

## EFFECT OF PHYSIOLOGICAL STATE ON MEAT QUALITY: AN INSIGHT FROM BUFFALO

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### ABSTRACT

The present study aimed to observe the effect of buffalo's physiological stage (heifers, postpartum, dry) on the physicochemical and organoleptic characteristics of meat. The collected meat samples were analyzed for physicochemical parameters (pH, water holding capacity, cooking loss, and drip loss), and a pre-trained panel also evaluated the organoleptic attributes of fresh and cooked buffalo meat. The physicochemical properties showed that heifer meat was of better-quality regarding pH, water holding capacity, cooking loss, and drip loss than dry or postpartum buffalo meat. The heifer meat displayed better ( $P < 0.05$ ) fresh meat odor, color, taste, and juiciness compared with the postpartum buffalo meat. The palatability of meat and mouth-filling properties was comparatively higher ( $P < 0.05$ ) in heifer meat. Cooked meat heifer meat showed lower ( $P < 0.05$ ) hardness and cohesiveness of mass, along springiness, and ease of swallowingness. High ( $P < 0.05$ ) saliva production and less ( $P < 0.05$ ) residual particle and tooth packing properties were observed ( $P < 0.05$ ) in heifer meat. Heifer meat was highly ( $P < 0.05$ ) acceptable due to better palatability and mouth coating basis. The overall meat-liking quality ratio was also greater ( $P < 0.05$ ) for heifer meat than postpartum buffalo meat. It is concluded that heifer meat was better in terms of physiological and organoleptic properties than dry and postpartum buffalo meat.

## 1. INTRODUCTION

In Pakistan, buffalo male calves and dry buffaloes are usually used for meat production and preparation of different value-added products. Buffalo meat is preferred over beef and mutton for value-added products because of its high taste palatability (Jaspal *et al.*, 2021; Di Stasio & Brugiapaglia, 2021). The procedure for slaughtering animals is also a main factor for meat acceptability and marketing in Pakistan and Muslim-populated regions (Farouk *et al.*, 2014). The chemical composition, physicochemical, nutritious, and organoleptic characteristics of buffalo meat resemble beef (Kandeepan *et al.*, 2009).

Previously, meat quality has been evaluated based on physicochemical or sensory attributes for meat obtained from buffalo of different ages, sex or finished at different feeding systems (Aksoy *et al.*, 2021; Cifuni *et al.*, 2014; Joele *et al.*, 2016; Kandeepan *et al.*, 2009; Nurainia *et al.*, 2013; Rao *et al.*, 2009b). The animal production stage is also a key feature that influences the meat quality and consumer perception (Węglarz, 2010); however, no previous information is available regarding the stage of buffalo on meat quality. Therefore, the current study was designed to determine the effect of the physiological stage (heifer, postpartum, dry) on the physicochemical and organoleptic characteristics of Nili Ravi buffalo meat slaughtered through the Halal method.

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## 2. MATERIALS AND METHODS

### Buffalo meat sampling

The buffalo meat samples were collected from government and private slaughterhouses in the periphery of Rawalpindi and Islamabad, Pakistan. Seventy-five meat samples (*longissimus dorsi*) were collected from slaughtered buffaloes through the Halal method. Twenty-five samples were collected for each category (heifers, postpartum and dry), and each group was confirmed during the antemortem inspection. The meat samples were transported to the lab for physicochemical and organoleptic quality evaluation.

### Assessment of physicochemical properties

#### pH

For the assessment of pH, a 10-gram meat sample was added to the 90 ml of distilled water and homogenized properly, and homogenized samples were immediately observed for meat pH evaluation by using a digital pH meter (Digital Pen pH Meter, CT-6022, Shenzhen Master Industrial Co., Ltd., China).

#### Water-holding Capacity (WHC)

About 8 grams of meat sample was mixed in 12 ml of 0.6 M NaCl solution and kept at 5°C in the water bath for 15 min. Later, the samples were centrifuged at 10,000 rpm for 15 min at 4°C using a refrigerated centrifuge machine (Laboratory Centrifuge machines, GL-26LM, Hunan Xingke Scientific Instruments, China). The supernatant was decanted and measured for WHC. WHC was expressed as ml of 0.6 M NaCl per 100 g of meat.

