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Evaluation of some Food Product Quality that Packaged under Vacuum

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ABSTRACT

This study was carried out to follow up the absorption of the exterior gases to interior vacuum-packaging products and measure the percentage of O_2, CO_2 and N_2 levels during 56 days of cold storage (4°C) and its effect on the quality stability using four different vacuum packaged products purchase from local retail market; beef frankfurter, chicken frankfurter, smoked whole herring and smoked fillet herring. The analysis at specific intervals of storage up to 14 days included, microbiological (counts of aerobic and anaerobic psychrotrophic microorganisms, coliforms at 37 °C, coagulase-positive staphylococci and Lactic acid bacteria and presence of Salmonella), physical and chemical (thiobarbituric acid values, pH, and Warner- Bratzler shear force), sensory (acceptance testing using a 9-point hedonic scale) and gas composition analyses were performed. All samples remained relatively stable with respect to the majority of the evaluated physical and chemical indexes and within the standards established by Health Protection Agency (HPA) for pathogenic microorganisms throughout the 56th storage period. However, with respect to shear force values and texture scores of smoked whole and fillet herring samples provided decreasing stability after 42 & 56 days of storage despite presenting good appearance preference. The results emphasized that changes in the quality of different products packaged under vacuum are unsignificantly influenced by the cold storage periods if vacuum-packaging process will done adequately, using packaging material with low permeability of gases, then sealing best and kept the product in consistent refrigeration.

Key words: Vacuum, packaging, chilling temperature, shelf-life, storage, gases absorption, abused temperature.

Introduction

Vacuum packaging has proven to be efficient in extending the shelf life preserving the sensory characteristics inherent to the meat product for period sufficiently long for its turnover, but the challenges currently facing the meat industry is the "blowing" of packages of vacuum-packaged by microorganisms.

As a result of an increasing demand for ready to use fish and meat products, a need has emerged for further studies involving the possibility of extending shelf life of the vacuum packaging refrigerated meat. It is quite known that this conservation technology, when applied to perishable food as fresh meat, results in a shorter shelf life.

Aytunga and Semra (2015) showed that successful storage of vacuum-packaged meat products requires the following precautions, i.e, the use of oxygen-impermeable films, through evacuation, control of seam or slip closures, good hygiene; appropriate storage temperatures and low illumination.

Recently: researchers classified packaging materials (Table 1) according to its degree of permeability to water vapor, aromas and gases, especially oxygen (Tamador *et al*., 2016).

Table 1: Classified packaging materials according to its degree of permeability to water vapor, aromas and gases, especially oxygen

Degree of gas permission	Permeability	Gas – permeability			Water-vapor permeability
		O_2 cc/m²/24hrs.	N_2 cc/m²/24hrs	CO_2 cc/m²/24hrs	gm/m²/24hrs/atm
High	HDPE	3501	2301	5185	0.7
Middle	PA/PE	23	5	72	3.0
Low	PET/AL/PE	0	0	0	0

HDPE: high density poly ethylene, PET: Polyester, PA: Polyamide, AL: Aluminum foil

Even under ideal conditions (Lack of oxygen and chilled temperature), food that is not cooked may harbor pathogenic and anaerobic bacteria, which can grow during the storage of the product. These foods are expected to have a long shelf life, some up to 100 days. Thus, even an initial population of anaerobic of 10^1/g or less can multiply and achieve numbers that could cause deterioration or make the food insecure. If

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the food is submitted to temperature abuses, the situation is aggravated. Some mesophilic and anaerobic bacteria that are unable to grow at temperatures lower than 5°C can occur during short rises in temperature, drastically reducing the shelf life of safety of the product (Nurcan *et al*., 2012).

During refrigeration, the vacuum allows the shelf life of the meat to be extended by reducing oxidation and the growth of aerobic microorganisms of the established meat packaging systems, the vacuum has been the most widely used in the institutional market for the distribution of whole pieces (Sarantopoulos *et al*., 2002). In North America, approximately 85% of fresh meet and most processed meats are packed in a modified atmosphere, including the vacuum system (Rafaella *et al*., 2014).

