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Determination of the Quality and Shelf Life of Sous Vide Cooked Turkey Cutlet Stored at 4 and 12ºC

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ABSTRACT

The aim of this study was to determine the quality and shelf life of sous vide turkey cutlet stored at 4 and 12ºC. Samples were packaged under vacuum into polyamide-polypropylene pouches, cooked using sous vide technology (65ºC/40 min), chilled at 3ºC and stored at 4 and 12ºC for 5 weeks. Microbial (TMAB, lactic acid bacteria, *Enterobacteriaceae*, moulds and yeasts, *Salmonella* spp., *L. monocytogenes*, *Cl. perfringens*), physical–chemical (pH, water activity, TBARS, L*a*b* colour, texture profile analysis and shear force) and sensory (appearance, colour, odour, flavour, juiciness, chewiness and acceptance) parameters were determined. According to the results of mesophilic bacterial counts and sensory analysis, the shelf life of the sous vide turkey cutlet, cooked at 65ºC for 40 min, was determined as 28 days at 4ºC while 15 days at 12ºC. *Salmonella* spp., *L. monocytogenes*, *Cl. perfringens* were not detected in turkey cutlet samples during the storage period. It was detected that sous vide cooked provided convenient ready-to-eat foods and a long shelf life for turkey cutlet.

INTRODUCTION

Owing to the development of the technology, people's changing lifestyles and the customers' increase of expectation for food that is easy to prepare, high quality, maintains its fresh taste, the demand for food which is partially processed, contains low amount of additives, is unsterilized but has extended shelf-life and has been increasing in the food industry. While people are spending less time cooking meals in the kitchen, they prefer to consume fast food. However, due to the fact that fast food causes unhealthy nutrition habits and thus obesity, consumers are in quest for alternatives for food. On account of these reasons people tend to consume convenience and packaged food which maintains its nutritional value, is easily consumed and which contains few additives as possible. This change in consumer trends has been taken into consideration in the industrial area, thus; manufacturers have focused on the research about methods of food preparation and presentation and increased the production of ready to eat food (Aucoin 1997; Ergezer & Gökçe 2003; Mol & Özturan 2009). In particular new technologies are being investigated and many studies are being carried out in order to increase the quality and shelf life of the poultry meat products that attract great attention in ready to eat food industry. Sous vide (SV) is an alternative method that is able to meet all of these needs.

Sous Vide is a French term which means "under vacuum". SV cooking is the process of cooking the raw food products or the food treated with raw food products at controlled temperatures and time in the heat-resisting vacuum packaging and circulating water bath. Although SV cooking technique has been used by famous restaurant

chefs since 1970s, it became popular in the mid-2000; thanks to its easy application and suitability for many products, a rapid increase in its use in the catering sector, restaurants, homes and industrial processes has been observed (Baldwin 2011). Fast food industry gives importance to this technique and is constantly studying how to improve it on the ground that with SV method by only heating and without microbiological contamination, a pre-cooked meal is served to the consumer, thus; it has an increased product shelf life and short service time (Jang *et al*. 2006; Roldan *et al*. 2013).

For the human nutrition, the importance of animal food is vital. Poultry meat in which also turkey takes place is preferred instead of red meat due to its low levels of cholesterol, high protein/calorie ratio and low fat content. Furthermore, turkey is rich in B group vitamins as thiamin (B1), riboflavin (B2), niacin (B3) and pyridoxine (B6), and the minerals potassium, calcium and phosphorus. Because of these features, turkey is preferred by conscious consumers. On the other hand, its being able to be grown to high body weight, carcass yield, high rate of edible meat give privilege to convert it into mass food production and meat products (Sipahi 2006; Çolak *et al*. 2011).

The significant level of microorganism contamination of poultry meat products especially during cutting operations is an important issue. This situation often leads to rapid contamination of meat and threaten the health of the consumer. It is stated that it leads to some food borne illnesses caused by the consumption of poultry meat, particularly salmonellosis. Therefore, processing the food or packaging with different kinds of methods, increasing the shelf life of the product and preventing contamination that may occur during these processes is of prime importance (Atasever *et al*. 2000; Çolak *et al*. 2011). Additionally, the physiological satisfaction borders in humans against poultry are very low due to the sensory quality of these meats. In other words, continuous consumption of it is unlikely. Saturation limits of poultry meat products can be increased by transforming it into various products with adding some ingredients (salt, spices, mono sodium glutamate) and as a result, more poultry meat products consumption can be realized (Atasever *et al*. 2000).

