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Influence of Multi-layer Flexible Films and Modified Atmosphere Packaging on Sensory Properties of Fresh Ostrich Meat

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ABSTRACT

In this study the effect of different concentrations of two gas mixture (carbon dioxide, nitrogen) ,and also vacuum condition and flexible multi-layer films has been studied on sensory evaluation of fresh ostrich meat at refrigerator condition (T= 4 ^{0}C) . Samples were packaged in 3 kinds of flexible multi-layer containers under different gases,{3-layer$PET_{(12)}/AL_{(12)}/LLD_{(100)}$) ,and 4-layer ($PET_{(12)}/AL_{(7)}/PET_{(12)}/LLD_{(100)}$) and 3-layer($PET_{(12)}/AL_{(7)}/LLD_{(100)}$ }. Ordinary condition as a control packaging was compared with three type of modified atmosphere packaging: ($N_2$70%+ $CO_2$30%), ($N_2$30% + $CO_2$70%), and vacuum conditions, in this project. Fresh ostrich meat were performed sensory evaluation, in different (15 days), with 12 treatment 3 run, statistical analysis and comparison of data, were done by software SAS (Ver:9/1) and Duncan's new multiple range test, with confidence level of 95% (P <0.05). The shelf life of fresh meat ostrich (according to organoleptic properties) were reported in 4-layer under gas compositions 1 & 2 , 15 and 13 days and under vacuum conditions it was 10 days. In 3-layer (AL:12) the shelf life was 14 and 10,7 days under the gas compositions 1 & 2 and vacuum conditions. Under gas compositions 1 & 2 ,with 3-layer (AL:7), the shelf life was 10 and 7 days and under vacuum conditions it was 6 days. Sensory evaluation showed that increasing CO2 concentration increased shelf life. During the period of this experiment sensory properties (appearance, color, texture, smell, taste, dripped water) of samples in various conditions, had significant differences. According to these results, the best condition for sensory evaluation belonged to treatment under modified atmosphere CO2 70% with flexible pouch 4-layer,since water vapor permeability in this 4-layer was less than 3-layer and increasing percentage of CO2, maintained long-term shelf life and organoleptic properties of fresh ostrich meat.

Keywords: Modified atmosphere packaging (MAP), fresh ostrich meat, sensory properties, flexible multi-layer films (3-layer and 4-layer).

INTRODUCTION

The objective of any system of food packaging lead to prevent or delay adverse changes in appearance, taste, smell and texture [26,28]. Enzymatic reaction that affects the sensory quality of raw meat cause undesirable results, so this reaction should preferably be reduced or stopped [6,11,26,28]**.** Ostrich meat is valuable products from birds used include: meat, skin, feathers and eggs [1,3,14]. Ostrich meat due to low fat, low sodium and high in unsaturated fatty acids which, in comparison with beef and chicken protein, the lowest cholesterol levels compared to other red meat such as veal and sheep, a lot of iron (red meat) is a good source of vitamins A, B1, B6, B 12 can be substituted as new red meat instead of other presented meats [1, 13]. Fresh ostrich meat is usually sold before 24-48 hours after death and must be cold immediately. Packaging of fresh and frozen ostrich meat (crushed and minced) are needed for shelf life prolongation [1,2,10]. Modern techniques of meat packaging are considered to maintain the microbial quality and appearance of the product [14,16]. The shelf life of products can be increased by inhibiting or retarding the growth of undesirable flora [11,15,25-28]. This can be achieved by manipulating the environment of meat

