Manas Journal of Engineering
ISSN 1694-7398 | e-ISSN 1694-7398

Volume 7 (Issue 1) (2019) Pages 34-41

Some quality qualifications of cooked meat sous vide in the storage process

Tarih Eren Babür [1, *], Kemal Kaan Tekinşen [2], Ümit Gürbüz [2,3]

[1,*]Muğla Sıtkı Koçman University, Fethiye ASMK Vocational High School, Muğla, Turkey, ernbabur@gmail.com, ORCID: 0000-0003-3164-0783

[2] Selçuk University, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology, Konya,Turkey, kktekinsen@selcuk.edu.tr, ORCID: 0000-0003-3287-3925

[3] Kyrgyz Turkish Manas University, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology, Bishkek, Kyrgyzstan, ugurbuz@selcuk.edu.tr, ORCID: 0000-0002-0980-0181

ABSTRACT

This study was carried out to determine the physicochemical and microbiological quality characteristics of some meat samples (*Longissimus dorsi*, LD; *Longissimus lumborum*, LL; *Longissimus thoracis*, LT) that were cooked in sous vide method at different time combinations (2 and 4 hours) at 70°C during the storage process. Meats used as materials in the study were obtained from 22-24 months old Simental cattle. All experimental meat samples were cut in 2x15 cm size and salted. Salted meat samples were vacuum-packed and cooked by sous vide method. Cooked meat samples were stored at 2 ± 2°C for 7 days. Physicochemical and microbiological analyzes were performed on the 0., 3., 7th days of storage.

It was observed that the pH values of the samples remained within acceptable limits during storage and the pH values increased as the cooking time increased. it was observed that cooking loss rates increased in parallel with increasing cooking time, and this increase was more clear in LL samples In addition, it was determined that as the cooking time of LT and LD samples gets longer the cooking loss increased and it affected the values of a * (redness) and L * (brightness). it was observed that no living microorganism produced in any samples taken into analysis during storage.

As a result; not finding microorganisms in the samples with sous vide technique for 7 days in the storage period, it is believed to strengthen the reliability of safe food production. It is concluded that sous vide method can provide advantages especially in terms of long shelf life and close to consumer preference.

ARTICLE INFO

Research article
Received: 30.05.2019
Accepted: 14.06.2019

Keywords:
Meat quality,
Cooking methods,
Microbiological quality

**Corresponding author*

1. Introduction

Consumers now prefer products that are most similar to the fresh product in terms of their appearance and quality and that are treated very little. Therefore, in the last ten years, it has gained importance in the research and implementation of alternative technologies in food processing and preservation both in food industry and academic field [1]. The sous vide technique, also called vacuum cooking technique of alternative cooking methods, first appeared in France in the 1960s and started to be used in countries such as America, Canada, Belgium and Singapore. Sous vide technique is recognized by the vacuum packaging process that prevents the development of microorganisms and high organoleptic properties, especially in meat products, and is preferred as an alternative method [2, 3, 4]. Today, only in France, there are 87 enterprises producing by sous vide method, and they produce about 10,000 tons of sous vide products per year. Due to its ease, the sous vide cooking method is widely preferred in catering sector providing services in transportation vehicles such as trains, airplanes, etc. as well as in food and beverage businesses such as hotels, restaurants [3].

The sous vide technique differs from the traditional cooking methods in two respects. The first is by vacuuming the raw product in a heat-resistant, plastic food bag; the second one is the application of the cooking process at fully controlled temperatures. Due to the sous vide technology, which is a kind of pasteurization process, the foods are cooked in vacuum

packaging. The temperature is distributed homogeneously throughout the cooking process and thus the heterogeneous temperature and color distribution in the traditional cooking method is not observed in the sous vide method. Therefore, in conventional cooking methods, processes such as turning or mixing applied to ensure homogeneous cooking of food are not required in this method [5].

Peiretti et al. [6] reported a decrease in the rate of carnosine formed by the incorporation of the alanine and histidine amino acids in the meat after heat treatment, a decrease in carnosine loss (50%), especially in the boiled meat due to its water soluble property. Because of the fact that the meat does not come into contact with water in the sous vide technique, the components with water-soluble properties remain in the food and the nutrient loss is minimal. In sous vide technique, food is put into heat-resistant plastic bags and vacuumed. The vacuumed bag is cooked according to the appropriate temperature-time parameter by placing the temperature in the cooking pot fully controllable and in the water circulation. At the end of cooking, the product removing from the water and is served directly by frying on a grill or pan [5, 7]. The process steps applied in the sous vide cooking method are shown in Fig. 1.