#### Cooking loss

To determine the cooking loss in the meat sample, a 20-gram meat sample was placed in a polyethylene bag and heated in a water bath at 72°C internal temperature. Afterward, the cooked-out was drained, and the cooked mass was cooled to room temperature. Finally, the cooking loss was measured by weighing using a digital weighing balance (lab analytical balance, USS-DBS8, Joyfay International LLC, China).

#### Drip loss

A sample of 50 grams of raw meat samples was sealed in polyethylene covers and placed at 4°C for 24 hours. After 24 hours of refrigeration, the samples were wiped, dried with filter paper, and weighed. The weight of the sample was used to calculate the drip loss using the following formula:

$$\text{Drip loss} = \frac{\text{Actual Weight} - \text{Weight after refrigeration}}{\text{Actual Weight}} \times 100$$

### Organoleptic meat quality via sensory evaluation

The buffalo meat samples collected from different categories were submitted for sensory evaluation. A pre-trained panel of five judges was called for an evaluation of the olfactory and visual attributes (color, odor, texture) of fresh meat. The meat samples were boiled in water to evaluate other organoleptic attributes (hardiness, cohesiveness of mass, springiness, swallowingness, saliva production, residual particle, tooth pack, mouth coating, and palatability). The boiled meat was cut into smaller (2×2cm) pieces, and the judges assessed via smelling, chewing, pressing, tasting, and eating the meat as per the given protocol to them mentioned in the method of sensory evaluation of meat. At the end of the session, the judges scored it on the given proforma against each characteristic of meat.

### Statistical analysis

The data was analyzed after tabulating on SPSS software sheets (SPSS version 17.0.1 Chicago, IL, USA). The pH, water holding capacity, and cooking losses were analyzed using one-way ANOVA, whereas the Tukey test was used to assess the significance of the parameters. The drip loss and organoleptic characteristics were analyzed by using the *chi*-square test. A significance level of  $P < 0.05$  was used.

## 3. RESULTS AND DISCUSSION

### Physicochemical properties of fresh meat

The data presented in Table 1 indicated that the pH of fresh heifer meat was significantly lowered ( $P < 0.05$ ) than meat obtained from postpartum and dry buffaloes. Dry buffalo meat has greater ( $P < 0.05$ ) water-holding capacity compared to postpartum or heifer meat. In addition, the cooking loss and drip loss values were higher ( $P < 0.05$ ) in dry buffalo meat than in buffalo heifer meat.

### Sensory evaluation of fresh meat

The sensory evaluation of fresh meat quality from heifer, postpartum and dry buffaloes is presented in Table 2. The odor of fresh heifer meat was significantly better ( $P < 0.05$ ) than the postpartum buffalo meat and graded as good quality. However, the odor grades for dry buffalo meat, were similar ( $P < 0.05$ ) among the groups and deemed acceptable for consumption. Fresh meat color and texture were received significantly higher grades ( $P < 0.05$ ) for heifer meat, whereas the color and texture for dry and postpartum buffalo meat did not differ ( $P < 0.05$ ) and were rated as acceptable.

### **Organoleptic properties of cooked meat**

Table 3 displays the organoleptic assessment of cooked meat obtained from the heifer, postpartum and dry buffaloes. Cooked meat of heifer had low ( $P < 0.05$ ) hardness compared to dry and postpartum buffalo meat. The results of cohesiveness of mass indicated maximum resistance ( $P < 0.05$ ) in postpartum buffalo meat than dry heifer meat. Less springiness and ease of swallowingness were ( $P < 0.05$ ) observed in heifer meat compared to postpartum buffaloes. Cooked meat of the heifer was much better ( $P < 0.05$ ) in saliva production than dry or postpartum buffalo meat. Likewise, heifer meat significantly reduced residual particle and tooth-packing properties ( $P < 0.05$ ). Mouth coating property was highest ( $P < 0.05$ ) in heifer meat but decreased ( $P < 0.05$ ) in meat obtained from dry and postpartum buffalo.