packaging [9]. Vacuum and modifying atmosphere packaging (MAP) is techniques which can be used in the food industry to extend shelf-life of food products [17]. Modified atmosphere packaging (MAP) is also a useful technique for various researches. Also, chemical, enzymatic and microbial activities are controlled so that the major risks that may occur are avoided or reduced [12,17]. Ostrich meat without efficient processing is a potential source of pathogenic microorganisms, aerobic and anaerobic bacteria and Salmonella and a pH close to neutral (pH 5-6) and the suitable water activity cause the packed ostrich meat become an ideal environment for microbial spoilage [11,13,16]. Although, heating and freezing meat affect microorganisms effectively, it deactivates proteins and some other physiological reactions, thus causes undesirable changes in flavor, texture, and nutrients content in meat [4,5,26,28]. However, modified atmosphere packaging (MAP) which is a non-thermal method for food storage and deactivates microorganisms is widely used to prolong the shelf life and improve the quality of perishable food stored in the fridge temperature [4,5,25-28]. All mentioned in this study include the initial CO2/ N2 concentration (%) in the head space of pouches as the independent variable for the gas atmosphere demonstrated that CO2 exerts as an antimicrobial effect in the water-phase of the food product [12,15,25-28], therefore except the effect of intrinsic, extrinsic and processing parameters on the CO2 solubility, the concentration of dissolved CO2 in the water-phase of the food product should be incorporated in this study as independent variable [12,17]. Nitrogen (N2) is a non-reactive gas that has no smell or taste, unlike carbon dioxide, is not absorbed in food or water [3,15]. It is used as a filler gas to replace oxygen and thus prevent spoilage or to replace carbon dioxide and prevent package collapse [6,17,25-28]. Other hand the multi- layer films have been used for packaging fresh ostrich meat are plastic films laminated with aluminum [18-24]. These laminated packages with some metal component can considerably change the food temperatures and also microwave transparent with a high melting point instead of can [18-24]. The most common packages that have been tried, are individual pouches made of microwave transparent rigid films such as polyethylene (LLD), and polyethylene terephthalate (PET), which are barrier films and aluminum foil [18,24-28]. In this project, we investigate about the effects of MAP with gas composition s (%30 N_2 + %70 CO_2), (%70 N_2 + %30 CO_2) and vacuum with 2 kinds of flexible multilayers 3-layer (Al:7 & Al:12),and 4-layer in 15 days on sensory properties of fresh ostrich meat [26,28]. We try to prove MAP can substitute thermal processing in conservation industries, and these multilayer flexible films can extend the shelf life of fresh meat, and also improve the sensory properties of samples [25-28].

MATERIALS AND METHODS

Preparation of fresh ostrich meat

Ostrich fresh meat (10 kg weight) were chosen for this experiment taken from local supermarket in Mashhad -Iran. These samples were washed and cut to slices (7cm *15 cm) .Temperature was controlled in order to decrease to ambient temperature (T=25 ° C). Samples were ready for packaging. Pouches contained 100 g , fresh ostrich meat .This research was conducted to 5 treatments in 3 run{($N_2$70% + $CO_2$30%), ($N_2$30% + $CO_2$70%), vacuum condition, ordinary condition)}. Samples were packaged into three multilayer flexible films**.** [7,8, 20-23, 25-28].

Modified Atmosphere Packaging

Henkelman packing machine, model Boxer-200A was used in this project. Samples were packed into three multilayer flexible pouches (3-4 layers) under modified atmosphere. After packaging, samples were put in refrigerator immediately, for evaluation sensory properties during 15 days [15,26,28].

Fig 1.(A) Modified atmosphere packaging, (B) gas analyzer, (C) gas flash tank(Model: Boxer-200A) [15,26,28]

Samples packaging and storage

All pouches (fresh ostrich meat), put at refrigerator temperature (T= 4° C). Analytical characteristics of these barrier containers were shown in table 1 [15,19-23,25-28]

Table 1- Analytical characteristics of containers [15,19-23,25-28]

Sample	Layers	Thickness (µ)	Tensile of sealing film (N)	O.T.R ($ml/m^2.day$)	W.V.T.R ($g/m^2.day$)
PET/AL/LLD	100/12/12	124	58.88	0	0.11
PET/AL/LLD	100/7/12	119	48.89	0	0.50
PET/AL/PET/LLD	100/12/7/12	131	61.03	0	0.089

PET: Poly Ethylene Terephthalate; LLD: Low Density Poly Ethylene; AL: Aluminum

Sensory properties

Evaluation of sensory properties (appearance, color, texture, Smell, taste) has been designed according to numerical parameter for each samples of ostrich meat, as you see in table 2. These properties have been described with marking system. Best Marking System was 1-5 (1-Very Good; 2-Good; 3-Medium; 4- Weak; 5- Very Weak). At least 100 members of panel (tester) were chosen for this study. The usage of multiple comparison test, were studied simultaneously, and specific test (marking system) for each samples, had done after 3,7,10,15 days of packaging. In multiple comparison test, samples with the code number were given to panel, and they were asked to compare the control ostrich meat (ordinary condition samples) and coded ostrich meat (under modified atmosphere and vacuum), and filled application form (table below) [26,28].

