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Shelf-life and Microbiological Profiler of Chicken Wing Products Following *Sous vide* Treatment

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Abstract: Chicken wings were vacuum-packaged and cooked (*sous vide*) at 75 and 90°C until the internal temperature reached 73.8°C was reached. The cooked samples were stored at 2 and 7°C, separately. The TBA values, aerobic plate count, aerobic and anaerobic plate counts and Warner-Bratzler (WB) shear force of the samples were evaluated weekly for 7 wk. The *sous vide* treatment chicken wings had lower TBA values, aerobic and anaerobic plate counts throughout the 7 wk of storage when compared with the control. The *sous vide* treatment did not affect the WB shear force of chicken wings. At 2°C, the *sous vide* cooked chicken wings had a shelf life of at least 7 wk. Results demonstrate that *sous vide* treatment was an effective method to prevent lipid oxidation during storage and enhance shelf life of chicken wing products.

Key words: *Sous vide*, chicken-wing, oxidation, shelf-life

Introduction

Poultry meat is one of the most popular muscle foods in the U.S. The per capita meat consumption has increased from 56.1 lb in 1985 to 95.8 lb in 1999 (USDA, 2000). Further processing and the development of new products have contributed to the increased demand for poultry meat (Baker and Bruce, 1989). In 1965, only 4% of all U.S. broilers were marketed as further-processed products. However, further-processed products occupied more than 36% of U.S. broiler market in 1995 (Roeningk, 1995). The primary factors to consider for the growth of further-processed poultry are the demands for convenience foods in retail and food service markets (Baker and Bruce, 1989).

Extending the shelf life of poultry products are a major concern for the poultry industry. The shelf life of poultry depends on several factors, particularly initial bacterial loads, storage temperature and the gaseous environment around the product (Mead, 1990). Hence, any technique that could control these factors may be the key for the extension of the shelf life of poultry products. Lipid oxidation is another concern for processed poultry products. It causes deterioration in the quality of products and results in the development of rancid off-flavors and odors.

Recently, there has been an increasing interest in the *sous vide* cooking for the catering and retail markets. The *sous vide* processing prolongs the shelf life and inhibits chemical processes such as oxidation in foods. Additionally, *sous vide* processed products can also retain their freshness and flavor even after several weeks of refrigerated storage (Rhodehamel, 1992). *Sous vide* treatment is described as a processing technique whereby foods are packaged by vacuum and

subsequently pasteurized using a time/temperature combination sufficient to destroy all vegetative pathogens (Kramer, 1988; Schafheitle and Light, 1989). Since *sous vide* products are vacuum packaged, anaerobic conditions can inhibit aerobic spoilage microorganisms and other chemical reaction. The *sous vide* cooked products should have a shelf life of about 4 wk when stored at refrigerated temperatures (Swientet, 1989; Rhodes, 1991; Simpson *et al.*, 1994). Consumer markets show an increased demand for convenience and high quality read-to-eat meals. *Sous vide* products appear to meet these demands and also limit the risks from post process contamination (Conner *et al.*, 1989; Schafheitle and Light, 1989; Rhodes, 1991).

Lipid oxidation and short shelf life are common problems for chicken wing products. Presently, these are limited reports on the stability of *sous vide* cooked chicken wings. Moreover, the cooking and storage temperature greatly affects microbial development and shelf life. Temperature also influences the oxidative rancidity and tenderness of poultry meat. Thus, the objective of this research was to study the effects of *sous vide* treatment on the shelf life and microbial loads of chicken wing products in relation to cooking and storage temperatures.

