The effect of meat marinating with lactic and citric acid on some physicochemical and electrophoretic pattern of beef burger

Hosseini, S.E.[1*], Esfahani Mehr, A.[2]

[1]*Department of Food Sciences & Technology, Sciences & Research Branch, Islamic Azad University, Tehran, Iran*

[2]*Department of Food Sciences & Technology, Shahre ghods Branch, Islamic Azad University, Tehran, Iran*

Key words:
acid marination, beef burger, electrophoretic pattern, meat, tenderness

Correspondence
Hosseini, S.E.
Department of Food Sciences & Technology, Sciences & Research Branch, Islamic Azad University, Tehran, Iran
Tel: +98(21) 44865474
Fax: +98(21) 44865464
Email: ebhoseini@srbiau.ac.ir

Received: 19 November 2014
Accepted: 26 January 2015

Abstract:

BACKGROUND: Meat products may be unacceptably tough because of the high connective tissue content of meats used in their manufacture. **OBJECTIVE:** The aim of this study was using meat acid marination method on some physicochemical and sensory characteristics of beef burgers. **METHODS:** Meat was marinated in three concentrations (0.5%, 1% and 1.5%) of lactic and citric acid solutions (1:4 w/v) at 4 °C for 15h and was used in formulation of beef burgers. **RESULTS:** According to control sample, the highest redness (a*) value was found in the lowest concentration of lactic acid while the lowest a* value was in the highest concentration of citric acid. Shear force value indicated that lactic acid had a tenderizing effect particularly at the lowest concentration and had a positive effect on overall acceptability. Electrophoresis of proteins showed that band intensity had decreased in 0.5% acid treatments, compared to the control sample. **CONCLUSIONS:** It seems that meat acid marination is an applicable technique to tenderize beef burgers with high percentage of meat.

Introduction

Maintaining the sensory and textural properties of meat products is a matter of challenge, which necessitates more effort to protect the product integrity, taste, flavor, and textural sensory attributes (Gehan & Emara, 2010). The meat industry should strive for more consistently tender products since tenderness is an important attribute for consumers. One method is acid marination, which can be used on whole cuts of meat (Desmond & Troy, 2001). The method has many other positive effects on palatability and shelf life of meat products. In this method, an acidic solution is incorporated into meat to alter the pH (Onenc et al., 2004; Serdaroglu et al., 2007). Most common ingredients of acidic marinades are organic acid solutions (acetic acid, lactic acid, citric acid, etc.), vinegar, wine, or fruit juice (Aktas and Kaya, 2001; Burke & Monahan, 2003; Ergezer & Gokce, 2011). Tenderizing by acidic marination leads to the weakening of structures, proteolysis by cathepsins, and increasing conversion of collagen to gelatin at low pH during cooking (Berge et al., 2001; Komoltri & Pakdeechanuan, 2012).

High concentration of lactic acid has a significant effect on tenderness and color although it develops a sour flavor in products (Desmond & Troy, 2001). Aktas et al. (2003) reported that meat marination with lactic and citric acid decreases shear force values. Burke and Monahan's (2003) study has shown that acid marination increased meat tenderness.

The present study was conducted to determine the effects of varying concentrations of lactic and citric acids on the physicochemical, textural, and sensory properties of beef burger.

Materials and Methods

Preparation of meat: We used hindquarter meat for marination; cut it into 2kg pieces and laid in commercial lactic and citric acid solutions (0.5%,1% and 1.5%) at a ratio of 1:4 (meat: liquid) for 15h at 4°C. The meats then were removed from the marinade, dried lightly, and minced through a 10 mm plate.

Preparation of beef burgers: Beef burgers were formulated with hindquarter meat marinated (40%), hindquarter meat (20%), flank (30%), onion (8%), and salt and spices (2%). After mincing meats and onion through a 10 mm plate, they were mixed in a paddle-type mixer with salt and spices for 5min and reminced through a 3 mm plate. The mixture was then formed into discs of 100g and kept frozen at -18 °C.

pH and weight changes: The pH of the meat was measured directly using a probe type electrode before and after marination (Yusop et al., 2010).

The meats weight was recorded before and after marinating. Excess marinade was carefully drained off by applying paper towel to the meat surfaces (Yusop et al., 2010). Calculation for marinade uptake was as follows:

% marinade uptake = marinated weight - raw weight/raw weight × 100

The Moisture of beef burger samples was determined as described by Aktas et al. (2003).

