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www.journals.rifst.ac.ir
Journal of Research and Innovation
in Food Science and Technology
6 (2017), 1, p. 1-4

Research Institute of Food Science and Technology

An Investigation Into the Effect of Verjuice Concentration on the Physicochemical and Textural Properties of Beef

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Receive Date: 2015.10.25 **Accept Date: 2017.01.08**

Abstract

This study was performed in order to examine the effect of verjuice concentration on the physicochemical and textural properties of beef *Biceps femoris*, which aimed at improving its tenderness and enhancing its marketability. To that end, verjuice (0, 30, 70 and 100%) and sodium chloride (2% w/w) were injected into the beef pieces with dimensions of 3×15×15 cm^3 (10% of each piece initial weight). Then, for the uniform distribution of the solution on the surface and deep parts of the beef, the samples were immersed in verjuice solution (with the same concentration as was injected and at a ratio of 4:1) and stored at 4 °C for 12 h. The results showed that as verjuice concentration increased, pH decreased significantly (P<0.05). Furthermore, storage in verjuice solution caused a significant increase (P<0.05) in the weight gain, cooking loss and water holding capacity (WHC) of the samples. The color parameters of $L*$ and $b*$ of the treated samples were significantly (P<0.05) higher than those of the control, whereas their $a*$ were lower. The samples stored in verjuice 100% for 12 h had the highest Myofibrillar Fragmentation Index (MFI) and sarcomere length, while they had the lowest Warner-Bratzler Shear Force (WBSF). Therefore, it was concluded that verjuice solution can act as a replacement for the chemical tenderizers applied in the meat industry without any negative effect on other quality attributes.

Keywords: Beef *Biceps Femoris,* Tenderization, Textural Properties, Verjuice

Introductıon

Meat tenderness is regarded as one of the most important quality features from the consumer point of view (Huff-Lonergan *et al*., 2010). It is influenced by various parameters such as sarcomere length and myofibril, also structure integrity of connective tissue (Zhao *et al*., 2012). Hindquarter muscle (mainly *Biceps femoris* muscle) has the highest WBSF and lowest tenderness than any other muscle of beef (Morgan *et al*., 1991; Rhee *et al*., 2004). Acid marination was introduced as a widely used technique to improve the technological and functional characteristics of meat such as tenderness, WHC, flavor (Yusop *et al*., 2010). Also, this progress increases shelf life of the product by reducing bacterial growth especially pathogen ones (Pathania *et al*., 2010). Lowest repulsion force between protein molecules occurs at their isoelectric pH (about 5.3) as a result of the equal amounts of positive and negative charges. This charge balance is disturbed by reducing the pH below the isoelectric point (increasing the positive charge), causing repulsion forces, which leads to swelling of myofibrillar proteins and weakening the meat integrity (Hinikle, 2010). As a result, acid marination weakens the connective tissue and collagen integrity of meat (Berge *et al*., 2001).

Verjuice is an unfermented juice of green grapes, which has a low pH value and Tartaric acid as predominant acid (Pour Nikfardjam, 2008).
So, the aim of the present study was to investigate the effect of different verjuice concentrations on the physicochemical and textural characteristics of beef *Biceps femoris*.

Methods
The beef *Biceps femoris* were cut in to 15×15×3 cm^3 pieces. Then the solution containing 0, 30, 70, and 100% of verjuice and 2% of NaCl (w/w) was injected in to them (total injection was 10% of the initial weight of meat), and they were stored at 4 °C for 12 h (verjuice to meat ratio was 4:1 v/w). Finally, the following analyses were conducted on the prepared samples.

Marinade uptake
Percent of marinade uptake of samples was calculated using the following equation.

$$\text{Marinade uptake (\%)} = \frac{W1 - W2}{W1} \times 100$$

Where W_1 and W_2, represent the weight (g) of sample before and after injection of the verjuice, respectively.