Table 2 .Evaluation of sensory properties (appearance, color, texture, taste, smell) of samples

Sensory properties						Products
NOTE	Smell	Dripped Water	Texture	Color	Appearance	

Very Weak	Weak	Medium	Good	Very Good
5	4	3	2	1

STATISTICAL ANALYSIS

In order to describe the variables of this experiment, we must design a model to analysis relationship between fresh ostrich meat, and type of treatments during different storage times on sensory properties. Statistical analysis of data, was performed by software Statistical Analysis System (SAS: 9/1) with Anowa test, and comparison of data was performed by Duncan's new multiple range test, with confidence level of 95% (P <0.05).

RESULTS

Sensory properties of fresh ostrich meat in different conditions

According to the variance analysis table 3, the effect of the type of containers, and the effect of times, and also the effect of different gas compositions on sensory properties (appearance, color , texture , smell, dripped water) have been significant level (P <0/01). The main effect of the containers, and times on the sensory properties have been significant at 1%. As were observed in table 3, the effect of gas compositions on sensory properties (appearance, color , texture , smell, dripped water) has been significant (P <0/01), and the effect of the different gas compositions on the trait (texture) has been significant (P <0/05) and double interactions (layers and gas composition) and (layers and time) according to the variance analysis table on properties (appearance, color , texture , smell, dripped water) and also double interactions on (gas composition and time) on the traits (texture-appearance) showed non-significant level; however, it has been significant level at (P <0/01) on traits (smell ,color). Triple interactions effected on (layers, gas composition and time) on traits (appearance, color , texture , smell, dripped water) were shown non-significant level.

Table 3-Analysis of variance mean squares traits in response to treatments

smell	Dripped Water	Texture	Color	Appearance	Degrees of freedom	Variables
1.72^{**}	1.91^{**}	2.46^{**}	1.69^{**}	1.07**	2	**Container**
1.05^{**}	29.12^{**}	0.08^{**}	1.74**	0.63^{**}	2	**Gas Composition**
0.02^{ns}	0.07^{ns}	0.06^{ns}	0.02^{ns}	0.02^{ns}	4	**Container * Gas Composition**
111.23^{**}	169.62^{**}	104.80^{**}	102.30^{**}	99.55^{**}	3	**Time**
0.25^{*}	0.09^{ns}	0.13^{ns}	0.21^{ns}	0.18^{ns}	6	**Container * Time**
0.56^{**}	2.67^{**}	0.27^{**}	0.84^{**}	0.165^{ns}	6	**Gas composition * Time**
0.02^{ns}	0.21^{*}	0.09^{ns}	0.03^{ns}	0.03^{ns}	12	**Container * Gas Composition * Time***
0.143	0.12	0.181	0.145	0.167	148	**Error**
13.03	10.03	14.87	13.54	14.83	-	**Coefficient of Variation (CV)**

***, * and ^{ns}, significance at 1% and 5% and non-significance, respectively.*

According to table, 4 & 5, The best mark of sensory properties except dripped water belonged to 4-layer container, with (70% CO2 + 30% N_2) after initial control sample (day zero), and the worst mark of sensory properties except dripped water observed in 3- layer (AL:7) with vacuum condition and (30% CO2 + 70% N_2) too, due to the thickness and type of gas compositions .As you see in table 4 , layer 2 had the best score for having a desirable texture, and color in containers 1, 2, and 3. Samples of container 2 in control condition (day zero) had the highest score for a desirable color and appearance, and there was no significant difference in containers 1, 2 and 3.

However, it had significant difference with the initial control sample (day zero). Samples of container 2 after the control (day zero) had the highest score for a desirable appearance.