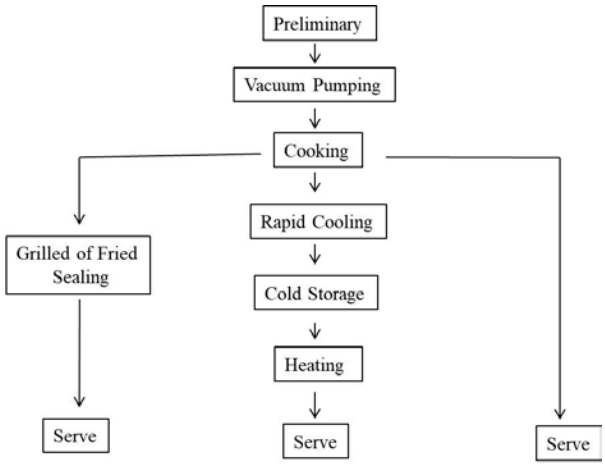
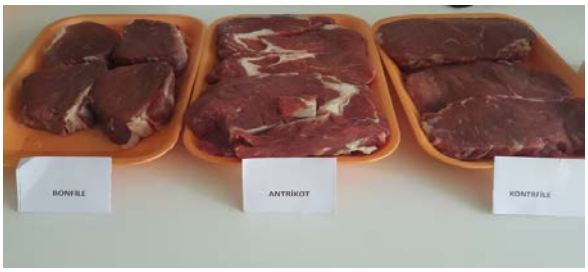


Figure 1. *Processes used in sous vide cooking method [7]*

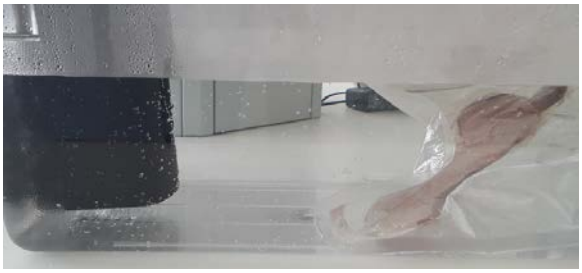
2. Materials and methods

In the preparation of the experimental specimens added salted %0,2, 2 x 15 cm sliced tenderloin (Longissimus dorsi, LD), loin (Longissimus lumborum, LL) and entrecote (Longissimus thoracis, LT) preparations were used. The meats used as material in the study were obtained from 22-24 months old Simental cattle. Meat samples were vacuum packed using vacuum bags (Electrolux Sous Vide Vacuum Bags, Polyscience, USA) with certificate of conformity to food production. Then they were baked in the sous vide unit (Sous Vide Professional Crative Series, PolyScience, USA) for 2 and 4 hours at 70°C. They were stored at 2 ± 2° C for 7 days following rapid cooling with the help of ice tanks. The samples were examined in terms of physicochemical and microbiological characteristics on the 0, 3 and 7th days of storage. Analyzes of the meat samples prepared 3 times were performed in parallel. The preparation and cooking steps of the samples are shown in Figure 2, respectively.



(I)

(II)



(III)

(IV)

Figure 2. *Preparation steps of experimental meat samples (I: grouping, II: salting and vacuuming) and sous vide process (III: cooking, IV: rapid cooling)*

2.1. Physicochmical Analysis

Four different analyzes including pH, cooking loss, reflectance color analysis and Warner Bratzler shear force analysis were performed within the scope of physicochemical analyzes. The pH values of the prepared meat samples were determined at 25 ± 1°C by electronic pH meter (Inolap-Series Wtw 7310) [8]. Cooking loss was weighed with precision scales at the end of the cooking process and were calculated with the help of the following formula [9].

$$Cooking\ loss\ (\%) = \frac{Weight\ Before\ Cooking\ -\ Weight\ After\ Cooking}{Weight\ Before\ Cooking} \text{x } 100$$

Reflectance color analysis was performed with the help of a Minolta chrome meter (CR-400 model, Konica Minolta). For this purpose, the color measurements on the surface of each sample using a colorimeter with diffusion range of 8 mm in D Diffuse / O mode with D65 illumination, 2° observer, are expressed as brightness (L *), redness (a *) and yellowness (b *) [10].