The shelf life of poultry meat products is based on the bacterial load of the product, characteristic of the storage environment and the degree of lipid oxidation on the product. Various methods carried out under these conditions have importance in increasing product shelf life (Wang *et al*. 2004). Since oxidation is prevented thanks to vacuum packing in SV product, oxidation-induced bad taste and odor formation decreases, contamination which may occur during storage is prevented and the growth of aerobic bacteria is inhibited. Therefore, the shelf life of the product is prolonged. During cooking, aroma components and moisture's remaining substantially in food, efficient transformation of heat from water into food, with the exposure of the whole product to a uniform temperature same crispness of food from outmost to the center also provide improvement in sensory properties of the product. Thus, with SV cooking a product that is both savory, nutritious also has longer shelf life compared to standard products (Baldwin 2011). Many studies (Wang *et al*. 2004; Diaz *et al*. 2008; Mol *et al*. 2012; Singh *et al*. 2016; Hernández *et al*. 2017) have been carried out to determine the shelf life of SV cooked products and studies showed that the shelf life can vary according to the properties of the product. Mol *et al.* (2012) showed that the shelf life of the SV bonito, cooked at 70ºC for 10 min, was 28 days at 4ºC while 15 days at 12ºC. In another research Diaz *et al.* (2008) stated that SV cooked pork loin was unacceptable after 10 weeks. It was seen that SV cooked and packaging provided a long shelf life for meat products. This agrees with other studies on SV meat-based meals (Simpson *et al.*, 1994; Hansen *et al.*, 1995; Nyati, 2000; Vaudagna *et al.*, 2002; Wang *et al.*, 2004). Within this context, putting turkey cutlet, which is acquired with the addition of spices, on fast food product industry processed by SV method will meet the consumer needs and also provide microbial safety of the product. By foreseeing that the products that are SV cooked have longer shelf life than the raw products in the markets, instead of raw turkey cutlets that have 8-day shelf life in the refrigerator on the market, it is aimed at developing an alternative product which is cooked, ready for use and has longer shelf life, thus; meeting the needs of consumers.

MATERIAL AND METHODS

Preparation of SV products

Turkey cutlet samples were provided from the company of Bolca Hindi, in Bolu, Turkey. The samples were cut into 8 x 8 x 1 cm pieces, packaged under vacuum into polyamide-polypropylene pouches and cooked at 65ºC for 40 min using The Sous Vide Professional (ORKA, İstanbul, Turkey). After cooking, the samples were immediately iced until reaching an internal temperature of 3ºC in 10 min. After chilling,

samples were stored at 4 and 12ºC. Three different packaged Turkey cutlet portions were cooked and analyzed in each analyzing day. Analyses were made at 0, 7, 14, 21, 28, 35 storage days for the storage of 4ºC and 0, 3, 6, 9, 12, 15, 18, 21 days for the storage of 12ºC.

Microbiological analyses

In the process of microbiological analyses of turkey cutlet samples, a 10 g sample taken under aseptic conditions was homogenized using 90 mL of 0.1% peptone water (Merck, 1.02239.0500, Germany). Decimal serial dilutions were prepared in 0.1% peptone water and appropriate dilutions were surface plated, in duplicate, onto agar dishes. Selective agar medium and incubation conditions are shown in Table 1. In addition, the presence of *Listeria monocytogenes* and *Salmonella* spp. were investigated in the samples.

The presence of *L. monocytogenes* was analyzed according to ISO method (ISO 11290, 1996). 25 g sample was aseptically transferred in 225 mL Half Fraser Broth (Lab M, LAB164, UK) for pre-enrichment and incubated at 30ºC for 24 h. 0.1 mL inoculum was transferred into 10 mL Fraser Broth (Lab M, LAB211, UK) and incubated at 37ºC for 24-48 h. A loopful sample from cultured enrichment medium were streaked on a plate of both Oxford Agar (Merck, 1.07004.0500, Germany) and PALCAM Agar (Merck, 1.11755, Germany) and incubated at 37ºC for 24-48 h. Greenish-grey colonies were picked up and further identification tests (Gram staining, catalase activity, motility, hemolysis activity and carbohydrate fermentation) were conducted. For the purposes of *Salmonella* spp. isolation, 25 g sample was incubated for 16-20 h at 35-37ºC by adding buffered peptone water (Merck 1.07228 Merck, Darmstadt, Germany) for pre-enrichment. One milliliter of the mixture was transferred to 10 mL Rappaport & Vassiliadis Broth (Merck 1.07700, Germany) and incubated for 24 h at 41.5ºC. Another 1 mL of the mixture was transferred into 10 mL Muller–Kauffmann Tetrathionate/Novobiocin Broth (Oxoid, CM1048, UK) and incubated for 24 h at 37ºC for selective enrichment. A loopful inoculum from both broths were separately transferred to Brilliant green Agar (Lab M, LAB34, UK) and XLD Agar (Lab M, LAB032, UK) which are used as selective agar medium. After incubation for 24 h at 37ºC, biochemical tests were performed for typical colonies (ISO 6579, 2002).