The deterioration of vacuum-packaged chilled raw products-like meat-is frequent; sometimes it occurs in large proportions of the same batch. The bacteria that have been isolated from vacuum-packaged products can be classified as aerobic or anaerobic, depending on the conditions under which it occurs and the microorganisms involved (Rafaella *et al*., 2014) and have been characterized as either new species or as species that were previously considered to be harmless. Examples of such species include Clostridium species, Enterococcus spp., and some others from the Enterobacteriaceae family. These bacteria are present in the environment but are probably not the dominant species of the microbiota. For meat contaminants, the use of vacuum and long-term storage at refrigeration temperatures may promote the growth of some of these bacteria, allowing them to become dominant and deteriorate the product, and the availability of oxygen determines the type of organism that will grow. (Tamador *et al*., 2016).

Vacuum-packaged meats are generally quite stable at low temperatures, while the shelf life of meat that is packaged with films that are highly permeable to oxygen is approximately one week, the shelf life of vacuum – packaged meat is around 3 to 12 weeks, when stored at 0 °C (Katarzyna *et al*., 2015).

Lowest temperature that can be used without the product freezing (–1.5 °C) in higher than the minimum temperature for the growth of some psychrotrophic bacteria. Preventing growth of these organisms requires freezing (Holley and Gill, 2005). Despite the increased shelf life, fresh meat packed under vacuum will deteriorate after some time.

The conservation of the vacuum inside the package is achieved by the complete removal of air from the head space and appropriate sealing using heat-sealing machines. If the product contains dissolved oxygen, however, aerobic and microaerophilic microorganisms may still be able to grow at refrigeration temperatures. This can also occur if the material is relatively permeable to atmospheric oxygen. Thus, low concentrations of residual oxygen, especially in packages containing meat with a high pH, will contribute to rapid deterioration. (Holley and Gill, 2005).

Several microorganisms have been found in vacuum-packaged chilled meat, including lactic acid bacteria, the population of lactic acid bacteria is generally below the limit of detection (10 CFU/g), but it increases during storage. Lactic acid bacteria ferment glucose and other substrates that are present in meat. When these substrates are depleted, growth stops, typically whien the population reaches 8 log/cm^2 (Nurcan *et al*., 2012).

Also Clostridium spp. such as C. estertheticum, which is able to grow at refrigeration temperature can grow and cause different types of spoilage, can cause pack distension and have been identified as causative agents of blowing vacuum packages (Singh *et al*., 2011). The deterioration caused by psychrotrophic & psychrophilic clostridium is associated with proteolysis, loss of texture, accumulation of liquid in packages and an unpleasant smell, mainly hydrogen sulfide gas (Mieke *et al*., 2014).

Recently, new genera, such as Enterobacteriaccea, have also been shown to cause the same problem in vacuum-packaged meat. It is characterized by unpleasant odors and/or greening of the meat, instead of gas production (Naveena *et al*., 2015). The proliferation of this bacterium in vacuum packed meat is generally limited to products with a pH greater than 5.8 and is more likely to occur with temperature abuses above 6 °C (Stasiewicz and Lipinski, 2014).

Recent research on blown packs of chilled fresh meat stored at 4°C detected in New Zealand detected a moderate to high number of pathogenic Enterobacteria. The researchers demonstrated the potential of them to cause blown pack, when these species were artificially inoculated (10^5 CFU/g) in vacuum packed chilled lamb and stored for 21 days at 4°C (Katarzyna *et al*., 2015).

Studies on the composition of gases and volatile compounds in vacuum packaged chilled meat are scarce. The group of Bromberg (2003) detected the presence of CO_2 and N_2 in rump steak samples with blown pack problems. This gas composition suggests the psychrotrophic clostridium are probable causative agents; however, this genus was not isolated from the samples studied.

