined by HPLC with external standard method.

2. Statistical analysis and model selection

The test data were analyzed by EXCEL and SPSS19.0 software. The multiple regression analysis was used to estimate slaughtering traits of Binlangjang male buffalo, with related prediction models obtained.

3. Results and discussion

3.1. The change law in slaughter performance of Binlangjang buffalo at different ages

Dressing percentage, meat percentage and carcass meat yield are important indicators for judging the slaughter performance. Dressing percentage decreases with age, ranging from 48.73% to 54.93%, with that of adult bulls six percentage points lower than that of suckling calves, which is consistent with reports by Manafiazar et al. (2007), Rosalina et al. (2007, 2008) and Kandeepan et al. (2009). Dressing percentage is closely related to variety, age, feeding levels and feeding management. Kandeepan et al. reported a 55.50% dressing percentage for the Mediterranean buffalo, 53.00% for the Australian buffalo and 43.00–57.00% for the obsolete old buffalo. The average dressing percentage in the modern farming mode is 55.40–59.00% (Kandeepan et al., 2009; Arshadullah et al., 2017). At the same age, dressing percentage of Binlangjang buffalo is 3.77% lower than that of buffalo, which is like that of gayals (Qiu et al., 1995; Fan, 2005). The low dressing percentage of buffalo is closely related to its big proportion of non-edible parts (Manafiazar et al., 2007; Rosalina et al., 2007, 2008).

The net meat and meat yield rate of carcass increased with age, respectively in the range of 34.58–38.59%, 62.95–75.34%. Meat yield rate of carcass varies with the dressing percentage which changes with carcass composition in consistence with reports by Joksimovic et al., Bhat et al., and Sharma. For buffaloes with dressing percentage at 43–44%, meat yield rate is 65–70%; while at 51.4%, the net meat rate is 66.8% (Joksimovic and Oqnjanovic, 1977; Bhat and Lakshmanan, 1998; Sharma, 1999; Ong et al., 2017). The meat-bone ratio increased with age, falling in the range of 1.93–2.94.

3.2. The change law in meat features of Binlangjang buffalo at different ages

3.2.1. Comparison of muscle physiological characteristics of Binlangjang male buffaloes at different ages

Marbling, backfat thickness, rib eye area, flesh color and muscle fiber are greatly influenced by age, with significant differences demonstrated (P .05). Marbling, backfat thickness and rib eye area increased with age, but marbling tended to be stable after 12 months of age. The backfat did not deposit before 5 months of age, but subcutaneous fat gradually deposited from 6 months of age. Marbling was lower than that of Rosalina et al., which might be because Binlangjang buffalo is lighter for the same age of buffalo (Rosalina et al., 2007) The rib eye area was consistent with that

Table 1
Change rule of slaughter performance on BLJ male buffalo at different ages.

Months	0–3 (n = 3)	4–6 (n = 3)	12–18 (n = 3)	24–36 (n = 3)
BW, kg	51.94 ± 15.98a	104.8 ± 31.27a	223.17 ± 31.64b	382.83 ± 79.42c
CW, kg	28.53 ± 11.37a	55.20 ± 17.23a	108.75 ± 11.57b	196.09 ± 33.09c
Meat, kg	17.96 ± 8.41a	36.39 ± 9.21a	79.02 ± 9.11a	147.73 ± 13.92a
Meat bone ratio	1.93 ± 0.75	2.23 ± 0.28	2.72 ± 0.11	2.94 ± 0.13
Dressing percentage, %	54.93 ± 2.77	52.67 ± 3.74	48.73 ± 1.76	51.22 ± 1.03
Meat percentage,%	34.58 ± 7.94	34.72 ± 0.44	35.41 ± 1.18	38.59 ± 1.00
Carcass meat yield, %	62.95 ± 11.72	65.92 ± 2.66	72.66 ± 0.38	75.34 ± 0.88

Means with different superscripts within the same row significantly differ ($P < 0.05$).

Table 2
Comparison of physical properties of carcass in BLJ buffalo at different ages.