Physical-Chemical Analyses

Physical and chemical quality parameters like pH, water activity, thiobarbituric acid value, peroxide value, CIE L*, a*, b* color and instrumental texture were determined to evaluate SV cooked turkey cutlet spoilage. The pH was measured with a pH meter (Thermoscientific-Orionstar-A211, UK) (TSE, 1990) and water activity (aw) was measured using a water activity meter (Novasina Labmaster, UK) (Ensoy 2004). Oxidation was expressed as thiobarbituric acid reactive substances (TBARS) (expressed as mg malonaldehyde/kg sample) using a Spectrophotometer (Tarladgis *et al*. 1960). Peroxide value was measured by titrating with $Na_2S_2O_3.5H_2O$ using starch as indicator. Total acidity was determined as mq O_2/kg oil (AOAC 1990). Color was measured on turkey cutlets using a Chroma meter (Minolta CR-300, UK) and results were expressed as CIE L*, a*, b* (Hunt *et al*. 1991).

Texture profile analysis (TPA) and Warner Bratzler shear force were measured using a texture analyser (TA.XT Plus Stable Micro Systems, UK) equipped with a load cell of 30 kg. For TPA 1.5 x 0.8 x 1.5 cm uniform portioned meat samples were used. The samples were compressed perpendicular to the muscle fibers with a 100 mm diameter cylindrical probe with two consecutive cycles of 65% compression. For each sample, nine cubes were obtained and texture variables hardness, cohesiveness, springiness, gumminess and chewiness were calculated. Shear force was measured in 1.5 x 1.5 x 5 cm meat samples. Each sample was cut perpendicular to the muscle fibers with a Warner–Bratzler shear. The testing conditions were: 20°C room

Table 1 – Selective media and incubation conditions in microbiological analyses of selected microorganism

Microorganism	Selective medium	Incubation conditions		
		Temperature (°C)	Time	Aerobic / Anaerobic
TMAB	PCA (Merck 1.05463)	28°C	48-72 h	Aerobic
LAB	MRS (Merck 1.10660)	30°C	48-72 h	Anaerobic
Enterobacteriaceae	VRBD Agar (Merck 1.10275)	37°C	24 h	Aerobic
Moulds and yeasts	YGC (Merck 1.16000	28°C	5 days	Aerobic
Cl. perfringens	TSC Agar (Merck 1.11972)	37°C	24 h	Anaerobic

TMAB, total mesophilic aerobic bacteria; LAB, lactic acid bacteria; VRBD, violet red bile glucose agar; MRS, de Man Rogosa and Sharpe; YGC, yeast extract glucose chloramphenicol; TSC, tryptose sulphite cycloserine.

temperature, pre-test speed of 2 mm/sec, test speed of 1 mm/sec and after-test speed of 10 mm/sec with 15 g trigger force. Six determinations were performed for each cooked sample. Texture profile calculations were done as described by Bourne (1978).

Sensory analyses

For the sensory analyses, samples were placed on glass plates labelled with random three digits and were heated 30 sec. with a microwave oven (Samsung M17-13, 600 W, 2450 MHz). The warmed samples were immediately presented to the 10 educated judges. Water was used between samples to cleanse the palate. SV cooked turkey cutlet was evaluated in terms of appearance, colour, juiciness, odor, chewiness, flavor and overall acceptance. Each sensory property was graded using a point scale ranging from 1 to 9. The scales used were: 1 (very dry appearance) to 9 (very juicy appearance) for appearance; 1 (very pale) to 9 (very bright) for color; 1 (very dry) to 9 (very juicy) for juiciness; (non-perceivable) to 9 (strong intensity) for odor, chewiness, flavor and overall acceptance (Kolsarıcı & Candoğan 1995). The mean score was calculated for each sample group and sample was accepted as "spoiled" or unacceptable if the score was determined as lower than four.

Statistical analyses

All parameters were analyzed by a one-way analysis of variance using the general linear models procedure of SPSS 16.0 (Analytical Software, New York, USA) and significant factors (p<0.05) between the groups were analyzed by using Duncan post hoc test.