Table 4: Comparison of sensory properties (appearance, color, texture, smell, dripped water) for different layers

Smell	Dripped Water	Texture	Color	Appearance	Treatments / layers
1^{c}	1^{b}	1^{b}	1^{c}	1^{b}	Day(0) / control
2.891^{ab}	3.550^{b}	2.953^{a}	2.931^{b}	2.82^{ab}	**layer1: 3-layers(AL:12)**
2.821^{b}	3.644^{a}	2.891^{a}	3.892^{a}	2.791^{b}	**layer 2: 4-layers**
3.453^{a}	3.553^{b}	3.384^{a}	3.960^{b}	2.894^{a}	**layer 3: 3-layers(AL:7)**

As you see in table 5 , In trait smell, there was no significant difference between the gas compositions 1 , 2 and 3, but there were significant difference between these three compositions and control sample (day zero), and samples under gas composition 1 had the best score after the zero control sample for having a desirable smell ,and then, the gas composition 3 had a desirable score. In this study the trait texture, there was no significant difference between the three gas compositions, but generally, there was a significant difference between these three gas composition and the initial control sample (day zero). Samples under gas composition 1, after the initial control sample (day zero) had the best score for having a desirable texture, and then samples under gas composition 2 with a slight difference, had the best score for having a desirable texture. In trait color, there was a significant difference between the gas composition 1 with the gas compositions 2 & 3. Samples under gas composition 1 after the initial control sample (day zero) had the best score for having a desirable color, and gas compositions 2 & 3 had almost similar scores. In traits appearance, there was no statistically significant difference between the gas composition 1 and 2 and 3, and generally, there was a significant differences between the gas compositions 1,2 and 3 with the initial control sample (day zero), and the samples under gas composition 1 after initial zero control had the best score for having a desirable appearance, and then gas composition 3 (vacuum) had a better score for having a desirable appearance.

Table 5: Comparison of sensory properties (appearance, color, texture, smell, dripped water) for different gas compositions

Smell	Dripped Water	Texture	Color	Appearance	Treatments / gases
1^{b}	1^{b}	1^{b}	1^{c}	1^{b}	Day(0) / control
2.80^{a}	4.05^{a}	2.301^{a}	2.650^{b}	2.653^{a}	**CO_2 70% +N_2 30%**
3.05^{a}	3.601^{b}	2.96^{a}	2.962^{a}	2.850^{a}	**CO_2 30% + N_2 70%**
3.01^{a}	3.45^{b}	3.03^{a}	2.971^{a}	2.711^{a}	**vacuum**

According to table 6 , In this study trait smell, there was no significant difference between day 0 and day 3. However, between the days 0, 3, with days 7 and 10 and 15 there was a significant differences, and scores increased from day 0 to day 15. In trait texture, there was a significant difference between day 0 and day 3, but there was a significant difference between days 0 and 3 and days 7 and 10 and 15. In trait color, there was no significant between the days 0 and 3, but there was a significant difference between days zero and 3 with the days 7 and 10 and 15. In trait appearance, there was no significant difference between days 0 and 3, but there was a significant difference between days 0 and 3 with days 7 and 10 and 15.

Table 6: Comparison of sensory properties (appearance, color, texture, smell, dripped water) for different days

Smell	Dripped Water	Texture	Color	Appearance	Treatments / Days
$^{d}1$	1^{d}	$^{d}1$	$^{d}1$	$^{d}1$	Day(0) / control
1^{d}	1^{d}	1^{d}	1^{d}	1^{d}	**3**
2.560^{c}	3.140^{c}	2.590^{c}	2.45^{c}	2.480^{c}	**7**
3.681^{b}	3.671^{b}	3.671^{b}	3.591^{b}	3.213^{b}	**10**
4.690^{a}	4.473^{a}	4.550^{a}	4.461^{a}	4.332^{a}	**15**

According to figures 2-5, Effect of different multi-layer films were observed after 3,5,7,10,15 days of on sensory evaluation, The lowest mark of sensory properties belonged to 4-layers and then 3-layers (AL:12). All treatments of ostrich meat after 3 day of storage had obtained similar score (3: very good), was similar to initial control (zero-day). The lowest mark of all sensory properties belonged to 4-layers except dripped water after 7 day of storage. The lowest mark of all sensory properties belonged to 4-layers, and then layer 3-layers (AL:12) after 10 day of storage.

The lowest mark of all sensory properties belonged to 4-layers, and the highest mark was for layer 3-layers (AL:7) after 15 day of storage.