Materials and Methods

Sample preparation: Fresh chicken wings were obtained from Mississippi State University Poultry Research Center and cut into drumettes, wingnetts and wingtips. For the vacuum packaged treatment, cut-up chicken wing parts in their natural proportions were randomly placed in vacuum pouches (Oxygen permeability 1.0 cc/100 in²/24 hr. At 25°C, 760 mmHg

difference in pressure, International Kenfield Distributing Co. Rosemont, IL) before air evacuating and heat sealing using a Multivac A300 (Multivac, Inc., Kansas City, MO) vacuum packaging machine. The control treatments were made by placing parts in the pouches, cooked at their respective temperature and time, and then heat. In order to reach an internal temperature of 73.8°C, the samples were cooked in a water bath at temperatures of 75 and 90°C for 24 min and 13 min, accordingly. After cooking, the samples were cooled immediately in an ice water bath for 10 min.

The cooked packaged chicken wings were divided evenly and stored at two different temperatures, 2 and 7°C, separately. The total plate counts, total anaerobic counts, TBA values, and texture of the samples were measured at zero time, and repeated weekly for 7 wks. Gram stains of the isolates were conducted after 3, 6, and 7 wks of storage.

Microbial analysis: Samples were placed into a sterile poultry bag, weighed aseptically, and an equal amount of 0.1% Bacto-peptone (Difco, MI) solution was added and shaken vigorously for 1 min. The pour-plate technique (APHA, 1976), was applied for enumerated the microbial load. The aerobic and anaerobic microbial loads were enumerated by using Standard Plate Count Agar (Difco, MI) and Anaerobic Agar, respectively. The anaerobic plates were incubated in a GasPak anaerobic chamber (IQ BBL) at 30°C for 24 hr.

Plates obtained from both the aerobic and anaerobic plates exhibiting approximately 30 colonies per plate were used for isolation. All colonies from the selected plates were isolated, purified and transferred to PCA slants. Fresh cultures prepared from PCA slants were then gram stained using Hucker's modification as recommended by the Society of American Bacteriologists and observed microscopically.

2-Thiobarbituric acid (TBA) values: The TBA values were measured by the distillation method (Tarladgis *et al.*, 1960). Ten grams of the chopped sample were used. TBA values were expressed as mg of malonaldehyde per 1,000g of sample.

Texture measurement: Cores (1.27 cm diameter) were taken from the drumette samples and sheared at right angles to the fiber orientation by using a Warner-Bratzler shear device with 50 x 0.1 lb capacity (G.R. Electric Mfg. Co., Manhattan, KS). Measurements were expressed as the lb force required to shear the cross-section areas from each core.

Statistical analysis: The experiment was conducted using a completely random design (Steel and Torrie, 1980) with at least four replications. Statistical analysis was performed on all data by analysis of variance

(ANOVA) (SAS, 1990). Where difference occurred ($P < 0.05$) the least significant difference (LSD) test was used to separate the means (Steel and Torrie, 1980).

Results

Microbial analysis: Regardless of cooking water temperature or storage temperature, the *sous vide* treated samples exhibited lower ($p < 0.05$) total aerobic plate counts than those of the non-vacuum packaged controls throughout the 7 wk storage period (Fig. 1). The *sous vide* treated chicken wing parts cooked at 90°C had a consistently lower ($P < 0.05$) microbial counts than those cooked at 75°C. As expected, the microbial counts for samples stored at 7°C increased faster than those stored at 2°C (Fig. 1).

In all treatments, no colonies were detected from the anaerobic plates for chicken wings during the first week of storage (Fig. 2). After 2 wk of storage, most of the anaerobic counts increased as the storage time progressed. *Sous vide* treated chicken wing parts cooked at 90°C and stored at 2°C had the lowest anaerobic counts throughout the 7 wk storage period as compared to the other treatments (Fig. 2).

For all treatments except samples cooked at 75°C and stored at 7°C, anaerobic counts of the *sous vide* treated chicken wing parts were lower than those of non-vacuum packed controls (Fig. 2). Regardless of packaging method and storage temperature, anaerobic counts from samples cooked at 90°C were lower ($p < 0.05$) than those cooked at 75°C, and the samples stored at 2°C had lower ($p < 0.05$) anaerobic counts than the samples stored at 7°C (Fig. 2).