Months			0–3 (n = 3)	4–6 (n = 3)	12–18 (n = 3)	24–36 (n = 3)
Marbling score	12th–13th ribs		1.17 ± 0.62	2.00 ± 0.00	3.50 ± 0.41	4.00 ± 0.41
Backfat thickness, cm	12th–13th ribs		0.00 ± 0.00	0.55 ± 0.25	3.08 ± 0.63	4.40 ± 1.05
Ribeye area, cm^2	12th–13th ribs		21.92 ± 5.61a	29.89 ± 4.03ab	34.96 ± 4.98bc	62.61 ± 18.47bc
pH	LT		6.31 ± 0.02	6.34 ± 0.01	6.42 ± 0.04	6.44 ± 0.05
	BF		6.34 ± 0.02	6.35 ± 0.03	6.43 ± 0.02	6.44 ± 0.04
Water holding capacity, %	LT		41.06 ± 0.15	40.55 ± 0.18	39.94 ± 0.17	39.47 ± 0.38
	BF		41.00 ± 0.17	40.47 ± 0.19	39.81 ± 0.17	39.42 ± 0.41
Meat clocor	LT	L^*	44.68 ± 3.87	37.79 ± 6.8	35.22 ± 2.53	29.22 ± 1.98
		a^*	18.36 ± 1.21	20.78 ± 0.21	21.22 ± 0.45	23.89 ± 1.48
		b^*	1.85 ± 0.46	1.37 ± 0.71	0.54 ± 0.08	2.14 ± 1.01
	BF	L^*	45.47 ± 2.78	38.76 ± 5.03	36.97 ± 1.51	30.81 ± 1.55
		a^*	17.05 ± 1.36	19.65 ± 1.18	22.29 ± 1.39	22.14 ± 1.15
		b^*	2.10 ± 0.58	1.34 ± 0.74	0.63 ± 0.12	2.35 ± 0.93
Shear force	LT		2.03 ± 0.12	2.20 ± 0.25	3.11 ± 0.29	4.43 ± 0.69
	BF		2.16 ± 0.17	2.62 ± 0.51	3.34 ± 0.27	4.76 ± 0.83
Fiber diameter, um	LT		11.06 ± 6.19a	18.25 ± 3.94ab	27.24 ± 1.08bc	30.83 ± 1.35bc
	BF		17.56 ± 0.92a	23.58 ± 5.64ab	28.69 ± 0.45bc	35.45 ± 4.58bc

Means with different superscripts within the same row significantly differ ($P < 0.05$).

Table 3
The model of carcass traits.

Index	Model (x, months)	R^2	Moel (x, body weight)	R^2
Marbling score	$y = 1.147x^{0.3536}$	0.903	$y = 1.3143\ln(x) - 3.792$	0.9096
Backfat thickness	$y = -0.0009x^2 + 0.1604x + 0.1111$	0.8879	$y = -1E - 05x^2 + 0.0196x - 0.9179$	0.9291
Ribeye area	$y = -0.005x^2 + 1.1653x + 20.363$	0.9544	$y = 0.0002x^2 + 0.0257x + 20.903$	0.9551

High correlation between marbling, backfat thickness, rib eye area and live weight ($R^2 = 0.9096, 0.9291, 0.9551$).

reported by Rosalina et al. (2007 and 2008). Marbling, backfat thickness and rib eye area have a high correlation with live weight, with the correlation coefficients respectively 0.9096, 0.9291, 0.9551.

Muscle pH value is greatly affected by pre-slaughter live weight. Muscle pH, which directly reflects the strength of glycogenolysis, is closely related to other meat quality indicators as one of the important indicators to determine muscle quality (Komariah, 1999). There were no significant differences.

In the pH values between biceps femoris and longissimus dorsi ($P > 0.05$), with pH value in the range of 6.31–6.44, which is in the range in studies by Manafiazar et al. (2007), Rosalina et al. (2007 and 2008), Kumagai et al. (2012), and Awan et al. (2014). This may be due to a similar metabolic rate after slaughter between animal breeds. Liu et al. suggested that pH values above 5.45 indicate high quality beef (Liu and Ge, 1997).

The results showed that the water loss rate of biceps femoris and longissimus dorsi gradually decreased with age ($P > 0.05$), demonstrating insignificant differences. The results are inconsistent with the study results of Rosalina et al., and Kashif, which is closely related to fat content, pH and time elapsed after slaughter (Rosalina et al., 2007; Awan et al., 2014).

With the increase of age, the color of longissimus dorsi and biceps femoris deepened, and glossiness decreased. The glossiness of biceps femoris and longissimus dorsi over 24 months of age was significantly different from that of 3 month old ($P < 0.05$). The flesh color of dorsal longissimus was superior to that of biceps femoris, which is consistent with research results of Rosalina et al. (2008) and Awan et al. (2014).

Shear force value and muscle fiber diameter are the most important indexes to reflect the tenderness of muscle, and the two are highly correlated. Rao et al. (2009) and Nurainia et al. (2013) suggested that buffalo muscle fiber diameters are affected by age but not by gender. The results showed that muscle fiber diameter increased with age, and the difference was significant ($P < 0.05$), but dorsal longissimus was more tender than biceps femoris. The muscle fiber diameters of 18–24-month-old Binlangjang buffalo were less than those of Beaver swamp buffalo and Azerbaijan hybrid buffalo of the same age (Rosalina et al., 2007, 2008; Kumagai et al., 2012). This is because muscle fiber diameter is influenced by age, nutritional status, developmental status, and muscle performance levels (Choi and Kim, 2009). As age increased, shear force value of longissimus dorsi and biceps femoris decreased first and then increased.

Table 4
Comparison of chemicai composition of carcass in different ages BLJ buffalo.