RESULTS AND DISCUSSION

Microbiological Analyses

During the storage, the total mesophilic bacterial counts exceeded the permissible limit 5 log cfu/g, on the 35th and 21st days of storage at 4 and 12°C, respectively (Table 2). However, it was mentioned that the low temperature storage gave the SV processed product the enhanced storage stability but there may also be loss of sensory properties of the product during storage (Gonzalez-Fandos *et al*. 2005). For this reason, only the microbial limit prescribed for cooked foods cannot be an index for SV products. Some researchers showed that microbiological quality of cooked meat can be achieved with SV technology (Diaz *et al*. 2008). Similar to our results, Can & Harun (2015) reported that the TMAB count was below the limit of detection until day 42 in chicken meatballs samples were SV cooked at 90°C for 20 min and stored at 2°C. Nyati (2000) studied the microbiological quality of turkey breasts SV cooked at an internal temperature of 70°C for 2 min and stored up to five weeks at 3°C. Total plate counts of 3.31 logcfu/g were found after five weeks, showing similar counts to the raw material. On the other hand, no pathogens, such as *L. monocytogenes*, *Salmonella* spp. and *Cl. perfringens* were found, and as well counts below 1 log cfu/g *Enterobacteriaceae*, lactic acid bacteria, mould and yeast were found during the storage. Shakila *et al*. (2009) informed that the absence of these microorganisms could be mainly because of the combination of vacuum packaging, cooking and low temperature storage and SV cooking has resulted in the destruction of these groups of bacteria. Our results are in agreement with those reported by Shakila *et al*. (2009), who did not detect viable lactic acid bacteria in SV fish-cakes samples during 16 weeks of storage and by Can & Harun (2015) who detected LAB number was below 1.0 logcfu/g in SV chicken meatballs samples during 10 weeks of storage.

Physical-Chemical Analyses

Table 2 and 3 show the mean values and standard deviations for the physical-chemical spoilage indices measured in SV cooked turkey cutlet stored at 4 and 12°C. The highest pH value was determined as 6.22 at day 18 for 12°C storage and 6.23 at day 21 and 28

Table 2 – Physical–chemical and microbiological results of SV cooked turkey cutlet stored at 4°C

	Days					
	0	7	14	21	28	35
pH	6.13 ± 0.02 ^{a}	6.14 ± 0.03 ^{a}	6.17 ± 0.03 ^{ab}	6.23 ± 0.03 ^{b}	6.23 ± 0.03 ^{b}	6.18 ± 0.03 ^{ab}
Water Activity	0.982 ± 0.00 ^{c}	0.983 ± 0.00 ^{cd}	0.988 ± 0.00 ^{d}	0.982 ± 0.00 ^{c}	0.976 ± 0.00 ^{b}	0.970± 0.00 ^{a}
TBA	0.61 ± 0.02 ^{b}	0.04 ± 0.01 ^{a}	0.09 ± 0.02 ^{a}	0.96 ± 0.13 ^{c}	1.15 ± 0.02 ^{d}	1.32 ± 0.01 ^{e}
Peroxide Value	1.15 ± 0.13 ^{ab}	0.72 ± 0.02 ^{a}	1.78± 0.40 ^{abc}	2.98 ± 1.17 ^{cd}	2.47 ± 0.17 ^{bcd}	3.52± 0.29 ^{d}
L*	69.43 ± 0.19 ^{ab}	71.32 ± 0.69 ^{c}	69.13 ± 0.08 ^{ab}	70.13± 0.56 ^{b}	69.12 ± 0.08 ^{ab}	68.80 ± 0.24 ^{a}
a*	7.22 ± 0.20 ^{a}	8.12 ± 0.01 ^{b}	9.96± 0.20 ^{d}	8.37 ± 0.17 ^{b}	8.23 ± 0.10 ^{b}	9.41± 0.09 ^{c}
b*	20.16 ± 0.65 ^{a}	21.66 ± 0.46 ^{bc}	23.12 ± 0.78 ^{d}	20.40 ± 0.36 ^{a}	22.40 ± 0.30 ^{cd}	23.62 ± 0.36 ^{d}
TMAB	2,05 ± 0,01 ^{a}	2,94 ± 0,02 ^{b}	3,32 ± 0,12 ^{c}	4,07 ± 0,06 ^{d}	4,48 ± 0,04 ^{e}	5,89 ± 0,07 ^{f}

Means with different superscripts are significantly different (p<0.05).