After 3 wk of storage, the incidences of aerobic microbial groups from both the *sous vide* treated samples and non-vacuum packed controls were similar (Table 1). The gram-positive cocci species were the dominant organisms found on chicken wings, which accounted for 42-53% of the total microbial population of the samples. The incidence of the gram-positive and -negative rod species from the isolates of aerobic count plates were approximately 20-28% and 19-36%, respectively. No yeast was detected for all treatments after storage of 3 wk. No apparent difference was noted between the two cooking water and storage temperatures.

The incidence of gram-positive cocci species in the chicken wings decreased with storage time increased, however, gram-positive rod species increased for aerobic counts after storage for 7 wk. The incidence of gram-negative rod species for aerobic counts increased for non-vacuum packaged controls and decreased for the *sous vide* treated samples. After 7 wk of storage, the isolates from the aerobic counts represented 13-32% yeast species of the total microbial populations of the *sous vide* treated samples. No yeasts were detected on non-vacuum packaged controls under aerobic conditions. Results also indicated that the *sous vide*

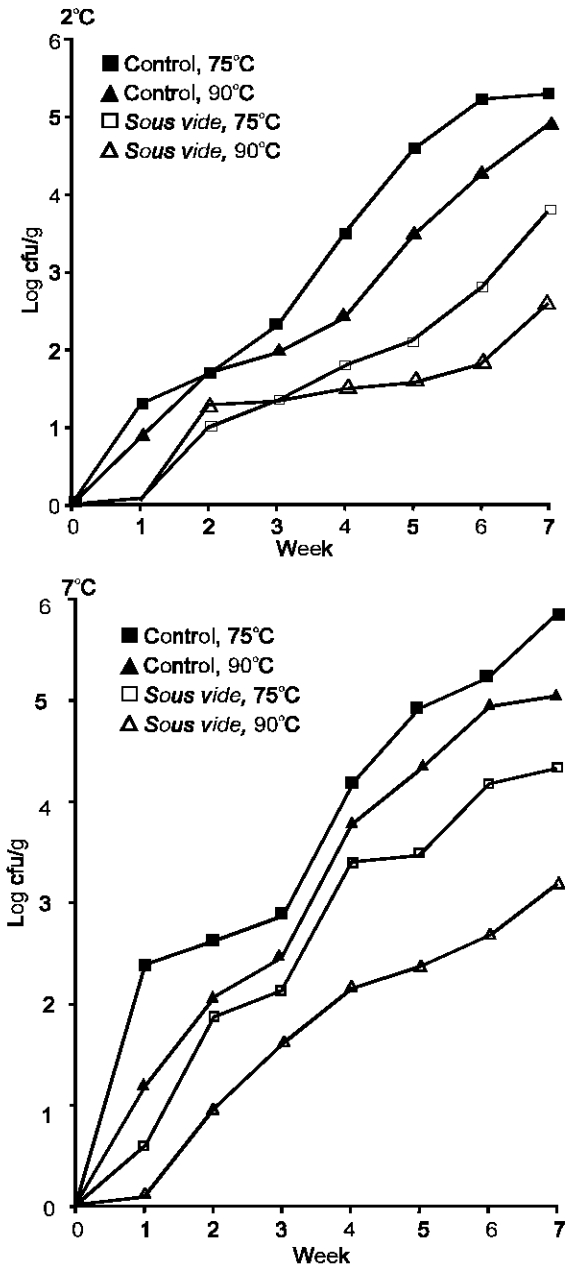


Fig. 1: Effects of sous vide treatment on the aerobic microbial counts of cut-up chicken wings which stored at 2 and 7°C

treatment to chicken wings could raise the growth of yeasts. The growth of yeast was observed on non-vacuum packaged controls under anaerobic conditions. An anaerobic environment seems to be favored for the growth of yeasts.