Samples for shear force analysis were removed from their packs on the specified days of storage and brought to room temperature. Samples with a diameter of 1.27 cm and a diameter of 2 cm were taken from the samples reaching room temperature with a special probe.The shear force values of the samples were determined with the help of the Warner Bratzler Share (WBS) V Slot Blade probe of the double sleeve texture device of TA.HDPlus (TA, Stable Mycrosystems Godalming, Surrey, UK) in Selcuk University Food Engineering laboratory [11].

2.2. General count of live microorganisms

he analysis was performed according to the Food and Drug Administration Bacteriological Analytical Manual (FDA BAM) [12]. 1 ml each of the dilution tubes was taken and plate count agar (Merck 1.12535) was applied to the medium by casting plate. Following incubation at 37 °C for 48 hours, colonies between 30 and 300 were counted and evaluated by taking the dilution coefficient into account.

2.3. Statistical Analysis

SPSS 21.00 package program was used for statistical evaluation of the data obtained from the study. Variance analysis was applied to statistical data; differences between significant variance sources were also determined by applying the Tukey test [13].

3. Results and discussion

Because of its quality characteristics and vacuum pack, sous vide cooking is more recognizable due to the advantages in terms of making the product more durable against storage conditions.
Especially in the last years, for food and tourism sectors, food prepared with sous vide technique - an alternative cooking method- is storaged for a long time without breaking the cold chain food.. In order to detect changes in meat that may occur meat during the cold chain and which may affect consumer preference, pH, cooking loss, color, (Warner Bratzler Share Force WBSF) and microbial properties are important in the one week storage period.

In the study, the pH values were found to be acceptable level (5.74 - 6.01) on the 0, 3 and 7 days of storage. The pH values of the experimental samples increased during the storage period and the pH values of the LD were similar on the 0 and 3 days of storage and on the 7th day it was found to significantly increased ($p < 0.05$) (Table 1). Similar studies [14, 15] have reported that an increase in pH values during storage is observed, while the increase in pH observed during rest may be related to alkaline metabolic products resulting from protease activity [16].

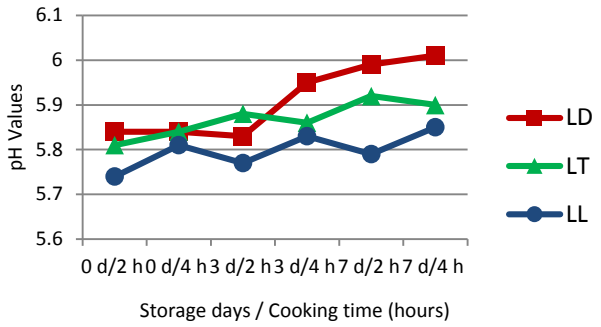


Figure 3. *pH values of samples during storage*

Table 1. *pH, cooking loss, color and WBSF analysis findings of the samples prepared by sous vide method during storage.*