Pavankumar *et al*., (2003) investigated the effects of vacuum packaging on the micro quality of tandoori chicken stored at 4°C or -18°C. Chicken stored without vacuum packaging as a control. Microbiological quality of tandoori chicken under vacuum was unacceptable after storage at 4°C,

compared to 6 days storage without vacuum packaging. Aerobic plate count increased from an initial level of 3.67 CFU/g to 6.75 CFU/g by the 15th day in vacuum packaging while it reached 6.18 CFU/g in control packs by the 6th day of storage at 4^{o}C. Psychrotroph counts also increased markedly from an initial level of 0.05 to 6.18 CFU/g in control packs by the 6th day and 5.69 CFU/g vacuum packaging by the 15th day. APC of the tandoori chicken increased marginally in packs during the storage period of 40 days at -18^{o}C to reach a level of 4.75 CFU/g from an initial count. Results indicated that the shelf life of tandoori chicken was extended considerably at lower temperatures under vacuum.

Fernandes *et al*., (2014) evaluated the stability of vacuum packaged lamb lion, stored at 4^{o}C for 28 days. In spite of maintenance of the main physical and chemical quality parameters during the evaluated period, the authors noticed an important increase of spoiling microorganisms counts from the 7th to 14th day of storage, limiting the product shelf life.

The objective of this paper:

Firstly; Is to give an overview of the permeability of exterior gases to interior vacuum packs, which occur during cold storage of random chicken, meat and fish product samples was taken from local retail market immediately after production.

Secondary; Is to study the effect of this relatively permeate gases on the microbial quality, sensory attributes and the shelf life of the samples during cold storage at 4^{o}C.

Material and Methods

Four vacuum-packaged samples in polyamide/polyethylene packaging material were purchased from a local retail market, immediately after its production (April 2016).

These samples included; Beef Frankfruter, Chicken Frankfruter, smoked whole Herring and smoked fillet Herring.

All Samples were kept under refrigeration (4^{o}C) for 56 days and were drawn for analyses at specific intervals of storage up to 14 days. Physical, chemical and sensory evaluations of samples were analyzed on 1, 14, 28, 42, 56 days of storage period. All analyses were performed in Food Technology Institute, Department of Food Engineering & Packaging Laboratory. The analyses were replicated twice.

Physical analyses:

Head space gas analysis:

Gas compositions in packages were measured during storage by Oxygen gas analyzer WITT-GASETECHNIK Gmb H & CO, KG, Germany. It was measured by directly sinking the needle into package, O_2 and CO_2% were monitored by digital screen, according to the method described in Sarantopoulos *et al*., (2002).

Shear force value:

The procedure of Smith *et al*., (1991) was followed with suitable modification for determining the shear force value. Shear force (kg) required to shear 2 cm cubes of each sample was measured with the help of Warner-Bratzler (W-B) shear press of 25kg capacity. Minimum of twenty shear force recordings (kg/cm^2 cubes) were noted from each sample.

Chemical analysis:

pH determination:

The pH value was recorded by a pH meter (Hanna 210 pH meter). Five grams of minced sample were blended with 50 ml. of distilled water. The slurry was filtered with #1 whitman filter paper. The filtrate pH was measured using the pH meter. The measurements were taken after the end of microbiological analysis for each sample (Strange *et al*., 1977).

Total Meat Oxidation Testing (TBA):

The extent of lipid oxidation was determined by the TBA method. TBA was determined after one day of production and every 14 days during storage at 4°C. lipid oxidation level of samples was assessed by measuring 2-thiobarbituric acid reactive substances (TBA) method. After sample preparation steps, 10-g sample was reacted with thiobarbituric acid rective substances. Absorbance values were evaluated by using Schimadzu UV-1601 Spectrophotometer (Japan) at 538 nm wavelength (Strange *et al*., 1977).