The incidences of anaerobic groups from both the *sous vide* cooked chicken wings and controls were similar. Approximately 39-67% of the isolated anaerobic bacteria from all treatments were the gram-positive cocci species

when stored for 3 wk. The incidence of the gram-positive rod species ranged from 20-34%. No yeast was observed for the anaerobic group for all treatments during storage for 3 wk (Table 2). The incidence of gram-positive cocci from the anaerobic counts decreased and both gram-positive and -negative rod species increased as storage time progressed.

Results demonstrated that the dominant organisms on the chicken wing parts with or without the *sous vide* treatment were gram-positive cocci species during storage for 3 wk. After 7 wk storage, gram-positive rod species represented the major group for the *sous vide* cooked chicken wing parts.

TBA values: The *sous vide* treated wings exhibited lower ($P < 0.05$) TBA values throughout the 7 wk storage period, as compared to those of the non-vacuum packed controls (Fig. 3). The TBA values of the wings increased ($P < 0.05$) as storage time progressed. *Sous vide* treated chicken wing parts cooked at 90°C stored at 2°C had lowest TBA values throughout the 7 wk storage. The TBA values of *sous vide* treated samples stored at 2°C were lower ($P < 0.05$) than those stored at 7°C when cooked at 75 or 90°C. The cooking water temperature (75 or 90°C) did not affect ($P > 0.05$) TBA values of the *sous vide* treated wing parts. In contrast, the TBA values for the non-vacuum packed samples cooked at 90°C were higher ($p < 0.05$) than those cooked at 75°C when stored at 2°C. Regardless of storage time and cooking water temperature, TBA values of *sous vide* treated chicken wing parts ranged from 1.0-2.0 during 7wk storage (Fig. 3).

Texture: After 2 wk of 2 or 7°C storage, the shear values of chicken meat from drumettes cooked at 75°C tended to be higher ($p < 0.05$) than those of samples cooked at 90°C (Fig. 4). The *sous vide* treatment did not affect ($P > 0.05$) the texture of chicken meat from wings as measured by the WB shear device. There were no major changes ($P > 0.05$) in the shear values of the *sous vide* cooked chicken wing parts during 7 wk of refrigerated storage (2 or 7°C).

Discussion

Microbial analysis: Potter (1986) reported that lower storage temperatures slow microbial growth and activity. Hansen *et al.* (1995) reported that the *sous vide* cooked roast beef was microbiologically stable for at least 5 wk at a storage temperature of 2°C. In this study, the results demonstrated that the shelf life of *sous vide* cooked chicken wings were greater than 7 wk when stored at 2°C (Fig. 1). The results also indicated that the cooking water and storage temperatures were critical to the growth of anaerobic bacteria for the *sous vide* products (Fig. 2). Asensio *et al.* (1988) reported that about 70% of the microorganisms on vacuum packaged pork were