Palatability of meat was highly acceptable ( $P < 0.05$ ) for heifer meat compared to dry and postpartum buffalo meat. The overall meat-liking quality ratio was significantly higher ( $P < 0.05$ ) for heifer meat compared to postpartum buffalo meat. However, the overall meat-liking quality of dry buffalo meat did not differ from that of heifer and postpartum buffalo meat. The pH is the basic and most vital factor for assessing the quality of the meat. It is greatly associated with other meat properties such as water-holding capacity and emulsifying ability. In the present study, a higher pH was observed in meat obtained from dry and postpartum buffaloes, which indicates that meat of dry and postpartum buffalo meat has higher glycogen depletion, which is an increment of pH. The current results showed higher pH values than the normal values (Kandeepan & Biswas, 2007), and this difference might be related to the sampling timings and the time duration from collection to analysis. Additionally, this lower pH in heifer meat could be associated with the stress factors during transportation from the village side to the slaughterhouse area. The lower pH in postpartum buffalo meat is usually related to lactation stress and higher water-holding capacity. In addition, feeding regimen, sex, and age are major contributory factors affecting meat pH (Kandeepan *et al.*, 2009). Additional studies are required to check the pH of raw, stored, or cooked meat quality obtained from different physiological status animals through different means (lactic acid concentrations, glycogen contents, protease activity, etc.).

WHC is the most important factor for processing meat into different meat products. Like other properties, WHC also depends upon the emulsion stability and juiciness of the meat or meat products. A 16.95ml/10mg water holding capacity was recorded in meat obtained from dry female buffaloes, indicating a

higher WHC than heifers. There is a contrasting report about buffalo age and WHC relationship (Ilavarasan *et al.*, 2015; Kandeepan *et al.*, 2009). High protein feeding to young stock could also increase the WHC in meat, and castration also increases the WHC in male stock due to higher protein denaturation. This report indicates that lactation could be another factor for higher WHC than dry animals. The fiber diameter between the two age groups of buffaloes was different, and higher fiber diameter in adult buffaloes is indicative of WHC (Ilavarasan *et al.*, 2015); therefore, a study is necessary to assess the fiber diameter and its correlation with WHC of buffalo meat obtained from different physiological states buffaloes.

In the present study, less DL and CL were observed in the case of heifer meat than in dry or postpartum buffalo meat. DL and CL of meat directly relate to the water-holding capacity of subjected meat. Lambertz *et al.* (2014) reported that the water-holding capacity of buffalo meat is higher when animals are fed concentrate ration resulting in lower drip loss. When meat is subjected to heating, the juiciness of meat decreases due to higher coagulation of proteins and thermal shrinkage. Generally, the cooking losses are influenced by the meat type, trim time, temperature, pH, sarcomere length, and cooking method (Vaskoska *et al.*, 2021). Moreover, it has been stated that CL or DL is associated with the degree of damage to muscle fibers (Bai *et al.*, 2023) and the distribution of water in different histological compartments (Pinheiro *et al.*, 2020). The association of the degree of muscle fiber damage and water distribution in muscle fiber during different physiological conditions of subjected buffalo meat could reveal a better understating of the process of the meat or meat products.

The sensory attributes of meat and meat products fluctuate with the chemical or physical contents of meat. The tenderness of buffalo meat increased significantly with postmortem aging (Saleem *et al.*, 2021). The organoleptic properties of fresh and cooked heifer meat were comparatively better and acceptable than the dry and lactating buffalo meat. It is noted that any deviation in fat contents or meat constitution greatly affects the sensory properties of meat products and further consumer acceptability for meat products (Ismail *et al.*, 2021). These sensory attributes are useful to discriminate the quality and consumer satisfaction to evaluate the meat and meat products of different species or breeds. The red color of buffalo meat content increase and lies between a color range from low redness to fair redness, providing an excellent indication to estimate the sensory attributes in buffalo meat and meat-derived products. The juiciness attribute depends upon the protein

contents and ash, and fat contents that also affect the juiciness of buffalo meat. The palatability property of buffalo meat is advantageous over beef, and it is even superior if it is obtained from the same age groups (Rajagopal *et al.*, 2015). Most buffalo meat's organoleptic characteristics like tenderness, juiciness, and hardness are comparable to beef; however, the low cholesterol contents of buffalo meat has a great advantage over beef that makes it a referable meat type for consumers (Guerrero-Legarreta *et al.*, 2020). The earlier studies reported that the flavor and odor of the meat are affected by the animal's age of the animal due to the higher intensity of connective tissue accumulation (Insausti *et al.*, 2021), which is a great factor in terms of meat quality and palatability.