Table 3 – Average values and standard deviations for physical-chemical spoilage indices in SV cooked turkey cutlet stored at 12ºC

	Days							
	0	3	6	9	12	15	18	21
pH	6.13± 0.02 ^{ab}	6.17 ± 0.01 ^{ab}	6.18 ± 0.02 ^{b}	6.19 ± 0.05 ^{ab}	6.19 ± 0.02 ^{ab}	6.20 ± 0.06 ^{ab}	6.22 ± 0.01 ^{ab}	6.10± 0.14 ^{a}
Water Activity	0.982 ± 0.00 ^{c}	0.980 ± 0.00 ^{c}	0.991 ± 0.00 ^{d}	0.980 ± 0.00 ^{c}	0.982 ± 0.00 ^{c}	0.990 ± 0.00 ^{d}	0.973± 0.00 ^{b}	0.963 ± 0.00 ^{a}
TBA	0.61 ± 0.02 ^{bc}	0.68 ± 0.02 ^{bcd}	0.31 ± 0.00 ^{a}	0.48± 0.12 ^{abc}	0.95 ± 0.07 ^{d}	0.43 ± 0.02 ^{ab}	0.74± 0.11 ^{cd}	0.65 ± 0.23 ^{bc}
Peroxide Value	1.15 ± 0.13 ^{a}	1.26 ± 0.11 ^{a}	1.39 ± 0.31 ^{a}	2.85 ± 0.56 ^{b}	2.87 ± 0.38 ^{b}	1.36 ± 0.24 ^{a}	1.66 ± 0.32 ^{a}	3.63 ± 0.34 ^{b}
L*	69.43 ± 0.19 ^{b}	67.50 ± 0.22 ^{a}	69.59 ± 0.37 ^{bc}	69.08± 0.40 ^{b}	70.30 ± 0.02 ^{c}	69.36± 0.10 ^{b}	69.46 ± 0.40 ^{b}	69.16 ± 0.28 ^{b}
a*	7.22 ± 0.20 ^{a}	8.60 ± 0.40 ^{ab}	8.41 ± 1.08 ^{ab}	9.54 ± 0.31 ^{bc}	8.64 ± 0.59 ^{ab}	10.30 ± 0.58 ^{c}	9.68± 0.22 ^{bc}	8.39 ± 0.27 ^{ab}
b*	20.16 ± 0.65 ^{a}	21.73 ± 1.76 ^{ab}	22.56 ± 1.18 ^{abc}	24.15 ± 0.84 ^{bc}	24.63 ± 1.11 ^{c}	24.18 ± 0.37 ^{bc}	23.23 ± 0.11 ^{bc}	23.37 ± 0.31 ^{bc}
TMAB	2,05±0,01 ^{a}	2,73±0,02 ^{b}	2,76 ± 0,03 ^{b}	3,24 ± 0,10 ^{c}	4,38 ± 0,04 ^{d}	5,47 ± 0,02 ^{e}	6,78 ± 0,10 ^{f}	7,15 ± 0,07 ^{g}

Means with different superscripts are significantly different (p<0.05)

for 4ºC storage. Although during the storage the pH values of the samples stored at 4 and 12ºC increased, at the end of the storage the pH values decreased appreciably. These results can be interpreted as increase in pH with the precipitation of acid salts and decrease in pH with the precipitation of alkali salts in meat (Ergönül 2004). During the storage pH changes in turkey cutlets stored at 4ºC was found significant (p<0.05) but the changes in turkey cutlets stored at 12ºC was not found significant (p>0.05).

Water activity (aw) is a reference factor for spoilage in food (Diaz *et al*. 2011). During the storage period it was observed that the water activity values decrease gradually at each storage temperature. At the end of the storage while the samples stored at 4ºC have reached the water activity value of 0.970, the samples stored at 12ºC have reached the water activity value of 0.963. Due to the statistical analyses the changes in water activity values was found significant at each storage temperatures (p<0.05). The water activity results agree with the results in the study of Diaz *et al*. (2011) that the mean aw was higher than 0.9 and stable during storage. Stable aw values can be explained by polypropylene pouches presented good barrier properties to water vapor (Diaz *et al*. 2011).