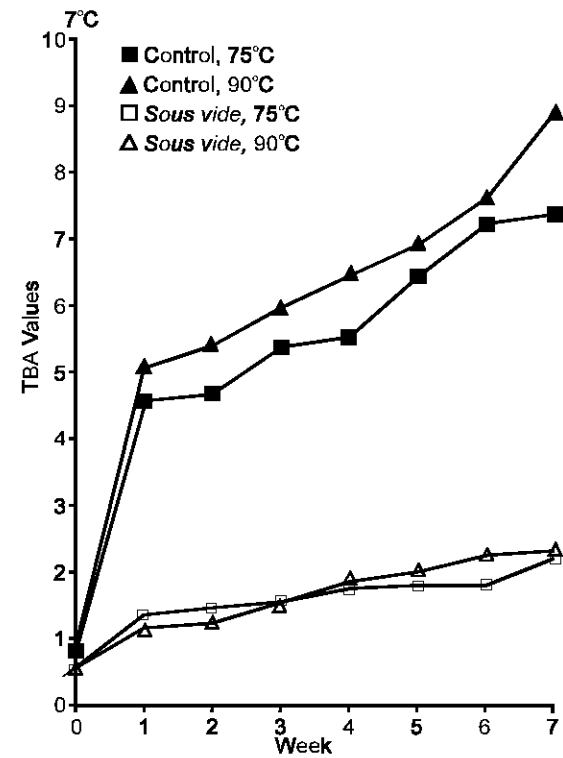
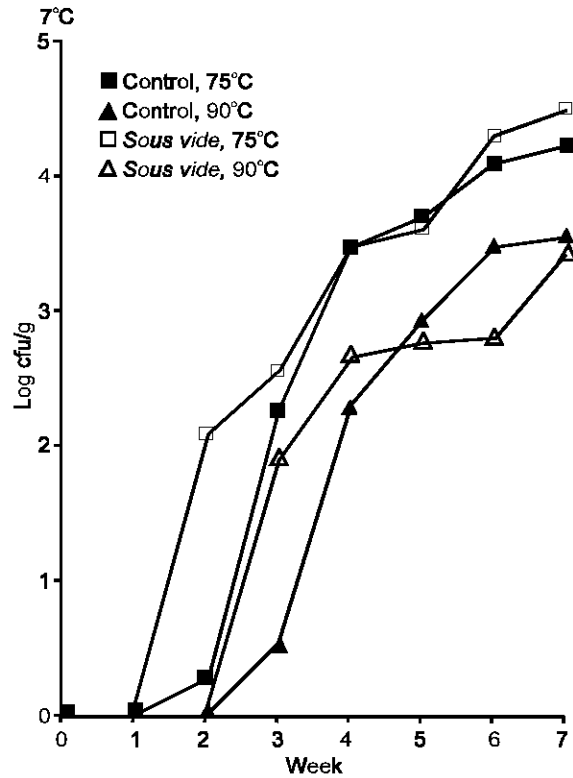
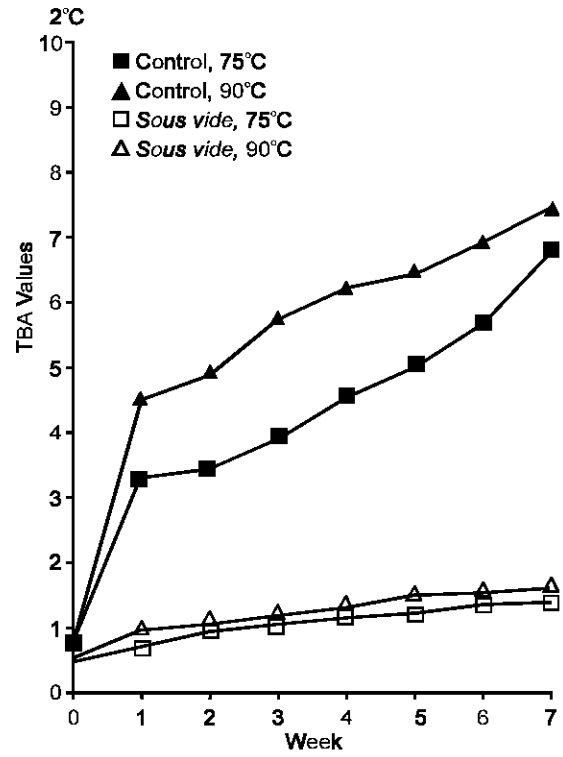
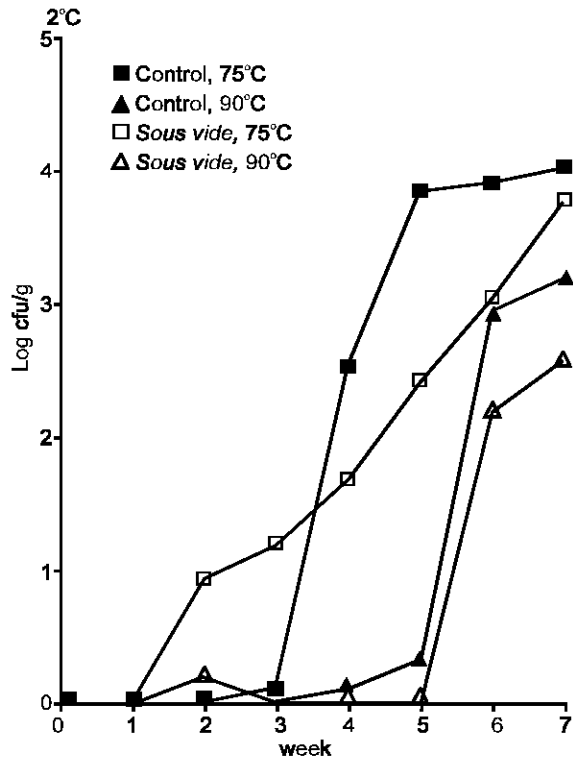