Quality	Samples	Heat / Time (hour)	Storage Days			*P*
			0.	3.	7.	
pH	LD	70˚C/2	5.83±0.00^{b}	5.83±0.04 ^{b}	5.99±0.00^{a}	0.027*
		70˚C/4	5.84±0.03^{b}	5.94±0.02 ^{b}	6.00±0.02^{a}	0.049*
	LT	70˚C/2	5.81±0.05	5.87±0.07	5.91±0.03	0.494
		70˚C/4	5.84±0.10	5.86±0.01	5.90±0.03	0.827
	LL	70˚C/2	5.74±0.02	5.77±0.05	5.79±0.00	0.592
		70˚C/4	5.81±0.10	5.83±0.20	5.85±0.25	0.381
Cooking loss (%)	LD	70˚C/2	29.24±0.32	31.65±4.12	34.68±2.44	0.474
		70˚C/4	31.11±0.20	32.16±1.90	32.99±3.79	0.869
	LT	70˚C/2	24.32±0.66	28.70±2.10	23.22±0.86	0.148
		70˚C/4	30.70±0.07	31.70±2.12	26.43±2.68	0.279
	LL	70 ˚C/2	31.40±0.97	34.72±1.79	29.58±3.47	0.401
		70 ˚C/4	39.98±2.13	37.99±10.93	29.95±0.41	0.570
L*	LD	70 ˚C/2	33.45±1.19	37.02±1.91	33.71±1.70	0.143
		70 ˚C/4	36.00±3.47	39.75±4.87	30.59±3.49	0.310
	LT	70 ˚C/2	35.79±1.59	35.24±1.19	35.74±1.46	0.962
		70 ˚C/4	32.28±0.98^{b}	35.23±1.64^{ab}	39.44±1.26^{a}	0.003**
	LL	70 ˚C/2	37.97±0.71^{b}	42.16±0.78^{a}	40.19±1.54^{ab}	0.048*
		70 ˚C/4	37.74±1.05	39.83±1.89	38.85±0.92	0.518
a*	LD	70 ˚C/2	14.77±0.17^{a}	12.77±0.39^{b}	14.39±0.41^{a}	0.002**
		70 ˚C/4	13.60±0.36^{a}	9.93±1.21^{b}	14.12±0.52^{a}	0.002**
	LT	70 ˚C/2	12.92±0.38	11.77±0.54	12.28±0.81	0.429
		70 ˚C/4	13.13±0.62	13.43±1.68	10.57±0.57	0.051
	LL	70 ˚C/2	12.08±1.69^{a}	10.00±1.14^{b}	10.66±1.06^{ab}	0.046*
		70 ˚C/4	12.73±0.39^{a}	10.11±0.50^{b}	11.19±0.62^{ab}	0.024*
b*	LD	70 ˚C/2	18.68±0.31	17.44±0.38	16.66±0.81	0.059
		70 ˚C/4	17.98±0.66	16.64±0.69	16.50±0.19	0.085
	LT	70 ˚C/2	15.73±0.26	16.78±0.45	16.33±0.79	0.425
		70 ˚C/4	15.90±0.58	17.94±0.84	17.74±0.64	0.093
	LL	70 ˚C/2	15.83±0.50	15.98±0.31	16.98±0.24	0.090
		70 ˚C/4	17.54±0.40	18.16±0.65	18.16±0.82	0.602
WBSF	LD	70 ˚C/2	29.14±0.41^{a}	25.02±0.37^{b}	30.63±0.99^{a}	0.019*
		70 ˚C/4	29.84±2.44	24.13±0.00	25.82±2.61	0.279
	LT	70 ˚C/2	27.08±2.04	33.77±3.08	30.79±1.11	0.255
		70 ˚C/4	25.20±2.32	29.97±3.21	36.11±0.84	0.100
	LL	70 ˚C/2	36.54±2.09	33.68±2.58	36.18±0.13	0.582
		70 ˚C/4	30.36±0.61	36.84±2.21	34.33±3.00	0.254

(Longissimus dorsi, LD; Longissimus lumborum, LL; Longissimus thoracis, LT)
a, b, c: Differences between days with different letters in the same line are important.
(*: p<0,05, **: p<0,01, ***: p<0,001)

During the storage period, it was observed that the cooking loss values in the samples varied between 23.20 - 39.98%. A parallel increase was observed in the loss of cooking values during the storage period in LD (Table 1). Çiçek et al. [17] showed that the cooking loss rates of the meat samples kept in the vacuum package increased during the storage period; they emphasize that the rate of 21.32% on the first day of storage increased to 27.44% on the last day of storage. Belibağlı and Ersan [18] stated that there was an increase in cooking losses in parallel with the storage time that samples with sous vide method. Most of the cooking loss in the meat occurs as a loss of water in the meat. As many researchers [19, 20, 21, 22] have stated, when the temperature of the meat reaches to 45 - 60 ° C, the fibers begin to shorten, and in 60 - 90°C, the

shortening takes place parallel to the axis of the muscle fibers and water between the muscle fibers leaks out. In this context, it is seen in Figure 4 that the cooking losses increase depending on the cooking time. The fact that the meat samples cooked for longer periods of time had higher cooking loss values than the samples cooked for 2 hours supports this view. There are similar studies [23, 24, 25, 26, 27] indicating that cooking losses are directly related to cooking time and cooking temperature. Zikirov [28] suggested that the cooking loss increased as the cooking time increased, and the cooking loss rates of samples cooked with sous vide method at 2°C and 4 hours at 75°C were 39.15% and 41.98%, respectively. Christensen et al. [24], who stated that the rate of cooking loss increased when they prolong the cooking time by keeping the temperature constant, supports the findings we obtained.