The beef burgers were cooked in 170°C fryer for 5 min and cooled for 10 min until reaching room temperature (Hosseini et al., 2011). The sample weights were recorded before and after cooking (Besbes et al., 2010). Calculation for cook loss was as follows:

% cook loss = raw burger weight – cooked burger weight/raw burger weight × 100

Color: The objective measurement of color lightness (L*), redness (a*), and yellowness (b*) was performed at the surface of raw beef burgers using a Hunter Lab system (color flex, USA). Before each measurement, the apparatus was standardized against a black and white tile. The corresponding color units were recorded (Ergezer & Gokce, 2011).

Shear force: After cooking beef burger tenderness was evaluated. All samples were sheared on an Instron Universal Testing Machine Model M350-10CT using a Warner-Bratzler shear force (WBSF) attachment, 500kg load cell at 240 mm/min crosshead speed (Komoltri & Pakdeechanuan, 2012).

Sensory evaluation: Cooked beef burgers were served to evaluate sensory attributes of tenderness, juiciness, flavor and aroma, color, and general acceptability. The panel consisted of eight members. The training consisted of presenting the treatments in three preliminary sessions to the panelists to familiarize them with the properties. Evaluation was performed based on 5 point hedonic scale, where 1 represented extremely dislike and 5 represented extremely like (Serdaroglu et al., 2007; Besbes et al., 2010).

Electrophoresis: Beef burger proteins were extracted from raw samples and submitted to sodium dodecyl sulphate- polyacrylamide gel electrophoresis (SDS-PAGE) according to Montowska and Pospiech (2007).

Statistical analysis: This experiment was conducted as a completely randomized block design using three replicates. Results were expressed as means ± standard deviation. Analysis of variance of all data was conducted using the SPSS software version 19. Means that were significantly different were separated using Duncan's multiple range.

Results

Marinade uptake and pH values of treated

Table 1. Marinade uptake and pH values of treated meat, moisture content, and cooking loss values of beef burger samples. (a-d) Means in the same column with different letters are different (p<0.05).

Acid	Concentration (%)	Cooking Loss (%)	Moisture (%)	Marinade Uptake (%)	pH
Lactic	0	28.43± 0.174 a	64.10± 0.141 a	1.12 ± 0.191 a	5.69 ± 0.189 d
	0.5	28.60± 0.141ab	67.20± 0.221 c	6.82 ± 0.103 c	5.56 ± 0.177 c
	1	29.54± 0.165 bc	67.90 ± 0.154 d	6.95 ± 0.256 c	5.37 ± 0.039 b
	1.5	29.82± 0. 127 c	66.75± 0.219 b	6.02 ± 0.188 b	4.97 ± 0.091 a
Citric	0	28.43± 0.174 c	64.10± 0.141 a	1.12 ± 0.191 a	5.69± 0.189 d
	0.5	28.38± 0.240 bc	66.10± 0.185 c	5.20± 0.128 c	5.46± 0.056 c
	1	29.66± 0.091 d	65.60± 0.255 b	4.08± 0.161 b	5.09 ± 0.127 b
	1.5	28.04± 0.197 a	67.05± 0.170 d	6.10 ± 0.211 d	4.89± 0.114 a

Table 2. Color values of beef burger samples. (a-d) Means in the same column with different letters are different (p<0.05).

Acid	Concentration (%)	L*	b*	a*
Lactic	0	51.18± 0.506 b	19.39± 0.410 a	8.84± 0.117 a
	0.5	49.18± 1.563 ab	18.22± 0.499 a	9.92± 0.531 bc
	1	49.51± 1.397 ab	19.28± 0.283 a	9.81± 0.704 b
	1.5	46.97± 1.495 a	18.13± 1.032 a	9.60± 0.504 ab
Citric	0	51.18± 0.506 c	19.39± 0.410 a	8.84± 0.117 ab
	0.5	49.48± 0.943 abc	18.59 ± 0.880 a	9.58± 0.320 bcd
	1	49.32± 1.511 abc	18.96± 0.241 a	9.11± 0.360 abc
	1.5	50.48± 0.241 bc	18.15± 0.854 a	8.56± 0.482 a

Table 3. Warner Bratzler shear force of beef burger samples. (a-d) Means in the same column with different letters are different (p<0.05).