TBA value (mg malon dialdehyde/kg sample) = 7.8×A
A= Absorbance value at 538 nm.

Sensory attributes:

Sensory colour & appearance, odour, texture and overall acceptability were evaluated by a panel of seven judge comprising of scientists of the institute by using 9-point Hedonic scale (Keeton, 1983).

Microbiological Examinations:

The effects of storage times upon microbial growth were studied. All results are average values of duplicate samples from four studied products and were expressed as log10 CFU/g (colony forming units/g).

Aerobic and anaerobic plate count:

Total counts of aerobic & anaerobic psychrotrophic microorganisms were performed according to the methodology described by Johnston and Tompkin (1992). Packages were aseptically opened and 9 grams of sample were mixed with 99 ml of sterile phosphate buffer in a stomacher bag. The content was stomached for 2 minutes in Seward Stomacher 400 (Tekmar, Cincinnati, OH). Pshychrotrophic counts were incubated at 35°C for 48 hours, anaerobically at 35°C for 5 days, and at 7°C for 10 days respectively.

The presence of Salmonella: was determined using a rapid pre-enrichment method (A.O.A.C, 2009). The incubation of the 10^{-1} dilution for 24h at 35°C.

Coagulase – positive Staphylococci: were identified following the A.O.A.C (2009). Samples incubated at 37°C for 24h. Confirmation was carried out with Petrifilm Staph Express disk when there were formation of different types of colonies.

Total coliforms: were identified using the methods of Horwitz and Latimer (2007). After inoculation, samples were kept at 37°C for 48h in order to verify the formation of colonies.

Lactic acid bacteria: were identified using the methods described by Lauzurica *et al*. (2005). The method employed deep inoculation, plates were placed unside down in jars containing generating anaerobiosis system and incubated at 36°C during 48 hours.

Statistical analysis:

Data were analyzed, following the procedure of Snedecor and Cochran (1980) in the computer center of the institute. Mean and standard errors were calculated for different parameters. The data were subjected to analysis of variance and paired comparison test. In significant effects, least significant differences were calculated at an appropriate level of significance.

Results and Discussion

Head space composition

The changes in gas composition and its volume in vacuum-packaging samples (Table 2) is dynamic and were occurred due to gas absorption into the products during the permeability of the materials and

sometimes due to microbial metabolism (Nurcan *et al*., 2012).

In the present study, a continuous markable increasing was observed in O_2 levels in all samples during 28 days of storage. This increase can be expected due to the relatively permeable of packaging material (Polyamide/ Polyethylene) at cold storage and/or due to oxygen absorbers, if heat-sealing system of pouches did not occur appropriately and gas flushed in slight vacuum.

After the 28 day, O_2 level began to decrease until the and of storage (56 days). Conversely, it was observed that CO_2 levels decreased over the first 28 days of storage, the observed decrease can be explained by its solubility in the humidity of product samples (Bingol and Ergun, 2011). At the same time N_2 level were increased during the storage, perhaps due to nitrogen has low solubilities in water and lipids (McMillin, 2008). The severe reduction in CO_2 levels after 42 and 56 days of storage in smoked whole & fillet herring samples which it reached 13.3 and 11.0% & 11.0 and 10.9% respectively (Table 2), can be expected due to increasing the tenderness of the fish muscles after this period of storage, and subsequent increasing the level of dissolved CO_2 volume in the surface of the muscles.