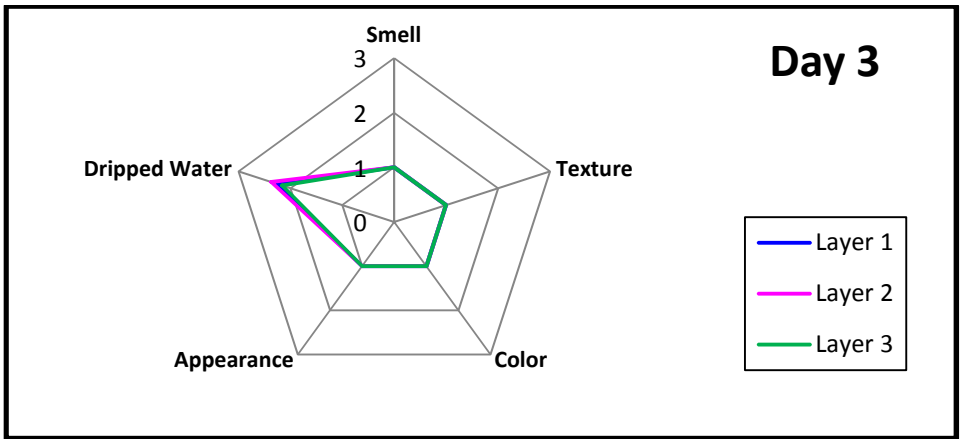

Figure 2: Effect of different layers after 3 days on sensory evaluation

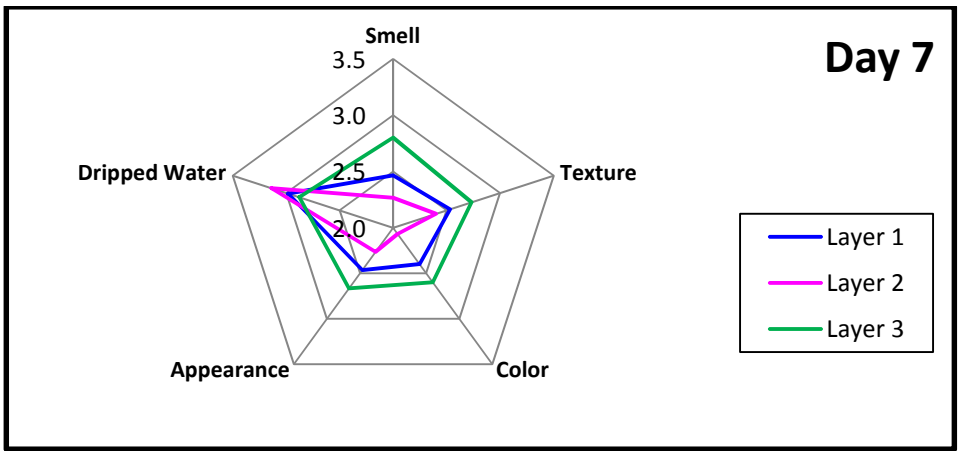

Figure 3: Effect of different layers after 7 days on sensory evaluation

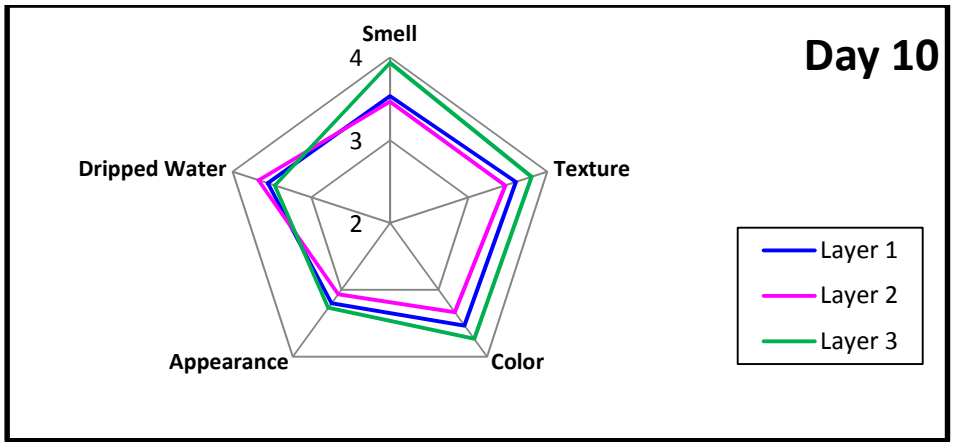

Figure 4: Effect of different layers after 10 days on sensory evaluation

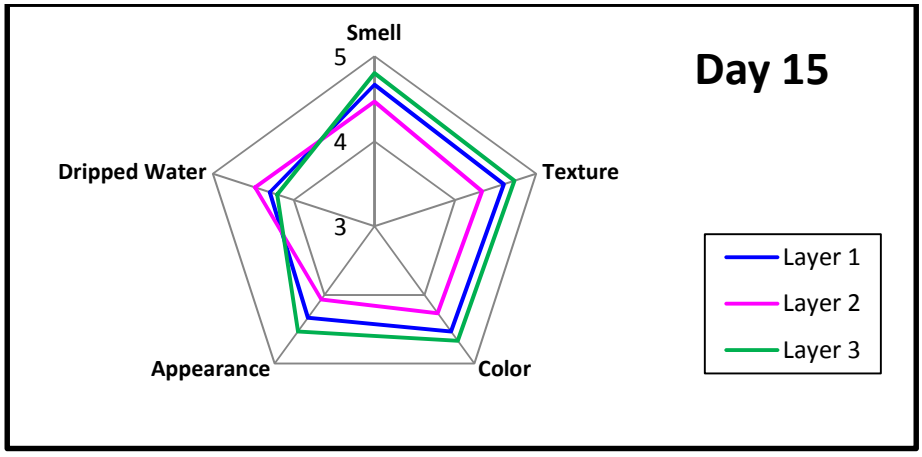

Figure 5: Effect of different layers after 15 days on sensory evaluation

According to figures 6-9, the effect of different gas compositions were observed after 3,7,10,15 days on sensory evaluations. The lowest mark of all sensory properties except dripped water belonged to gas combination 1 (70% CO2 + 30% N2) after 3,7,10,15 days .But highest mark observed in (30% CO2 + 70% N2) after 7, and after 10 days highest mark reported in (30% CO2 + 70% N2), and vacuum conditions too. Maximum mark of all sensory properties except dripped water belonged to vacuum after 15 days