The level of TBARS is related to the content of secondary lipid oxidation compounds, mainly aldehydes like malonaldehyde and it is important to identify the oxidation level of meat (Roldan *et al*. 2013). Oxidative rancidity cause off-flavor in poultry products during storage therefore TBARS values are used as an indicator to determine the level of oxidative deterioration of foods (Wang *et al*. 2004). Consumers are unlikely to detect these off-flavors in meat products at TBA values below a threshold of about 0.5 MDA/kg (Can & Harun 2015). The highest rate of TBARS value was determined as 1.32 mg malonaldehyde/kg sample at day 35 for 4ºC storage and 0.95 mg malonaldehyde/kg sample at day 12 for 12ºC storage. Due to the statistical analyses the changes in TBARS values was found significant at each storage temperatures (p<0.05). This variability that occurred during storage is thought to be the result of the changes of oxidation reactions' products. It was reported that when the TBARS value is below 1.0, oxidative rancidity usually cannot be detected by a sensory panel from chicken meat (Wang *et al*. 2004). In this study, the TBARS values of SV turkey cutlets were controlled on range of 0.61 to 1.32 during whole storage. Vacuum package is also an important factor to keep TBARS values under control. Similar to this result, Wang *et al*. (2004) reported that TBARS values of SV chicken wing parts ranged from 1.0-2.0 during 7 weeks storage.

Peroxide values of samples increased and decreased during the storage at each storage temperatures and the changes in peroxide values was found significant at each storage temperatures (p<0.05). The increases and decreases in peroxide values can be explained by the formation of malonaldehyde in the later stages of reaction and changes in the amount of the oxidation products (Roldan *et al.* 2014a). The samples stored at 4ºC as prescribed refrigerator temperature, reached highest peroxide value of 3.52 meq O_2/kg oil at day 35. Turkey meat is rich in polyunsaturated fatty acid (PUFA), and this high PUFA content causes the development of oxidative rancidity (Kayaardi *et al*. 2005). Similar results were reported by Kayaardi *et al*. (2005) for the turkey meat doner kebab samples. They found that peroxide values increased with storage time when samples were stored at 4ºC. Alasnier *et al*. (2000) also found out that oxidative values increased in stored poultry meat.

L* values of samples increased during the storage but at the end of the storage L* values became close to their initial values. a* and b* values were found to increase during storage for each storage temperatures. Also due to the statistical analyses the changes in L*, a*, b* values were found significant at each storage temperatures (p<0.05). These results agrees with the

results from Pakula & Stamminger (2012), who have shown that the denaturing of myosin molecules causes visible changes in meat color opacity. Also at higher pH and ionic strengths myofibrillar muscle proteins swell, which alters light reflection, since a swollen muscle protein structure would permit a deeper penetration of light in the tissue, leading to a darker appearance (Roldan *et al*. 2013). These results can explaine the increase in a* and b* values at each storage temperatures.

Textural Analyses

Table 4 and 5 shows the mean values and standard deviations for the textural analyses indices measured in SV cooked turkey cutlet stored at 4 and 12°C. At the end of the storage for both temperature, it was seen that values of shear force, cohesiveness, gumminess and resilience decreased while values of chewiness increased as well as value of adhesiveness was stable. The changes in all texture profile analysis values was found significant at each storage temperatures (p<0.05). Softer and flakier appearance was observed in the samples during storage. Protein degradation due to chemical and enzymatic activity may be the reason for the samples to become softer and flakier in the storage. Although heating inactivates part of the muscle proteases, residual protease activity continues in the refrigerated product (Diaz *et al*. 2008). According to Roldan *et al*. (2014b) the effect of the storage time on shear force was not clear, and only samples cooked at 60°C for either 6 h or 24 h showed a significant effect, with a decrease during the first week of storage and steady values or slight increase thereafter. Wang *et al*. (2004) reported that there were no major changes in the shear values of sous vide cooked chicken wing parts during the 7 weeks of refrigerated storage.

Sensory Analyses

Sensory analysis was crucial to detect the texture changes in the refrigerated SV cooked products. Levkane *et al*. (2010) informed that the shelf life of SV products ranges from 7 to 52 days depending on the food composition. Table 6 and 7 shows the mean values and standard deviations for the sensory spoilage indices measured in SV cooked turkey cutlet stored at 4 and 12°C. While significant decrease the values of appearance, color and chewiness were not observed, there was found to be a significant decrease in the values of flavor, odor and overall acceptance in both storage temperatures. For 4°C storage at day 35 and for 12°C storage at day 21, odor and flavor values of the samples have dropped below 4 points determined as the consumption limit which has been proposed

Table 4 – Average values and standard deviations for textural spoilage indices in SV cooked turkey cutlet stored at 4°C