Table 2: Changes in gas composition values* in package headspace during storage of samples at 4ºC for 56 days

Gas composition	Days	O_2 (%)	CO_2 (%)	N_2 (%)
Beef Frankfurter	14	1.4	51.7	46.9
	28	10.5	35.0	54.5
	42	8.9	36.1	55.0
	56	7.4	36.4	57.2
Chicken Frankfurter	14	2.9	49.9	47.2
	28	12.3	38.8	48.9
	42	10.6	39.3	50.1
	56	9.8	40.4	49.8
Smoked herrings (whole)	14	5.2	48.1	46.7
	28	16.7	32.5	50.8
	42	14.3	13.3	72.4
	56	12.5	11.0	76.5
Smoked herrings (Fillet)	14	6.3	46.7	47.0
	28	16.9	27.2	55.9
	42	14.7	11.0	74.3
	56	12.9	10.9	76.2

** Each value is the mean of three samples analysed.*

pH value

Initial pH values of all samples were between 5.50 and 5.60 (Table 3). Such as increase in pH reflects the degree of spoilage of the meat as a result of protein breakdown for the production of free amino acids which leads to the formation of NH_3 and amines, both of which are compound that result from alkaline reactions (Karabagias *et al*., 2011).

Nevertheless, in all vacumm-packaged samples, the pH decreased for a period of 14 days due to the production of lactic acid through lactic acid bacteria metabolism which was favored by the low-oxygen environment, in addition to the dissolution of CO_2 into the aqueous phase of the meat product (Gok *et al*., 2008).

After the 14 days, pH values of samples regularly showed an slight increase during the storage period (Table 3) to between 5.92 and 6.05 values at the end of the storage period.

Karabagias *et al*., (2011) defined that when pH reached above 6.2; meat products begins to deteriorate. All experimental samples did not reached the critical pH level until the end of storage (56 days), the minimum increasing in pH values of all samples during 7 weeks of storage could be attributed to its low storage temperature (4ºC) and to carbon dioxide dissolving in product samples.

Warner-Bratzler Shear Force values

Changes in Warner-Bratzler shear force values (kg/cm^2/cubes) of vacuum-packaging samples stored at 4ºC showed in Table (3): While shear force values of B.F, C.F, W.S and B.S samples were 0.83, 0.84, 0.77 and 0.75 kg respectively, at the beginning of the storage period (one day). These values did not changed up to 14 days. Maca *et al*., (1997) reported that hardness and fracturability of the vacuum-packed

beef patties stored at 4°C did not increase with storage up to 14 days. Our results are compatible with its reported values.

Samples became firmer on day 28, which these values increased to 0.90, 0.92, 0.84 and 0.80 kg for B.F, C.F, W.S and B.S samples respectively (Table 3). This is the maximum increase ratio of shear force was observed during the storage period, it may be due to solidification of meat fat.

During prolonged chilled storage, shear force values were decreased until the end of storage but the lowest shear force values was observed in herring samples after 42 and 56 days of storage.

Rodriguez-Calleja *et al*., (2010) reported that under anaerobic conditions, softerning might be related to autolytic activities, which during prolonged chilled storage tenderize the meat product, and ultimately degrade the texture of muscle tissues, furthermore, microbial growth causes to the changes in texture attributes of muscles. Therefore, smoked whole herring and smoked fillet herring samples were softer than beef and chicken frankfurter samples after 42 and 56 days of cold storage.

Table 3: Physico-chemcial properties of vacuum-packaging samples during storage at refrigeration (4°C)

Characteristics	Sample	Storage period per days				
		1	14	28	42	56
pH value	B.F	5.60	5.57	5.74	5.81	5.93
	C.F	5.57	5.53	5.70	5.79	5.92
	W.S	5.52	5.50	5.73	5.88	6.05
	B.S	5.53	5.50	5.69	5.83	5.96
TBA value (mg molonaldehyde per kg)	B.F	0.157	0.166	0.538	0.547	0.550
	C.F	0.151	0.159	0.520	0.538	0.539
	W.S	0.253	0.260	0.629	0.646	0.649
	B.S	0.247	0.253	0.608	0.624	0.628
Shear force value (kg/cm^2)	B.F	0.83	0.83	0.90	0.81	0.72
	C.F	0.84	0.84	0.92	0.84	0.76
	W.S	0.77	0.77	0.84	0.79	0.63
	B.S	0.75	0.75	0.80	0.77	0.59

B.F: Beef frankfurter *W.S: Whole smoked herrings*
C.F: Chicken Frankfurter *B.S: Fillet smoked herrings*

Thiobarbituric acid values

The level of lipid oxidation and increasing the TBA numbers was associated with the level of oxygen in vacuum-packaged meat and remained low if O_2 level remained low during storage (Zakrys *et al*., 2009).