Acid	Concentration (%)	Shear Force (N)
Lactic	0	35.51± 1.166 c
	0.5	26.71± 1.619 a
	1	32.57± 2.616 bc
	1.5	33.55± 0.226 bc
Citric	0	35.51± 1.166 b
	0.5	32.54± 2.248 ab
	1	40.97± 2.262 d
	1.5	39.84± 0.275 cd

meat and moisture content and cooking loss values of the beef burgers are shown in Table 1. Significant differences were found for pH, marinade uptake, and moisture content. The lowest cooking loss was observed in samples marinated with the highest concentration of citric acid.

Hunter color values (Table 2) of the raw beef burgers indicated that lactic acid had a significant effect on color values compared to the citric acid treatments and control. These beef burgers had higher a* values than control or other treatments. The Results revealed that acid marinating significantly decreased L* values of the beef burgers. According to Table 2, marinating with acid did not change b* values of beef burgers, compared to the control sample.

Acid marinated meats had significant effects on shear force values of beef burgers (Table 3). Lactic acid treatments had lower shear force values than the other samples, which have shown that marinating of meat with 0.5% lactic acid solution results in the most tender beef burger.

Sensory analysis of the beef burgers (Table 4) showed that acid marination increased tenderness of beef burgers compared to the control sample; however, beef burgers produced from the lactic acid treatments were more tender than beef burgers produced from citric acid treatments. The results showed that 0.5% lactic acid treatment was the juiciest sample. Beef

Table 4. Sensory evaluation of beef burger samples. [(a-d)] Means in the same column with different letters are different ($p<0.05$).

Acid	Concentration (%)	General Acceptability	Color	Taste and aroma	Juiciness	Tenderness
Lactic	0	3.00± 0.535 [a]	3.38± 1.061 [a]	3.13± 1.246 [a]	2.13± 0.641 [ab]	2.25± 0.886 [a]
	0.5	4.13± 0.641 [d]	4.25± 0.886 [b]	4.25± 0.886 [b]	4.13± 1.356 [d]	3.88±0.991 [d]
	1	3.38± 0.518 [abc]	3.38± 0.916 [a]	3.13± 1.246 [a]	1.50± 1.069 [a]	2.88± 0.641 [abc]
	1.5	3.13± 0.354 [ab]	3.63± 0.518 [ab]	3.00± 1.069 [a]	2.25± 0.463 [abc]	2.50± 0.535 [ab]
Citric	0	3.00±0.535 [abc]	3.38± 1.061 [ab]	3.13± 1.246 [a]	2.13± 0.641 [ab]	2.25± 0.886 [abc]
	0.5	3.50± 0.756 [bcd]	3.50± 0.756 [abc]	3.50± 1.069 [ab]	3.63± 0. 518 [d]	3.00± 0.756 [d]
	1	2.88± 0.641 [ab]	2.75 ± 0.463 [a]	2.75± 0.707 [a]	2.13± 0.835 [ab]	1.75± 0.463 [a]
	1.5	2.88± 0.354 [ab]	3.25± 0.463 [ab]	2.63± 0.744 [a]	2.63± 0.518 [bc]	2.00± 0.535 [ab]

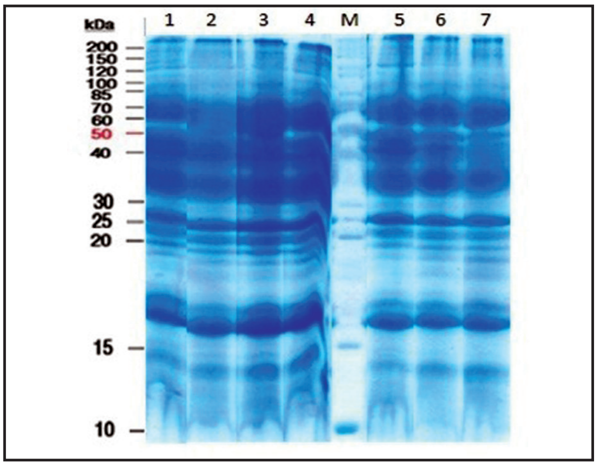

Figure 1. Electrophoresis pattern of the hamburger samples. M: marker, 1) control sample; 2, 3, 4) 0.5%, 1%, and 1.5% lactic acid treatments; 5, 6, 7) 0.5%, 1%, and 1.5% citric acid treatments.

burger treatments had similar color, taste, and aroma scores to the control except 0.5% lactic acid treatment which had the most general acceptability.