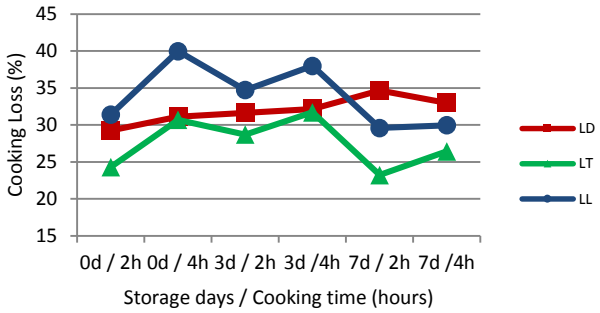


Figure 4. *Cooking loss values of samples during storage*

One of the important quality criteria for the consumer. Myoglobin, which gives the color of the meat, consists of the protein containing globulin and the non-protein part to which the iron element is attached. The color of the meat is due to the oxidation state of iron and the fact that this pigment absorbs and reflects the light of a particular wavelength [29]. In particular, it is known that the surface color of the meat in the storage process varies according to the reaction of myoglobin [30]. However, in this technique, cooking meat in a vacuum bag and stored in the same bag until consumption limits the contact with oxygen. Figure 5 shows that the L * levels of the samples vary between 32, 28 and 42,16 during storage and these values are limited. On the other hand, in respect of statistical, it was found that the differences in the 0, 3 and 7 days of storage of 2 hours of heat treated LL with 4 hours of cooked LT were significant ($p < 0.05$, $p < 0.01$) (Table 1). It is seen that L * values decrease as the cooking time increases in the samples (Figure 5). This may be related to the denaturation levels of meat proteins. Similar results were found by Zikirov [28]. The researcher stated that the L * values (47,18 and 43,09) decreased as the cooking time increased with the sous vide technique for 2 and 4 hours.

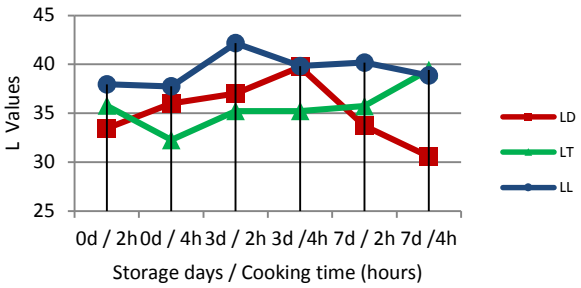


Figure 5. *L values of samples during storage*

a* values of the samples were determined between 9.93 and 14.77. While the values in days 0 and 7 were similar in LD during the storage period, on the 3rd day, a * values were lower than the other days and this difference was significant ($p < 0.01$). Furthermore, it was found that there was a significant difference ($p < 0,05$) on the 0 and 3 days of storage at the a * values of the LL samples; a * value obtained on the 7th day of storage was similar with the other days (Figure 6, Table 1). The decrease observed in the α * values of the samples during the storage process was also determined by many researchers [25, 31, 32].

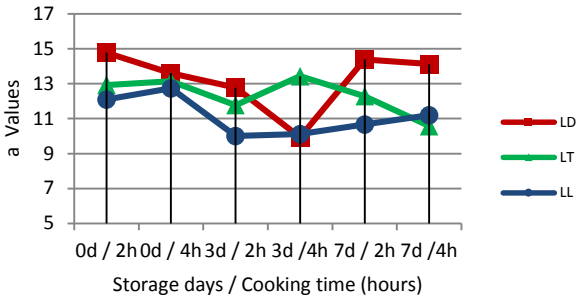


Figure 6. *A values of samples during storage*

It has been stated that the different heat time parameter is most affected by combinations applied in meat samples cooked with sous vide method [27]. While in our study, the cooking time of LT and LL samples cooked in sous vide method can be correlated with the increase in a * values and loss of cooking values, it may be associated with an increase in light absorbing properties with less water and a darker red color meat[33].

b* values, which were reported to be less effective on meat sensory characteristics and consumers' preference for meat [34], were determined between 15.73 and 18.68. While the b * value in other samples except LD was in an increase trend during storage, it was observed that this situation developed in the opposite direction in LD (Table 1). Çiçek et al. [31] also stated that they observed a decrease in the b * values of the meat samples (13,26 to 6,39) they kept in the vacuum package for a week during their studies. The b* increase

observed in LT and LL samples can be explained by the different amount of oil acting on the chemical composition of these preparations and the chemical and enzymatic changes in the oil [35].