Fig. 2: Effects of *sous vide* treatment on the anaerobic microbial counts of cut-up chicken wings which stored at 2 and 7°C

Fig. 3: Effects of *sous vide* treatment on the TBA values of cut-up chicken wings which stored at 2 and 7°C

Table 1: Incidence of aerobic microorganisms for cut-up chicken wings

Storage Temp. (°C)	Cooking Temp. (°C)	Treatment	% Incidence							
			G+ Cocci		G+ Rod		G- Rod		Yeast	
			3wk	7wk	3wk	7wk	3wk	7wk	3wk	7wk
2	75	Control	45	0	21	24	34	76	0	0
		Sous vide	51	19	20	61	29	6	0	13
7	90	Control	50	0	27	29	23	71	0	0
		Sous vide	53	18	28	50	19	0	0	32
	75	Control	48	0	28	30	24	70	0	0
		Sous vide	43	9	24	69	33	9	0	14
90	Control	42	0	22	37	36	63	0	0	
	Sous vide	48	12	24	45	28	15	0	27	

Table 2: Incidence of anaerobic microorganisms for cut-up chicken wings

Storage Temp. (°C)	Cooking Temp. (°C)	Treatment	% Incidence							
			G+ Cocci		G+ Rod		G- Rod		Yeast	
			3wk	7wk	3wk	7wk	3wk	7wk	3wk	7wk
2	75	Control	40	0	33	46	27	43	0	0
		Sous vide	60	15	25	49	15	23	0	13
7	90	Control	50	12	29	56	21	24	0	0
		Sous vide	67	7	33	66	0	15	0	32
	75	Control	52	0	28	57	21	36	0	0
		Sous vide	52	12	20	39	28	34	0	14
90	Control	39	6	33	48	28	35	0	0	
	Sous vide	55	4	34	57	10	20	0	27	

lactobacilli spp which is a gram-positive rod and the remaining 30% were the members of Enterobacteriaceae which is a gram-negative rod.

TBA values: Results agreed with those of Arafa and Chen (1975), who reported that TBA values of vacuum packaged precooked and pre-fried chicken parts were lower than those of the non-vacuum packaged counterparts throughout 6 mo of frozen storage. Brewer and Harbers, 1992) also reported that vacuum packaged pork had lower TBA values than all other packaging treatments. In 1983, Dawson and Gartner indicated that there was an increase in the rate of chemical reactions with an increase in temperature. This may be a reason for the increase in TBA values of chicken wings as storage temperature increased.

The TBA values were used as an indicator to determine the level of oxidative deterioration of foods containing fats (Sinnhuber and Yu, 1958; Gray, 1978). Oxidative rancidity will cause off-flavor in poultry products during storage. Loss of flavor in cooked meat during storage will produce a warm-over flavor (WOF) (Tims and Watts,

1958) and thus increases the TBA value of the product. It has been reported that oxidative rancidity usually cannot be detected by a sensory panel from chicken meat when the TBA value is below 1.0 (Baker *et al.*, 1972). Greene and Cumuze (1982) indicated that oxidized flavor could be detected by inexperienced taste panels in a range of TBA value between 0.6-2.0 for ground beef.