SDS-PAGE analysis of beef burger proteins on untreated meat and those marinated with lactic and citric acid is shown in Fig 1. The effects of lactic acid were generally similar to citric acid. Some components of meat proteins marinated with 0.5% lactic and citric acid solutions were clearly detected. Lactic and citric acid highly affected myofibrillar proteins at the density below 30KDa band. Actin degradation by acid was small as the density of this band was only slightly less than that of the control sample. The 31KDa band, which is assumed to be produced by troponin T degradation, was virtually unaffected by the acid treatment. The band migrating at the position of tropomyosin, troponin I, myosin, and tropomyosin C showed significantly lower density after the acid treatments was only 0.5% treatments.

Discussion

Previous works have already shown that acid type and concentration had significant effects on pH values and weight changes (Aktas et al., 2003). Compared to lactic acid, samples marinated with citric acid had lower pH values. Desmond and Troy (2001) and Ergezer and Gokce (2011) made similar observations during investigations with various organic acids. One reason for the difference in behavior can be the various pH values of the individual acids. This may result in stronger acidification of the solutions and subsequently of the muscles themselves, assuming a higher concentration of hydrogen ions as an important factor.

The water binding of proteins had better be below or above the isoelectric point (Ergezer & Gokce, 2011). In general, the closer the pH of meat is to the isoelectric point of its proteins, the more decreasing net charge and hence the number of water molecules bonding with them is (Serdaroglu et al., 2007). Aktas et al. (2003) observed a correlation between low degree of hydration of the myofibrillar proteins at their isoelectric point and a higher moisture loss during cooking.

The color results could be attributed to the closer pH of meat to the isoelectric point of proteins which decreases the water holding capacity (Serdaroglu et al., 2007). Therefore, L* values of the beef burger samples decreased. Aktas and Kaya (2001) reported that the lower pH values of acid treated samples, below the isoelectric point of proteins, may have resulted in denaturation of sarcoplasmic and myofibrillar proteins which may alter their water binding ability. The amount of water dispersed among the fibers could affect the reflectance ability of the meat.

Several researchers have reported improved sensory tenderness in association with a decrease in shear force values in meats due to marination with food acids (Ergezer & Gokce, 2011). Previously, it was reported that the acidic marinades were responsible for improving the tenderness of beef. The effects of organic acids on meat texture depend on pH drop after treatment that resulting in solubilization of the collagenous tissue and increased tenderness (Gault, 1985; Onenc et al., 2004). Results indicated that shear force values of beef burgers increased at the isoelectric point of meat proteins.

The results of the present study indicate that acidic marinating solutions affected the chemical and physical properties of beef burger. Low meat pH induced by lactic acid marination resulted in decreased shear force values and improved sensory properties of the beef burgers than control sample. The Hunter color a* value was the highest in lactic acid treatments. Marinating with lactic acid in comparison with citric acid leads to better results.

Acknowledgments

A very special thank is offered to Dr.khodabandeh for valuable assistance during the project.

References

1. Aktas, N., Kaya, M. (2001) The influence of marinating with weak organic acids and salts on the intramuscular connective tissue and sensory properties of beef. Eur Food Res Technol. 213: 88–94.
2. Aktas, N., Aksu, M.I., Kaya, M. (2003) The effect of organic acid marination on tenderness, cooking loss and bound water content of beef. J Muscle Foods. 14: 181-194.
3. Berge, Ph., Ertbjerg, P., Larsen, L.M., Astruc, Th., Vignon, X., Moller, A.J. (2001) Tenderization of beef by lactic acid injected at different times post mortem. Meat Sci. 57: 347-357.
4. Besbes, S., Ghorbel, R., Salah, R.B., Masmoudi, M., Jedidi, F., Attia, H., Blecker, C. (2010) Date fiber concentrate: chemical compositions, functional properties and effect on quality characteristics of beef burgers. J Food Drug Anal. 18: 8-14.
5. Burke, R.M., Monahan, F.J. (2003) The tenderisation of shin beef using a citrus juice marinade. Meat Sci. 63: 161–168.
6. Desmond, E.M., Troy, D.J. (2001) Effect of lactic and citric acid on Low-value Beef used for emulsion-type. Meat Products. Lebensm.-Wiss. u. – Technol. 34: 374–379.
7. Ergezer, H., Gokce, R. (2011) Comparison of marinating with two different types of marinade on some quality and sensory characteristics of turkey breast meat. J Anim Vet Adv. 10: 60-67.
8. Gault, N.F.S. (1985) The relationship between water-holding capacity and cooked meat tenderness in some beef muscles as influenced by acidic conditions below the ultimate pH. Meat Sci. 15: 15-30.
9. Gehan Kassem, M.A., Emara, M.M.T. (2010) Quality and acceptability of value-added beef burger. World J Dairy Food Sci. 5: 14-20.
10. Hosseini, F., Milani, E., Bolurian, Sh. (2011) Effect of microcrystalline cellulose as a fat replacer on physicochemical, textural and sensory properties of low fat hamburger. J Food Ind. 3: 371-378.
11. Komoltri, P., Pakdeechanuan, P. (2012) Effects of marinating ingredients on physicochemical, microstructural and sensory properties of go-

lek chicken. Int Food Res J. 19: 1449-1455.