The WBSF values of the samples ranged from 24.13 to 36.84 N, the lowest was LD, and the highest WBSF values were determined as LL samples (Figure 7). It is seen that the firmness ratios in the meat samples during storage are higher in LL and lower in LD. It is thought that the fat content they contain in determining the WBSF values of meat is effective. Thus. LD is softer than other meat because of its minimum meat content. It was determined that the storage time did not have a very determining effect on the WBSF values of meat samples (Figure 7).

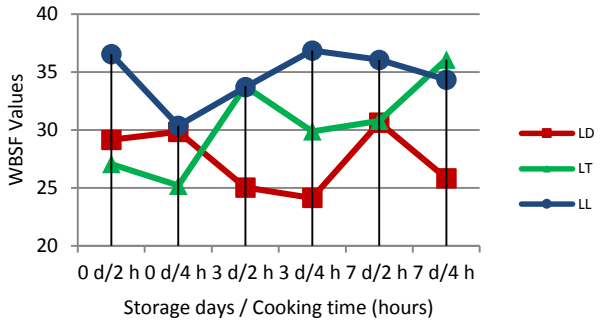


Figure 7. *WBSF values of samples during storage*

As a result of the analysis carried out during the storage, no live organisms were detected in any sample. This situation can be explained by cooking the meat samples prepared according to the hygienic conditions in accordance with the technique and then with rapid cooling and in suitable storage conditions (2 ± 2 °C). Some researchers [5, 30] reported that 70 °C heat treatment for microbiological safety in sous vide products is effective in the destruction of microorganisms, and rapid cooling after cooking provides protection of microbiological quality. It is further emphasized that the heat time combination applied to the meat and the failure of the cold chain after it are important for the microbiological quality of the product [4, 37]. However, it is also stated by many researchers [4, 15, 38, 39, 40, 41] that the use of vacuum packaging in the sous vide method further restricts the growth of microorganisms in the product and thus longer shelf life is obtained.

In fact, Özdemir and Şireli [42] emphasize that while vacuum packaging decreases the microbiological burden of the products, while *Brochothrix thermosphacta* is detected in only 28% of the vacuumed raw meat products, in majority of the non-vacuumed meat products participated in the study (48%) *B. thermosphacta* bacterium was found.

4. Conclusion

In the samples prepared with sous vide technique and stored for 7 days in the absence of general living microorganisms, sous vide technique is believed to strengthen the reliability of safe food production. However, the heat time combination to be applied should be determined according to the type of meat and hygienic production initial cost of microorganism need to be taken in to account.

During the storage period, the general live microorganism was not detected in the samples, and there was no significant difference between the cooking loss rates and the L * values between 0 and day 7th days of the storage iş related to their remainng in the vacuum package during storage. It is thought that the more widespread use of this technique will provide food enterprises with advantages in terms of food safety and fast serviceability.

Note:
This paper is produced from “Comparative Implemetation Of Traditional Cooking Methods and Sous Vide Cooking Methods İn Different Beef Preparates” PhD thesis titled 16202044, which is supported by SU BAP

References

[1]. Hecer C. “Et teknolojisinde ambalajlama yöntemleri”. Uludağ Unv. J. Fac. Vet. Med. 1, (2012), 57-61.

[2]. Balpetek D., Gürbüz Ü. “Use of ohmic heating system in meat thawing and ıts effects on microbiological quality”. MANAS Journal of Engineering, 6, 2 (2018), 129 – 142.

[3]. Meyer R.A. “Sous vide technology: American foodservice markets discovering the benefits”. Journal of Reataurant and Foodservice Marketing, 2, (2008), 51-62.

[4]. Yılmaz H. “Sous vide üretim tekniği kullanılarak hazırlanan macar gulaş yemeğinde mikrobiyolojik kalitenin değerlendirilmesi”. Master Thesis, Gazi Ünv. Ankara, Türkiye, (2014).

[5]. Haskaraca G., Kolsarıcı N. “Sous vide teknolojisi ve et teknolojisinde uygulama olanakları”. Akademik Gıda Dergisi, 11, 2, (2013), 94-101.