Cold or freezer storage does not inhibit the activity of lipases that break down fat (Limbo *et al*., 2010). The compounds produced during the oxidative degradation of lipids are the primary cause of deterioration in meat products quality during storage. Oxygen persent in the packaging has been shown to exert prooxidative effects and formation of harmful products like malondialdehyde (Gok *et al*., (2008).

Results of this study show that TBA levels of all samples were determined below the limit of 1mg MA/kg "the level of fat rancidity (Taylor *et al*., 2007). TBA values were 0.157, 0.151, 0.253 and 247 mg MA/kg for Beef, chicken Frankfurter, whole herring and fillet herring samples respectively. Levels of lipid oxidation remained low until the 14 day, in all samples and became more rapidity until the 28 day of cold storage, due to increasing the absorption of O_2. After this period and with the beginning of increase CO_2 level inside the packaging of the samples, lipid oxidation rate deceased which CO_2 will deaccelerated it and keeping the TBA scores. This was attributed to pH reduction.

At the end of storage period, TBA values reached to 0.550, 0.539, 0.649 and 0.628 for beef, chicken frankfurter, whole herring and fillet herring samples respectively.

The high level of TBA numbers in fish samples could be due to the high level of unsaturated fatty acids which facilitates the interactions of prooxidants with these fatty acids resulting in the generation of free radicals and propagation of oxidative reactions which led to shorten the shelf life (Limbo *et al*., 2010).

Microbiological stability

No Salmonella or Coagulase-positive staphylococci microorganisms (<10 CFU/g) were detected throughout the study period in the different product samples until the day 28 (Table 4). Only Staphylococci was detected at 42 days and 56 days of cold storage for the vacuum packaging of whole and fillet herring samples, but the counts remained within the acceptable limits established by HPA (2009). A sporadic

count of thermotolerant coliforms was detected at 14 days of storage for whole and fillet herring samples and at the 42nd day for beef and chicken frankfurter samples, which was likely due to possible contamination during manipulation.

Therefore, studied samples which packaged under vacuum and stored at refrigeration used in the present study remained with the safe acceptable limits.

The maximum acceptable counts for vacuum packed meat are 10^4 for thermotolerant coliforms, $3X10^3$ for coagulase – positive staphylococci and zero Salmonella in a 25g sample (HPA, 2009).

The obtained counts of aerobic and anaerobic psychrotropic microorganisms and Lactic acid bacteria are shown in Table (4). The results obtained revealed that the counts of anaerobic psychrotrophic microorganisms and Lactic acid bacteria remained stable from he beginning to the fourteen day of storage for all the four vacuum packaging samples with a markable increase in anaerobic counts.

A more rapid growth was noted for these groups from fourteen to the 28th day of storage except anaerobic ones, was decreased due to the increasing volume of O_2 inside the packages, during this period. Then less microbial growth was observed for all groups from the 28th day to the 42nd day of storage. On day 56th day of storage the level of growth increasing became similar to the level of the 28th day.

Less microbial growth in vacuum-packed samples, demonstrating the effective action of CO_2 on the microbiological stability in these products. This information is consistent with the literature, where concentrations of both CO_2 and O_2 equal to or greater than 10% can inhibit aerobic and anaerobic bacterial growth respectively (Livingston *et al*., 2004).

Table 4: Microbial populations for different vacuum-packaging product samples during storage at 4°C.