12. Montowska, M., Pospiech, E. (2007) Species identification of meat by electrophoretic methods. Acta Sci Pol Technol Aliment. 6: 5-16.
13. Onenc, A., Serdaroglu, M., Abdraimov, K. (2004) Effect of various additives to marinating baths on some properties of cattle meat. Eur Food Res Technol. 218: 114-117.
14. Serdaroglu, M., Abdraimov, K., Onenc, A. (2007) The effect of marinating with citric acid solutions and grapefruit juice on cooking and eating quality of turkey breast. J Muscle Foods. 18: 162-172.
15. Yusop, S.M., Osullivan, M.G., Kerry, J.F., Kerry, J.P. (2010) Effect of marinating time and low PH on marinade performance and sensory acceptability of poultry meat. Meat Sci. 85: 657-663.

مجله طب دامی ایران، ۱۳۹۴، دوره ۹، شماره ۲، ۱۰۸-۱۰۳

تأثیر ماریناد کردن گوشت با اسید سیتریک و اسید لاکتیک بر برخی ویژگی‌های فیزیکوشیمیایی و الگوی الکتروفورتیک همبرگر

سید ابراهیم حسینی[1*] عاطفه اصفهانی مهر[2]

۱) گروه علوم و صنایع غذایی، دانشکده کشاورزی و منابع طبیعی دانشگاه آزاد اسلامی واحد علوم و تحقیقات تهران، تهران، ایران
۲) گروه علوم و صنایع غذایی، دانشکده کشاورزی دانشگاه آزاد اسلامی واحد شهر قدس، تهران، ایران

(دریافت مقاله: ۲۸ آبان ماه ۱۳۹۳، پذیرش نهایی: ۶ بهمن ماه ۱۳۹۳)

چکیده

زمینه مطالعه: محصولات گوشتی تولیدی ممکن است که سفتی غیر قابل قبولی داشته باشند چراکه در تولید آنها از گوشت‌هایی با محتوای بافت پیوندی بالا استفاده می‌شود. **هدف:** هدف از این مطالعه استفاده از روش ماریناد کردن اسیدی گوشت بر برخی ویژگی‌های فیزیکوشیمیایی و حسی همبرگر می‌باشد. **روش کار:** گوشت در سه غلظت ۰/۵٪، ۱٪ و ۱/۵٪ از محلول‌های اسید سیتریک و اسید لاکتیک به نسبت ۱:۴ (گوشت: محلول) دردمای $4\ ^{o}C$ به مدت ۱۵ ساعت ماریناد شد و در فرمولاسیون همبرگر مورد استفاده قرار گرفت. **نتایج:** در مقایسه با نمونه شاهد، بیشترین مقدار قرمزی (a^*) در کمترین غلظت اسید لاکتیک مشاهده شد در حالیکه کمترین مقدار a^* در بیشترین غلظت اسید سیتریک بود. مقدار نیروی برشی نشان می‌دهد که اسید لاکتیک دارای اثر تردکنندگی به ویژه در کمترین غلظت بوده و یک اثر مثبت بر پذیرش کلی نمونه‌ها داشت. الکتروفورز پروتئین‌ها نشان داد که در مقایسه با نمونه شاهد، شدت باندها در تیمارهای ۰/۵٪ اسیدی کاهش یافت. **نتیجه‌گیری نهایی:** به نظر می‌رسد که ماریناد کردن اسیدی گوشت یک تکنیک کاربردی جهت ترد کردن همبرگرهای با درصد گوشت بالا می‌باشد.

واژه‌های کلیدی: ماریناد اسیدی، همبرگر، الگوی الکتروفورتیک، گوشت، تردی

*) نویسنده مسؤول: تلفن: ۴۴۸۶۵۴۷۴ (۲۱)۹۸+ نمابر: ۴۴۸۶۵۴۶۴ (۲۱)۹۸+ Email: ebhoseini@srbiau.ac.ir