	Days					
	0	7	14	21	28	35
Shear Force (g)	948.00 ^{d}	857.14 ^{cd}	676.79 ^{a}	726.60 ^{ab}	806.14 ^{bc}	847.45 ^{cd}
Hardness (g)	9099.50 ^{b}	10438.38 ^{b}	7464.48 ^{a}	7560.77 ^{a}	10425.22 ^{b}	9790.46 ^{b}
Adhesiveness (g.s)	-27.94 ^{b}	-24.77 ^{b}	-9.58 ^{c}	-39.00 ^{a}	-24.60 ^{b}	-24.42 ^{b}
Springiness (cm)	0.59 ^{ab}	0.55 ^{a}	0.64 ^{c}	0.60 ^{ab}	0.62 ^{bc}	0.57 ^{ab}
Cohesiveness	0.44 ^{c}	0.48 ^{d}	0.39 ^{b}	0.37 ^{ab}	0.36 ^{a}	0.37 ^{ab}
Gumminess	3845.35 ^{c}	3266.40 ^{ab}	3009.16 ^{a}	3889.50 ^{c}	4517.88 ^{d}	3670.56 ^{bc}
Chewiness	1968.58 ^{a}	2195.87 ^{a}	1887.87 ^{a}	2019.25 ^{a}	2871.10 ^{b}	2592.85 ^{b}
Resilience	0.13 ^{d}	0.17 ^{e}	0.11 ^{b}	0.12 ^{c}	0.10 ^{a}	0.10 ^{a}

Means with different superscripts are significantly different (p<0.05).

Table 5 – Average values and standard deviations for textural spoilage indices in SV cooked turkey cutlet stored at 12°C

	Days							
	0	3	6	9	12	15	18	21
Shear Force (g)	948.00 ^{d}	746.08 ^{b}	737.80 ^{b}	826.46 ^{c}	837.38 ^{c}	853.42 ^{c}	661.28 ^{a}	722.40 ^{ab}
Hardness(g)	9099.50 ^{b}	7928.82 ^{ab}	7656.79 ^{ab}	8408.55 ^{b}	6667.28 ^{a}	6721.53 ^{a}	10796.49 ^{c}	7658.13 ^{ab}
Adhesiveness (g.s)	-27.94 ^{ab}	-12.23 ^{c}	-27.95 ^{ab}	-23.04 ^{b}	-26.09 ^{b}	-34.68 ^{a}	-22.08 ^{b}	-28.18 ^{ab}
Springiness	0.59 ^{ab}	0.64 ^{d}	0.61 ^{bc}	0.58 ^{a}	0.58 ^{a}	0.59 ^{a}	0.57 ^{a}	0.62 ^{c}
Cohesiveness	0.44 ^{d}	0.37 ^{b}	0.34 ^{a}	0.35 ^{a}	0.47 ^{e}	0.38 ^{b}	0.38 ^{b}	0.40 ^{c}
Gumminess	3845.35 ^{cd}	3282.41 ^{abc}	2606.26 ^{a}	3604.17 ^{bc}	2784.15 ^{a}	4431.18 ^{d}	5804.17 ^{e}	3085.30 ^{ab}
Chewiness	1968.58 ^{ab}	1935.61 ^{ab}	1597.35 ^{a}	2061.71 ^{bc}	2013.42 ^{ab}	2519.16 ^{d}	2441.41 ^{cd}	2265.02 ^{bcd}
Resilience	0.13 ^{e}	0.11 ^{bcd}	0.10 ^{a}	0.09 ^{a}	0.13 ^{de}	0.12°C ^{d}	0.11 ^{bc}	0.11 ^{abc}

Means with different superscripts are significantly different (p<0.05).

Table 6 – Average values and standard deviations for sensory spoilage indices in SV cooked turkey cutlet stored at 4ºC

	Days					
	0	7	14	21	28	35
Appearance	6.90 ± 1.37	7.00 ± 0.87	7.00 ± 0.89	5.86 ± 1.77	6.25 ± 1.28	5.67 ± 1.75
Colour	5.80 ± 1.75	6.11 ± 1.45	5.67 ± 1.21	5.29 ± 1.89	5.63 ± 1.51	5.17 ± 1.17
Odour	6.70± 1.16 ^{b}	6.78 ± 0.83 ^{b}	5.50 ± 1.22 ^{ab}	4.86 ± 1.46 ^{ab}	5.13 ± 1.64 ^{ab}	3.83 ± 1.72 ^{a}
Flavour	7.30± 0.67 ^{c}	7.00 ± 0.87 ^{c}	5.83 ± 1.17 ^{bc}	4.57 ± 1.27 ^{ab}	5.00 ± 0.93 ^{b}	3.17 ± 1.17 ^{a}
Juiciness	6.80 ± 0.79 ^{bc}	7.00 ± 1.00 ^{c}	6.67 ± 1.03 ^{bc}	5.43 ± 0.53 ^{abc}	5.25 ± 0.89 ^{ab}	4.83 ± 2.14 ^{a}
Chewiness	7.50 ± 1.43 ^{c}	7.33 ± 0.87 ^{bc}	6.67 ± 1.03 ^{abc}	5.43 ± 0.79 ^{ab}	5.88 ± 1.55 ^{abc}	5.33 ± 1.75 ^{a}
Overall Acceptance	6.90± 0.88 ^{c}	6.78± 0.67 ^{c}	6.17 ± 0.75 ^{bc}	5.00 ± 1.41 ^{ab}	5.00 ± 0.93 ^{ab}	4.17 ± 1.47 ^{a}