[6]. Peiretti G.P., Medana C., Visentin S., Dal Bello F., Meineri G., “Effect cooking on carnosine and homologues, pentosidine and thiobarbituric acid-reactive substance content in beef and turkey meat”. Food Chem, 132, (2012), 80-85.

[7]. Mol Ş., Özturan S. “Sous vide teknolojisi ve su ürünlerindeki uygulamalar”. Journal of Fisheries Sci, 3(1), (2009), 68-75.

[8]. Lambooji E., Potgieter C.M., Britz C.M., Nortje G.L., Pieterse C. "Effect of electrical and mechanical stunning methods on meat quality in ostriches". Meat Sci, 52(3), (1999), 331-337.

[9]. Li X., Babol J., Wallby A., Lundström K. "Meat quality, microbiological status and consumer preference of beef gluteus melius aged in a dry ageing bag or vacuum". Meat Sci, 95, (2013), 229-234.

[10]. Röhrle F.T., Moloney A.P., Osorio M.T., Laciano G., Priolo A., Caplan P., Monahan F.J. "Carotenoid colour and reflectance measurements in bovine adipose tissue to discriminate between beef from different feding system". Meat Sci, 88, (2011), 347-353.

[11]. Huidobro F.B., Micguel E., Blasquez B., Onega E. "Acomparision between two methods (Warner Bratzler-texture profile analysis) for testing either raw or cooked meat". Meat Sci, 69, (2005) 527-536.

[12]. Food and Drug Administration (FDA) BAM, Bacteriological analytical manual, Aerobic plate count, Chapter 3, January (2001) edition.

[13]. Özdamar K. Paket programlar ile istatistiksel veri analizi I. Anadolu Ünv. Eskişehir. (1997).

[14]. Diaz P., Nieto G., Garrido M.D., Banon S. "Microbial, physical-chemical and sensoryspoilage during the refrigerated storage of cooked pork loin processed by the sous vide method". Meat Sci, 80(2), (2008) 287-292.

[15]. Harun F. "Tavuk köftelerinin sous vide yöntemi ile muhafazası". Cumhuriyet Ünv. Fen Bilimleri Ens. Master Thesis. Sivas, Turkey (2012).

[16]. Feiner G. "Meat products handbook pratictical science and technology". Cambridge: WoodheadPublishing Limited, (2006) 27-50.

[17]. Çiçek Ü., Karabıyıklı Ş., Çabuk D., İyiekmekçi B., Cevahiroğlu H. "Vakum ambalajlı olarak soğukta muhafaza edilen dana, kuzu ve tavuk etlerinin bazı fizikokimyasal ve mikrobiyolojik özellikleri." Gaziosmanpaşa Ünv. Ziraat Fak. Derg, 31(1), (2014) 54-62.

[18]. Belibağlı K.B., Ersan E., "Effects of storage on the quality of sous vide processed lamb liver." Harran Gıda ve Tarım Bilimleri Dergisi, 22, (1), (2018) 1-11.

[19]. Gençcelep H., "Et proteinlerinin fonksiyonel özellikleri." Gıda Teknolojileri Elektronik Dergisi, 2, (2008) 9-18.

[20]. Palka K., Daum H. "Change in texture, cooking losses and myofibrillar structure of bovine *M. semitendinosus* during heating". Meat Sci, 51, (1999) 237 – 243.

[21]. Rodriguez-Estralla M.T., Lercker G. "Effecet of different cooking methods on some lipid and protein components of hamburgers". Meat Sci, 45(3), (1997) 365-375.

[22]. Sanchez Del Pulgar J, Gazquez A, Rulz-Carrascal J, "Physico-chemical, textural and structural characteristics of sous-vide cooked pork cheeks as affected by vacuum, cooking temperature and cooking time". Meat Sci, 90(3), (2012) 828-835.

[23]. Becker A., Boulaaba A., Pingen S., Krischek C., Klein G. "Low temperature cooking of pork meat – physicochemical sensory aspects". Meat Sci, 118, (2016) 82-88.

[24]. Christensen L., Gunvig A., Torngren M.A., Aaslyng M.D., Knochel S., Christensen M. "Sensory characteristics of meat cooked for prolonged times at low temperature". Meat Sci, 90, (2012) 485-489.