#### 4. CONCLUSION

In conclusion, the quality of meat in buffaloes greatly depends on its physiological state. Moreover, the general acceptability of buffalo meat by consumers, based on sensory attributes, is strongly associated with the physiological state. The report helps point out areas of improvement for consumer satisfaction and suggest enhancement in the methodologies for processing buffalo meat products, which greatly affect the supply chain of the meat industry.

#### 5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

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**Table 1.** The assessment of pH, water holding capacity (WHC), cooking loss (CL) and drip loss (DL) of fresh meat from heifer, postpartum and dry buffalo

Physiological stage	pH	WHC (%)	CL (%)	DL (%)
Heifer	6.16±0.02 <sup>b</sup>	8.55±0.23 <sup>c</sup>	22.33±0.24 <sup>c</sup>	3.27±0.05 <sup>c</sup>
Postpartum	6.55±0.03 <sup>a</sup>	13.61±0.20 <sup>b</sup>	24.35±0.18 <sup>b</sup>	3.79±0.05 <sup>b</sup>
Dry	6.63±0.02 <sup>a</sup>	16.95±0.56 <sup>a</sup>	27.49±0.30 <sup>a</sup>	5.38±0.09 <sup>a</sup>

Different superscript along the column denote the significance ( $P < 0.05$ ) between the variables  
Data were presented in Mean± standard error

**Table 2.** Sensory evaluation of fresh meat quality of heifer, postpartum and dry buffalo slaughtered through halal method

Characteristics	Physiological stage		
	Heifer	Dry	Postpartum
Odour/Smell	3.3±0.14 <sup>a</sup>	3.0±0.14 <sup>ab</sup>	2.6±0.11 <sup>b</sup>
Colour	3.4±0.12 <sup>a</sup>	2.6±0.13 <sup>b</sup>	2.4±0.10 <sup>b</sup>
Texture	4.4±0.12 <sup>a</sup>	2.6±0.12 <sup>b</sup>	2.3±0.09 <sup>b</sup>

Different superscript along the row denote the significance ( $P < 0.05$ ) between the variables  
Data were presented in Mean± standard error

**Table 3.** Organoleptic assessment of cooked meat in Nili Ravi heifer, postpartum and dry buffalo

Characteristics	Physiological stage		
	Heifer	Dry	Postpartum
Hardiness	1.8±0.2 <sup>c</sup>	8.6±0.1 <sup>a</sup>	4.7±0.2 <sup>b</sup>
Cohesiveness of mass	1.9±0.1 <sup>c</sup>	7.7±0.2 <sup>a</sup>	5.2±0.3 <sup>b</sup>
Springiness	2.1±0.2 <sup>c</sup>	8.8±0.1 <sup>a</sup>	5.5±0.1 <sup>b</sup>
Swallowingness	2.1±0.1 <sup>c</sup>	7.8±0.3 <sup>a</sup>	5.7±0.2 <sup>b</sup>
Saliva production	8.3±0.3 <sup>a</sup>	5.6±0.2 <sup>b</sup>	5.2±0.2 <sup>b</sup>
Residual particle	1.9±0.2 <sup>c</sup>	7.6±0.2 <sup>b</sup>	5.5±0.2 <sup>a</sup>
Tooth pack	2.4±0.3 <sup>c</sup>	7.8±0.2 <sup>a</sup>	5.7±0.2 <sup>b</sup>
Mouth coating	8.8±0.1 <sup>a</sup>	2.7±0.2 <sup>b</sup>	6.2±0.2 <sup>b</sup>
Palatability	7.4±0.3 <sup>a</sup>	2.7±0.3 <sup>c</sup>	5.7±0.2 <sup>b</sup>
Overall acceptability	6.5±0.3 <sup>a</sup>	3.3±0.3 <sup>c</sup>	5.1±0.2 <sup>b</sup>

Different superscript along the row denote the significance ( $P < 0.05$ ) between the variables  
Data were presented in Mean± standard error