Means with different superscripts are significantly different (p<0.05)

Table 7 – Average values and standard deviations for sensory spoilage indices in SV cooked turkey cutlet stored at 12ºC

	Days							
	0	3	6	9	12	15	18	21
Appearance	6.90 ± 1.37 ^{ab}	6.86 ± 0.69 ^{ab}	6.78 ± 0.97 ^{ab}	7.71 ± 0.76 ^{b}	7.25 ± 0.71 ^{ab}	6.43 ± 1.62 ^{ab}	6.40 ± 1.35 ^{ab}	5.29 ± 2.06 ^{a}
Colour	5.80 ± 1.75	5.29 ± 1.11	6.11 ± 0.60	6.86 ± 0.90	6.00 ± 0.76	5.71 ± 1.50	5.80 ± 1.32	5.00 ± 2.08
Odour	6.70 ± 1.16 ^{c}	6.86 ± 0.69 ^{c}	6.78 ± 0.83 ^{c}	6.43 ± 1.27 ^{bc}	6.13 ± 0.99 ^{bc}	5.00 ± 0.00 ^{b}	5.00 ± 0.82 ^{b}	2.86 ± 1.35 ^{a}
Flavour	7.30 ± 0.67 ^{c}	7.23 ± 0.79 ^{c}	7.00 ± 0.87 ^{c}	6.71 ± 0.95 ^{c}	6.25 ± 1.28 ^{bc}	4.86 ± 1.35 ^{ab}	4.80 ± 1.40 ^{ab}	3.86± 1.68 ^{a}
Juiciness	6.80 ± 0.79 ^{b}	6.57 ± 1.13 ^{b}	6.89 ± 1.17 ^{b}	7.29 ± 1.11 ^{b}	7.00 ± 0.93 ^{b}	6.43 ± 1.81 ^{ab}	6.20 ± 1.62 ^{ab}	4.57 ± 1.27 ^{a}
Chewiness	7.50 ± 1.43 ^{b}	7.29 ± 0.76 ^{b}	7.33 ± 0.50 ^{b}	6.57 ± 0.98 ^{ab}	6.75 ± 1.04 ^{ab}	6.57 ± 1.51 ^{ab}	6.20 ± 0.92 ^{ab}	5.14 ± 2.12 ^{a}
Overall Acceptance	6.90 ± 0.88 ^{bc}	7.14 ± 0.38 ^{c}	7.11± 0.60 ^{c}	6.86 ± 0.90 ^{bc}	6.75± 0.71 ^{bc}	5.43 ± 1.27 ^{ab}	5.50 ± 0.97 ^{ab}	4.00 ± 1.73 ^{a}

Means with different superscripts are significantly different (p<0.05).

by Huss (1988). This result would be corresponded to protein degradation and lipid oxidation during the storage. Although heating at 70ºC inactivates part of the muscle proteases, residual protease activity continues in the refrigerated product (Diaz *et al*. 2008, Diaz *et al*. 2011).

CONCLUSION

For the termination of the storage besides the results of microbiological analysis, sensory analysis points primarily involved and when the flavor and odor points of the samples have dropped below 4 points, it was concluded that the samples have finished their shelf life. With the results of this study it was concluded that turkey cutlets which have cooked with SV method at 65ºC for 40 min protect their freshness for 28 days at 4ºC and 18 days at 12ºC. Considering that the raw turkey cutlet has a shelf life of 8 days, as reported by the producer company, SV cooked turkey cutlet will be more advantageous for the manufacturer and the consumer as well with its longer shelf life. Also product will be placed in the market in cooked and ready to eat forms so that the consumer's preparation time at home will be shortened. SV cooked turkey cutlets satisfy the needs of individuals who are willing to prepare food in a shorter period and it will be an alternative product in our spread fast food consumer society.

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