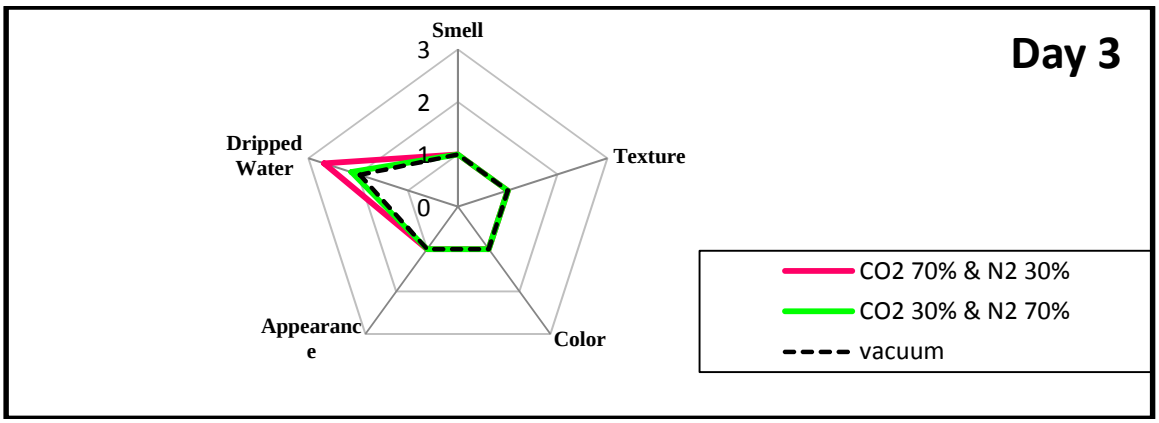

Figure 6: Effect of different gases after 3 days on sensory evaluation

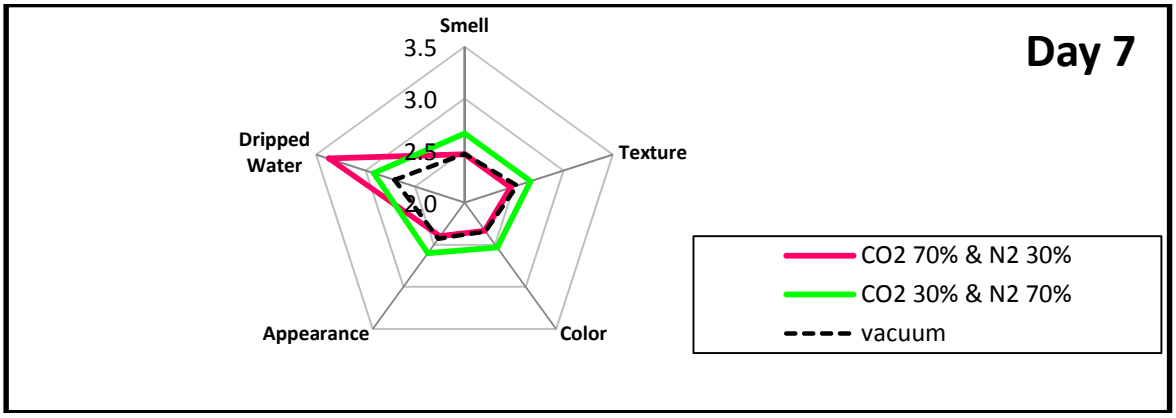

Figure 7: Effect of different gases after 7 days on sensory evaluation

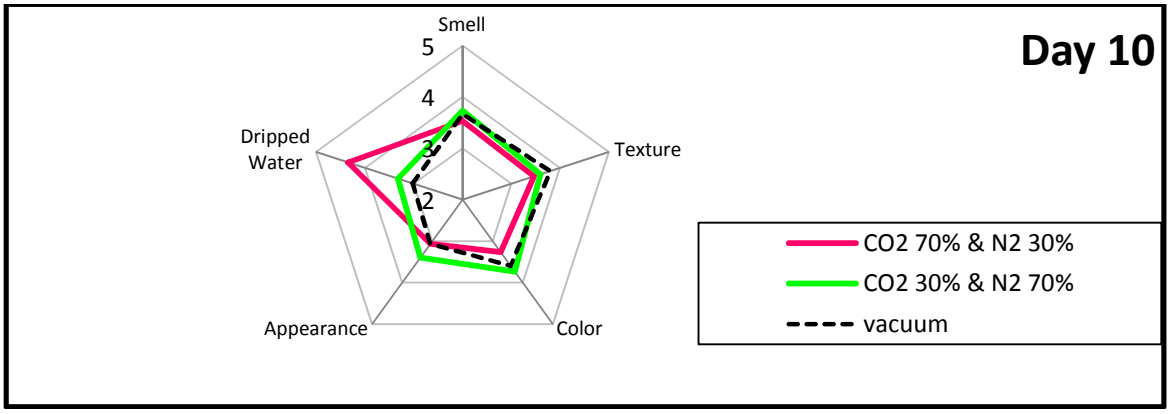

Figure 8: Effect of different gases after 10 days on sensory evaluation

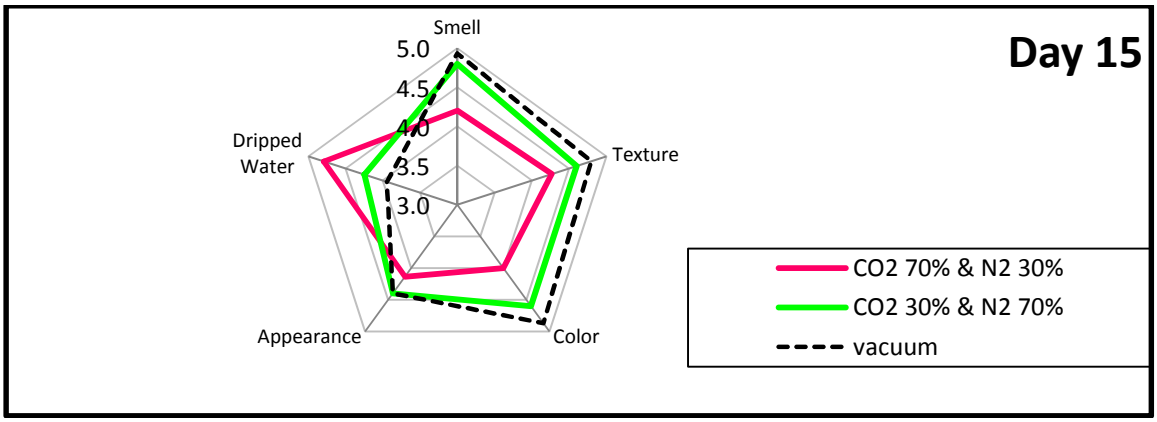

Figure 9: Effect of different gases after 15 days on sensory evaluation

DISCUSSION

After fifteen days of storage, the difference between the sensory properties in the samples were significantly related on gas compositions and containers, thus 4-layers had a better performance than 3-layers (AL: 12) and 3-layers (AL: 7) for preservation the quality of ostrich meat. Also according to sensory evaluation of different traits affected by different gas combinations in different times, were observed that the best sensory properties in terms of (color) , (texture) , (smell) ,(appearance) after fifteen days, belonged to gas composition 1 (N2 %30 , CO2 %70) but in terms of the amount of dripped water, the packages containing gas under vacuum and then the gas composition 2 (N2 %70 , CO2 %30), had a better score than the gas composition 1 (N2 %30 and CO2 %70). However, type of atmosphere (CO2 %70) and the thickness of the package, affected on the trait of smell and had the highest changes in comparison with other traits, which accrued by high concentration of CO2 and the low permeability of the package, caused reduction of pH and producing an acidic smell that was desirable .

Stier *et. al*.,1981, due to research about amount of aerobic and anaerobic microorganism in packed salmon fillet, the results ,were corresponded with this study. Vanderzant *et al.*, 2000 ,indicated that due to the shelf life growth of aerobic bacteria of beef steak packaged under vacuum and MAP condition in different barrier containers during 30 days were significant difference with ordinary condition as a control ,the results were similar to these results . Chouliara & Karatapanis, 2007, indicated that due to effect of modified atmosphere packaging on shelf-life extension of fresh chicken meat, the results of sensory properties, were corresponded with these results. Fernandez-Lopez *et al*., 2008, due to research about effect of packaging conditions on shelf-life of ostrich steaks, the results were similar to this investigation.