[25]. Garcia-Segovia P., Andres-Bello A. Martinez-Monzo J. "Effect of cooking method on mechanical properties, color and structure of beef muscle". Journal of Food Engineering, 80, (2007) 813-821.

[26]. Roldan M., Antequera T., Martin A., Mayoral A.I., Ruiz J. "Effect of different temperature– time combinations on physicochemical, microbiological, textural and structural features of sous-vide cooked lamb loins". Meat Sci, 93, (2013) 572-578.

[27]. Vaudagna S.R., Sanchez G., Neira M.S., Insani E.M., Picallo A.B., Gallinger M.M., Lasta J.A. "Sous vide cooked beef muscles: effects of low temperature-long time (LT-LT) treatments on their quality characteristics and storage stability". Int. J. of Food and Technology, 37, (2002) 425-441.

[28]. Zikirov E, "Sous vide pişirme yönteminin sığır etinde heterosiklik aromatik amin oluşumunu ve bazı kalitatif kriterler üzerine etkileri". Master Thesis. Atatürk Ünv. Erzurum, Türkiye (2014).

[29]. Taşçı F. "Etlerde meydana gelen renk değişikliği". Ayrıntı Dergisi, 4, 47. (2017)

[30]. Girolami A., Napolitano F., Faraone D., Braghieri A. "Measurement of meat color using a computer system". Meat Sci, 93, (2007) 111-118.

[31]. Çiçek Ü., Karabıyıklı Ş., Kılınçer F.N., Yıldırım A.T., Kurbandurdiyev H., Cevahiroğlu H. "Dana etinin bazı fizikokimyasal ve mikrobiyolojik özellikleri üzerine farklı ambalajlama yöntemleri ve depolama süresinin etkisi". Gaziosmanpaşa Ünv. Ziraat Fak. Derg, 30(2), (2013) 62-70.

[32]. Kahraman H.A. "Kemikli ve kemiksiz sığır kontrfilelerine farklı dinlendirme yöntemlerinin uygulanması ve kalite niteliklerinin belirlenmesi". Selçuk Ünv. Sağlık Bilimler Ens. Doktora Tezi. Konya. (2016).

[33]. Kim Y.H.B., Hunt M.C. "Advance technology to improve meat color". Ed. Joo ST: Control of Meat Quality Kerala, İndia: Research Signpost. (2011) p. 31-60.

[34]. O'Sullivan M.G., Byrne D.V., Martens H., Gidskehang G.H., Andersen H.J., Martens M. "Evaluation of pork colour prediction of visual sensory quality of meat from instrumental and computer vision methods of colour analysis". Meat Sci. 65(2), (2003) 909-918.

[35]. Renerre M. "Factors involved in the discoloration of beef meat". International Journal of Food Sci, and Tech, 25(6), (1990) 613-630.

[36]. Sebastia C., Soriano J.M., Iranzo M., Rico H. "Microbiological quality of sous vide cook-chill preserved food at different shelf life". Journal of Food Processing and Preservation, 34, (2009) 964-74.

[37]. Wang H., Badoni M., Zawadski S., McLeod B., Uttaro B., Yang X. "Effects on beef microflora of a three-step sous vide method". Nurturing Locally, Growing Globally, (2017) 484.

[38]. Jang J.D., Lee D.S. "Development of a sous vide packaging process dor korean seasoned beef". Food Control, 16(3), (2005) 285-91.

[39]. Özturan S., "Vakum ambalajda pişirilmiş (sous vide) balıkta kalite ve raf ömrünün belirlenmesi". Yüksek Lisans Tezi. İstanbul Ünv. Fen Bilimleri Ens. İstanbul, Türkiye (2009).

[40]. Shakila R.J., Jeyasekaran G. Vijeyakumar A., Sukumar D. "Microbiological quality of sous vide cook chill fish cakes during chilled storage". Intrernational Journal of Food Sci. And Tech, 44 11, (2009) 2120-26.

[41]. Topal Ş., Pala M., Saygı B. "Sous vide teknolojisinin geleneksel yemeklerimize uygulanması". Gıda/The Journal of Food, 2(2), (1996), 131-144.

[42]. Özdemir H., Şireli T. "Et ve et ürünlerinde Brochotrix Thermosphacta'nın bulunuşu". Gıda Derg. 26 (2), (2001), 115-120.