Sample	Aerobic bacteria (log 10 CFU/g)	Anaerobic bacteria (log 10 CFU/g)	Lactic Acid bacteria (log 10 CFU/g)	Total coliform (CFU/g)	Coagulase-positive staphylococci (CFU/g)	Salmonella (CFU/g)
Day1						
B.F	1.02	2.15	1.24	ND	ND	ND
C.F	1.13	2.19	1.30	ND	ND	ND
W.S	1.22	2.40	1.06	ND	ND	ND
B.S	1.27	2.62	1.10	ND	ND	ND
Day 14						
B.F	1.38	2.45	1.55	ND	ND	ND
C.F	1.49	2.53	1.67	ND	ND	ND
W.S	1.75	2.70	1.82	15	ND	ND
B.S	1.87	2.92	1.93	11	ND	ND
Day 28						
B.F	3.77	1.17	3.66	ND	<10	ND
C.F	3.84	1.16	3.89	ND	<10	ND
W.S	4.23	1.54	4.74	14	<10	ND
B.S	4.61	1.80	4.87	27	<10	ND
Day 42						
B.F	1.82	1.19	2.09	5	<10	ND
C.F	1.90	1.22	2.24	12	<10	ND
W.S	2.56	1.70	2.43	130	5	ND
B.S	2.78	1.99	2.67	240	12	ND
Day 56						
B.F	2.07	3.23	3.38	45	<10	ND
C.F	2.18	3.34	3.69	110	<10	ND
W.S	3.11	4.53	4.11	4100	14	ND
B.S	3.40	5.18	5.14	8200	23	ND

B.F: Beef frankfurter *W.S: Whole smoked herrings*
C.F: Chicken Frankfurter *B.S: Fillet smoked herrings*

Rafaella *et al*., (2014) states that a 50% inhibition of psychrotrophic microorganism growth can be achieved in systems containing atmospheres with 20% CO_2, and the samples submitted to this level exhibited lower microorganism counts on the order of one logarithmic cycle.

Results revealed that Lactic acid bacteria as facultative anaerobic bacteria are the most frequently isolated bacteria from the four different samples since they are tolerant to CO_2 and low temperature, and generally become numerically dominant in such environments. There was no difference between our notes and karabagias *et al*. (2011) statement. They found that Lactic acid bacteria were grown in high

concentration of CO_2 and in vacuum conditions as specific spoilage organisms, so, they constitute a substantial part of the natural microflora that occur in vacuum packaging meats.

Sensory attributes:

In general, all the sensory attributes that is colour & appearance, odour, texture and over all acceptability indicated a slight decreasing trend insignificantly throughout the entire storage period at 4°C in both different samples (Table 5).

However, texture scores of both products were non-significantly different during whole storage except the scores of day 42 and 56 for smoked whole & fillet herring samples as compared to 1st day scores for them which texture scores were significantly different ($p<0.05$).

Therefore, overall acceptability scores for whole storage period except 42 and 56 day in smoked samples were found non-significantly different. So the comparative study was not conducted for products own adequate vacuum packaging system and stored at good chilling conditions (1-4°C).

Table 5: Sensory attributes of vacuum-packaging product samples during storage at 4°C (Mean* ± SE)