Zand *et al*., 2010, indicated that due to shelf life extension of cooked chick and chick meal in multilayer flexible pouches 4-layer container was better than 3-layer, results were corresponded with these results. Zand & Mailova, 2010, due to research about the shelf life prolongation of packed meals in multilayer flexible pouches conducted 4-layer container was better than 3-layer, for preservation sensory properties, these results were reliable . Zand & Sotoudeh, 2013 , indicated that due to the influence of MAP in multilayer flexible pouches on sensory properties of chicken meal,the best result belonged to 4-layer under CO2 %70+N2 %30 ,that the results were corresponded with these results. Zand & Allahyari, 2013 , conducted due to the influence of MAP and different multilayer

flexible films on sensory evaluation of candy bread during 20 days, the results under CO2 %70 in 4-layer container ,were corresponded with these results . Zand, 2013, due to shelf life extension of mashroom meal in multilayer flexible pouches 4-layer container was better than 3-layer during 60 days, results on sensory evaluation, were corresponded with these results. Zand, 2013, indicated that due to the shelf life prolongation of packed vegetables meal in multilayer flexible pouches 4-layer container was better than 3-layer during 60 days, results on sensory evaluation, were corresponded with these results.

CONCLUSION

In the present study, it was concluded that, sensory properties and shelf life of packed fresh ostrich meat have been affected by different flexible multi-layer containers and different concentrations of two gas mixture (carbon dioxide, nitrogen), and also vacuum conditions during 15 days. Our results confirmed, the modified atmosphere packaging (MAP) was not lead to stop spoilage completely but delayed it .The effect of MAP was not adequate but using this technique inactivated microorganism without a significant adverse effect on food properties and also controlled organoleptic properties of ostrich meat samples. These parameters could be promoted, substitution of these barrier containers and MAP and instead of traditional packaging in food industries, due to a lot of privilege of them for shelf life extension of ostrich meat in long times.

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