In this study, the TBA values of non-vacuum packaged controls were more than 2.0 during the first week of storage. Regardless of storage time and cooking water temperature, the TBA values of *sous vide* treated chicken wing parts were controlled on range of 1.0 to 2.0 after 7wk storage (Fig. 3).

Texture: The results of this study (Fig. 4) agreed with Bouton and Harris (1972) who reported the higher temperature resulted in more tender meat exhibiting significantly lower shear force. Hansen *et al.* (1995) indicated that at 62°C the *sous vide* cooked roast beef became significantly more tender than at 59°C as measured by shear force. However, there was no

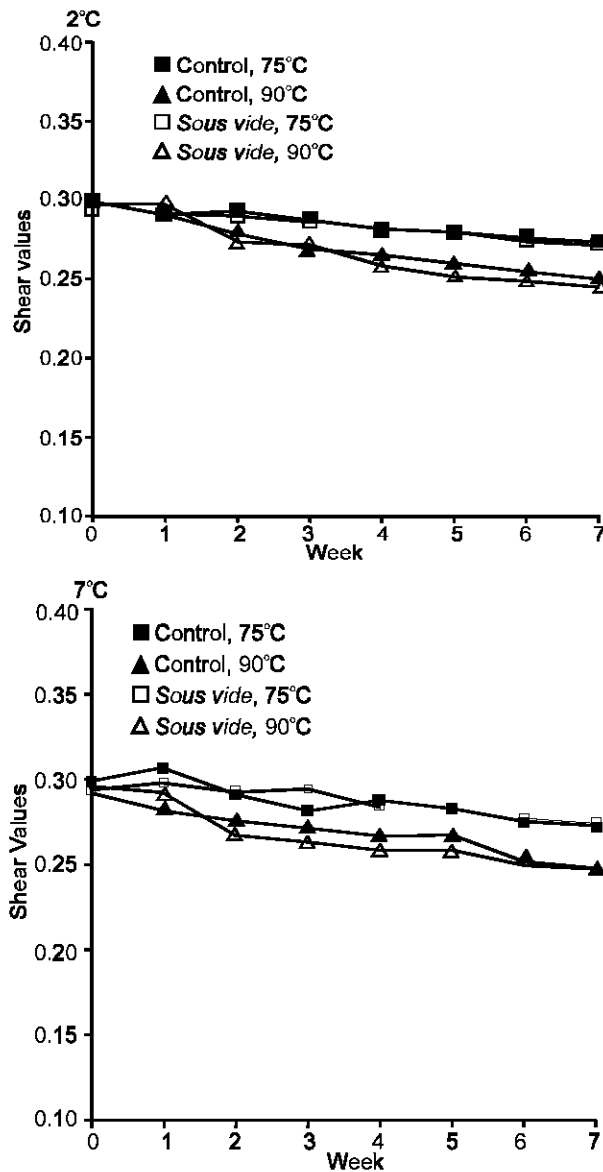


Fig. 4: Effects of sous vide treatment on the shear values (Kg forces/1.27cm² core) of cut-up chicken wings which stored at 2 and 7°C,

significant affect on the texture of chicken meat were treated by *sous vide* treatment (Fig. 4).

Conclusions: The growth of microorganisms on chicken wing parts was affects by cooking water temperature, storage temperature, packaging methods, and storage period. The *sous vide* treatment retarded the microorganism growth within 7 wk storage period in chicken products. The TBA values of the *sous vide* cooked wings were lower than those of the non-vacuum packaged controls throughout the 7 wk storage period. The *sous vide* treatment did nor affect the texture of the

wings as measured by the WB shear device. Based on the above results, it was concluded that the *soud vide* treatment was an effective method to prevent lipid oxidation and the development of WOF during storage and extend shelf life of chicken wing products. Moreover, cooking water and storage temperature are critical for the microbial growth of *sous vide* products.

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Wang et al.: Self-life and microbiological profiler of *sous vide* treated chicken wing products

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