Particulars	samples	Days of storage				
		1	14	28	42	56
Colour & appearance	M.F	$7.38^{a}\pm0.08$	$7.36^{ab}\pm0.08$	$7.33^{ab}\pm0.08$	$7.19^{ab}\pm0.08$	$6.98^{ab}\pm0.08$
	C.F	$7.35^{a}\pm0.08$	$7.32^{ab}\pm0.08$	$7.30^{ab}\pm0.08$	$7.11^{ab}\pm0.08$	$6.94^{ab}\pm0.08$
	W.S	$6.27^{a}\pm0.06$	$6.25^{a}\pm0.06$	$6.22^{abc}\pm0.06$	$6.08^{abcd}\pm0.06$	$5.91^{abcd}\pm0.06$
	B.S	$6.19^{a}\pm0.06$	$6.17^{a}\pm0.06$	$6.13^{ab}\pm0.06$	$6.02^{bcd}\pm0.06$	$5.80^{bcd}\pm0.06$
Odour	M.F	$7.28^{a}\pm0.06$	$7.25^{abc}\pm0.06$	$7.20^{abc}\pm0.06$	$7.17^{abc}\pm0.06$	$7.14^{abc}\pm0.06$
	C.F	$7.17^{a}\pm0.06$	$7.15^{abc}\pm0.06$	$7.12^{abc}\pm0.06$	$7.09^{abc}\pm0.06$	$7.05^{ab}\pm0.06$
	W.S	$6.54^{a}\pm0.07$	$6.52^{ab}\pm0.07$	$6.49^{abc}\pm0.07$	$6.44^{abc}\pm0.07$	$6.40^{bc}\pm0.06$
	B.S	$6.51^{a}\pm0.07$	$6.49^{ab}\pm0.07$	$6.46^{abc}\pm0.07$	$6.41^{bc}\pm0.07$	$6.37^{bc}\pm0.06$
Texture	M.F	$7.42^{a}\pm0.08$	$7.39^{a}\pm0.08$	$7.37^{ab}\pm0.08$	$7.32^{ab}\pm0.08$	$7.29^{b}\pm0.08$
	C.F	$6.74^{a}\pm0.05$	$6.71^{a}\pm0.05$	$7.68^{ab}\pm0.05$	$6.63^{ab}\pm0.05$	$6.61^{b}\pm0.05$
	W.S	$6.46^{a}\pm0.07$	$6.42^{ab}\pm0.07$	$6.37^{ab}\pm0.07$	$6.10^{abc}\pm0.07$	$5.76^{bcd}\pm0.07$
	B.S	$6.20^{a}\pm0.06$	$6.15^{ab}\pm0.06$	$6.10^{ab}\pm0.06$	$5.74^{abc}\pm0.06$	$5.51^{bcd}\pm0.06$
Overall acceptability	M.F	$7.33^{a}\pm0.06$	$7.31^{ab}\pm0.06$	$7.27^{abc}\pm0.06$	$7.24^{abc}\pm0.06$	$7.22^{abc}\pm0.06$
	C.F	$7.22^{a}\pm0.06$	$7.20^{ab}\pm0.06$	$7.16^{abc}\pm0.06$	$7.10^{abc}\pm0.06$	$7.08^{abc}\pm0.06$
	W.S	$6.46^{a}\pm0.05$	$6.43^{abc}\pm0.05$	$6.39^{abcd}\pm0.05$	$6.18^{abcd}\pm0.05$	$5.89^{bcd}\pm0.05$
	B.S	$6.25^{a}\pm0.05$	$6.23^{abc}\pm0.05$	$6.18^{abcd}\pm0.05$	$5.97^{abcd}\pm0.05$	$5.78^{bcd}\pm0.05$

** Means with different superscript in a row differ significantly (P<0.05)*
M.F: Meat frankfurter *C.F: Chicken frankfurter*
W.S: Whole smoked herrings *B.S: fillet smoked herrings*

Conclusion:

It is essential that the developments in packaging technology should reduce the cost, provide a longer shelf life and assure food safety.

In our comparative study using four different vacuum-packaged products stored at 4°C showed that vacuum packaging had the most preservative effect during storage time, if its vacuum system was carried out adequately and the packages contain a very low level of oxygen percent, which high-oxygen atmosphere packaging shortened shelf life by increasing microbial growth and lipid oxidation.

Samples did not show much change in their physico-chemical characteristics, microbiological profile and sensory attributes. Although, they all were in decreasing trend but their values were very well under the acceptable limit.

So we can say that, vacuum packaging for such meat products may be a good alternative to the modified atmosphere packaging combination. Though we cannot definitely comment on the shelf life of the product.

Also we can say that, abused storage temperature limits the shelf life of these products.

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