Months		0–3 (n = 3)	4–6 (n = 3)	12–18 (n = 3)	24–36 (n = 3)
Water, %	LT	78.8 ± 0.61	77.9 ± 0.59	75.7 ± 0.69	75.2 ± 0.08
	BF	79.0 ± 0.29	78.2 ± 0.12	75.5 ± 0.37	75.1 ± 0.43
Protein, %	LT	18.7 ± 0.50a	19.2 ± 0.71ab	22.4 ± 0.29b	22.5 ± 0.61b
	BF	18.8 ± 0.33a	19.2 ± 0.45ab	22.4 ± 0.21b	22.2 ± 0.82b
Fat, %	LT	0.9 ± 0, 05a	0.9 ± 0.00ab	1.1 ± 0.05b	1.3 ± 0.08b
	BF	0.9 ± 0.00	0.9 ± 0.05	1.1 ± 0.09	1.1 ± 0.05
Ash, %	LT	1.14 ± 0.07	1.10 ± 0.06	1.07 ± 0.06	1.09 ± 0.11
	BF	1.09 ± 0.02	1.08 ± 0.05	1.09 ± 0.03	1.04 ± 0.05
IMP, mg/100 g	LT	83.79 ± 4.53a	94.12 ± 3.01ab	105.77 ± 2.01bcd	123 ± 7.80cd
	BF	76.62 ± 3.32a	88.12 ± 1.86ab	103.51 ± 3.43bcd	119.4 ± 7.11cd
TC, mg/100 g	LT	233.26 ± 16.33a	190.99 ± 27.21ab	123.51 ± 9.60bcd	89.54 ± 10.62cd
	BF	223.23 ± 14.32a	181.07 ± 23.18ab	123.72 ± 6.06bcd	88.58 ± 10.19cd

Means with different superscripts within the same row significantly differ ($P < 0.05$).

3.2.2. Muscle nutritional characteristics of Binlangjang buffalo at different ages

The results of moisture, protein, fat and ash content are shown in Table 4. Muscle moisture decreased gradually with age, which was between 78.8% and 75.1%, but the difference was insignificant ($P > 0.05$). This is consistent with study results of Rosalina et al. (2007 and 2008), Kumagai et al. (2012) and Awan et al. (2014). The fat content was negatively correlated with moisture in the meat. The crude fat content did not chanonths of age, increasing with the increase of backfat thickness. There was significant difference between the 3 – month – old fat and 12 –month-old fat of longissimus dorsi ($P < 0.05$), which is consistent with study result of Joksimovic and Oqnjanovic (1977), but less than that in the results of Rosalina et al. (2007 and 2008), Banglen (2011), Kumagai et al. (2012), and Awan et al. (2014). This may be due to differences in age, variety, sex, daily ration and feeding management (Kumagai et al., 2012; Awan et al., 2014; Gao et al., 2017). The crude protein content showed a trend of increase with the age. There was little change after 12 months of age, which is consistent with report by Di Lucciaa (2003). There was a significant difference in the fat content between before 3-month and after 12-month of Longissimus dorsi ($P < 0.05$), and the similar results were obtained for protein content in the longissimus dorsi muscle and the biceps femoris ($P < 0.05$), which is consistent with the reports by Joksimovic and Oqnjanovic (1977), Rosalina et al. (2007 and 2008), Banglen (2011), Kumagai et al. (2012), however the results are higher than that in the result of Awan et al. (2014), which may be due to difference in daily ration and feeding management. The content of crude ash did not change significantly with age, wherein the difference was insignificant ($P > 0.05$). The change law of moisture, protein, fat, ash content is in line with the law reported by Tumal et al. (1962), Tang (2010).

Cholesterol content decreased with age, cholesterol content in 3-month-old longissimus dorsi was significantly different from that in 12 months of age ($P < 0.05$), and the minimum was 80.25 mg/100 g, which is consistent with study results of Komariah (1999) and Rosalina et al. (2007). The content of inosinic acid increased with age. The content of inosinic acid in 3-month-old longissimus dorsi was significantly different from that in 12 months of age ($P < 0.05$), and the highest was 133.11 mg/100 g.

4. Conclusion

The slaughtering performance and meat quality of Binlangjang male buffalo significantly changed with age. Marbling, backfat thickness and rib eye area are highly correlated with live weight, with correlation coefficients being 0.9096, 0.9291, and 0.9551, respectively. Based on the prediction model of live weight, the effects of different developmental levels and feeding management on slaughter performance and muscle physical properties can be reduced to a certain extent. Buffaloes was suitable for slaughtering for superior slaughter performance and meat quality after 24 months of age.

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Author contributions

Qing Li and Youwen Wang finished the experiment and wrote the manuscript. Wen Li and Huaming Mao conceived and designed the experiment. Liqin Tan and Jing Leng contributed significantly to analysis and manuscript preparation. Qiongfen Lu and Shuai Tian performed the data analyses. Siyuan Shao and Chengming Duan helped perform the analysis with constructive discussions. The authors were grateful to the staff of the dairy farms for their cooperation and assistance throughout this project.

Conflict of interest

There was no conflict of interests regarding the publication of this article.

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