Physicochemical tests
The pH, color parameters ($L^*a^*b^*$), moisture content, WHC, and cooking loss were measured using probe pH meter (Testo 230, Germany), Minolta Sensing Reflectance colorimeter model CR-410 (Konica, Japan), an oven (105 °C), Whatman No.1 filter paper together with a 2 kg weight (Sultana *et al*., 2008), and water bath at 80 °C (Honikel *et al*., 1998), respectively.

Texture analysis
Warner–Bratzler shear force (WBSF) of the samples was measured using a Texture Analyzer (Stable Microsystems, TA.XT, UK) (Byrne *et al*., 2000). For this purpose, the following process was performed on samples which were cooked in cooking loss test. Cooked samples were stored at refrigerator for 24 h, then texture analysis was done.

Myofibrillar fragmentation index (MFI)
MFI of the samples was determined using the MFI buffer, followed by reading the absorbance at 540 nm (Culler *et al*., 1978).

Sarcomere length
Sarcomere length was determined using an optical microscope with magnification of ×100 (Botha *et al*., 2007).

Statistical analysis
Research was conducted in a completely randomized design (CRD) with two replications. The data were analyzed using SPSS 16 software.

Results and discussions
Marinade uptake
Marinade uptake was improved by increasing the concentration of verjuice solution (P<0.05). Reducing the pH below the isoelectric point of meat proteins resulted in weight gain of samples during immersion in solution (Ke *et al*., 2009).

Physico-chemical characteristics of the treated meats
Increasing the verjuice concentration caused a decrease in pH values of samples (P<0.05). By increasing the verjuice concentration, L^* and b^* values increased, while a^* value showed a decreasing trend. The reason of increase in L^* and b^* parameters might be due to the denaturation of sarcoplasmic and myofibrillar proteins of the muscle in acidic media caused by verjuice. This

condition changes the amount of dispersed water between the muscle fibers, therefore affects the ability of meat to reflect the light (Arganosa & Marriott, 1989). Decrease in a^* value, was probably due to an oxidation of myoglobin into met-myoglobin (Mancini & Hunt, 2005), and denaturation of hemochrome and hemichrome pigments at acidic conditions. Increasing the concentration of verjuice improved the moisture content and WHC, respectively.
All samples treated with verjuice had higher cooking loss, although this difference was not significant compared to the control one (P>0.05). This result may be attributed to the solubilization of collagen and activation of lysosomal enzymes at acidic conditions.

Texture
Texture is the main factor which determines the acceptability of edible meats by consumers. Beef *Biceps femoris* in the present study had high WBSF, about 80 N, so could be categorized in a tough meat group based on the report of Suryati *et al*., (2008). Increasing the verjuice concentration decreased the WBSF of the samples. This might be attributed to the high WHC and increased solubility of connective tissue at pH values below the isoelectric point of the muscle proteins.

Myofibrillar fragmentation index (MFI)
MFI is an indicator to predict meat tenderness (Taylor *et al*., 1995). An increase in the verjuice concentration caused 55% increase in MFI. This might be as a result of cathepsin D activity in acidic pH (3-5), which caused a fragmentation of myofibrillar proteins (myosin heavy chain, Tytin, proteins M and C, Tropomyosin, and troponin T and I).

Sarcomere length
Higher concentrations of verjuice caused an increase in sarcomere length from 2.25 to 2.54 µm. This may occur due to the effect of positive charges of myofibrillar proteins at acidic pH on repulsion of Z lines of myofibrils from each other.

Conclusion
The results of this study introduce and confirm the verjuice as an effective acidic compound for improving the tenderness of beef *Biceps femoris* without negative effect on the other quality parameters. Higher MFI and WHC values and lower WBSF were the positive results of beef *Biceps femoris* marination in verjuice solution, which is economical and attracts consumer's attention. Therefore, regarding the abundant and affordability of verjuice in Iran, it might be suggested as an appropriate and cheaper alternative for the chemically tenderizing agents to improve the quality of the old and firm meats.

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