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The effect of the replacement of fat of cooked beef and turkey luncheon by fat replacers on their physical and sensory quality

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There is a great interest to produce healthier food as low-fat meat products without change the sensory quality of the products. Various aspects can be designed to decrease the fat content of the meat products. Technologically, the animal fat replaced with different combinations of fat replacers. In this study, four different combinations of fat replacers were used to beef luncheon and turkey luncheon, the sun flower oil, alginate, rice flour and gum Arabic to evaluate their sensory valuation. The results indicated that sensory analysis of cooked beef and turkey luncheon by the use of various fat replacers showed significant improvement of the sensory characteristics with the exception rice flour which adversely affect the color scores. Overall, it was observed that fat replacers can be used to produce healthier and more palatable beef and turkey luncheon.

Keywords: Fat replacers, Quality characteristics, Meat products

INTRODUCTION

Luncheon meat is one of the most acceptable meat products; it is a meat product which is commonly used worldwide. It usually consists of finely chopped meat and fat with or without some added cereals, cured with salt and nitrite that are heat processed (Ranken, 1984). As, Soliman, 1999 reported that beef burger, sausage and luncheon are common foods in the world due to their competitive price, fast processing and delicious taste So, more attention has to be paid to produce healthier and more delicious products.

Whereas, Fat contributes to key sensory benefits to meat and meat products (Jimenez - Colmenero, 2000; Tokusoglu and Unal, 2003). It is necessary to minimize the level of fat to assure texture, mouth feel, tenderness, juiciness, flavor, appearance and overall acceptability (Cole et al., 1960; Berry and Leddy, 1984; Pearson et al., 1987) and helps to compensate for overcooking by the consumer (Troutt et al,. 1992). However, reducing the fat content in low-fat meat products may alter the quality as the product becomes firmer, less juicy, darker in color, rubbery and more expensive (Keeton, 1994). The term fat replacer is used to describe a wide variety of products that replace certain or whole amount of the fat in foods; **Chavan, 2016** used fat replacer to change the sensory qualities of a food as little as possible while reducing its fat, cholesterol and calories content. Many fat replacers can be added to meat products to reduce the problems that were caused by fat reduction (Chang and Carpenter, 1997; Hughes et al., 1998).Also, Hodges (1994) stated that water may be substituted for fat; providing combination of total fat and water, on condition water does not

exceed 40% by weight of the finished product, improves the quality of meat products, but using water alone can result in technical problems (Claus et al., 1989). So, to overcome these problems water is generally used in combination with other ingredients as carbohydrates-based fat replacers including starches (Giese 1996). Bath et al., 1992; Nonaka 1997; Akoh, 1998 reported that binding of carbohydrate-based fat replacers, like dextrins, modified starches, and hydrocolloids by water reduce fat of meat products. Moreover, cholesterol level can be significantly reduced by replacing beef fat with other vegetable oils (Marquez et al., 1989; Paneras et al., 1998). Recently, there are growing efforts to find the best fat replacer for certain food that can replace fat with no change in the physical and sensory properties of food. Therefore, the aim of the present study is to assess the effects of the sun flower oil, alginate, rice flour and gum Arabic used as a fat replacer on the physical and sensory properties of beef and turkey luncheon even at different refrigeration periods.

MATERIALS AND METHODS

Samples

A total of forty commercially produced meat products samples representing twenty each of Egyptian beef luncheon and turkey luncheon were collected from different supermarkets in Giza and Cairo cities within one week of its production. Each sample was represented by three packages. The collected samples were transported to the laboratory as soon as possible in cooling ice box, and examined immediately after arrival to investigate its quality.

Luncheons cooking

The materials used in beef and turkey luncheons formulation are given in (Table 1).

Table (1) Batter Formulations with Different Fat Replacers (Kg)

		Beef meat			Turkey luncheon			
Ingredients	**T1**	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
Lean beef	5.000	5.000	5.000	5.000	-	-	-	-
Turkey meat	-	-	-	-	5.000	5.000	5.000	5.000
Ice	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
Salt	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
STP	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Sodium nitrite	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
Sun flour oil	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Sodium Alginate	-	-	-	-	-	-	-	-
Rice flour	-	-	0.300	0.300			0.300	0.300
Arabic gums	-	-	-					

* T1: plant oil, T2: plant oil+ alginate, T3: alginate+ rice flour, T4: alginate+ rice flour oil+ Arabic gum

Both of beef luncheon and turkey luncheon were experimentally produced following the directions of the Egyptian Standard Specifications of each (ESS 114/2005 for beef luncheon and 1696/2005 for poultry luncheon) and used as control samples. Fresh beef meat and turkey breast muscles were purchased from local producers at 48 hrs. post-mortem. The fresh materials were then deep frozen and stored at -18°C. four different meat batters (10 kg batches of each meat batter) were used to produce luncheons meat. For beef luncheon; the first batter (T1) was prepared with 15% sunflower oil instead of the beef fat, where beef meat was chopped in the bowel cutter (Laska) with 2.2% NaCl and 0.30% sodium tripolyphosphate. Plant oil was added at approximately -2°C, and finally the starch was added at 2°C. After that the meat batter was chopped to a final temperature of 8°C. The 2nd meat batter (T2) was prepared with 1.5 % sodium alginate and 15% sunflower oil, while the 3rd meat batter (T3) was prepared with 15% sunflower oil 1.5% sodium alginate plus 1.5% rice flour and the final trial was prepared with 15% sunflower oil, 1.5%sodium alginate, 1.5% rice flour and 0.5% gum Arabic. All the prepared meat batters were filled used automatic filler (Handtmanm VF 600) using polyamide casing and kept refrigerated for three hours before thermal treatment.

All the prepared meat batters were stuffed into polyamide casings using automatic filler (Handtmanm VF 600) and kept refrigerated for three hours before thermal treatment (I.T. 72◦C).

For production of turkey luncheon, the lean as well as the fat and the skin were minced at 3 mm plate.. Moreover, the same products were also produced with partial replacement of fat with different fat replacers (sun flower oil, sodium alginate, rich flour or gum Arabic) in the same pattern of beef luncheon.

The cooked beef and turkey luncheons were refrigerated for 12 weeks for biweekly sensory evaluation.

Sensory evaluation

A panel committee of twenty five well-trained tasters was used to assess the sensory evaluation of the products at 0,2,4,6,8,10 and 12 weeks of refrigeration.; aged between 20 to 50 years. Away from the sample cooking rooms, sensory tests were carried out in a separate room, which was at room temperature. The taster members prevented from eating, drinking or smoking for at least 1 hour before testing. All the samples were randomly coded and then the tasters were asked to score the color, tenderness, juiciness, flavor and overall acceptability using a numerical-score value from 0 to 8 according to its quality with 0 being low or undesirable while 8 being highly desirable.

Statistical analysis

The ANOVA test was used in statistical analyses to determine whether the fat replacer had any effect or any significant interaction with other independent variables on panel scores for each descriptive term. If fat content had a significant effect $P < 0.05$), then means were compared using multiple-range analysis Duncan's.

RESULTS

Sensory quality

Investigation of sensory attributes of market samples clearly indicated that the traditional Egyptian luncheon had mean tasting scores of 4, 4.5, 4.4, 3.5, 4 and 4.08 for color, flavor, taste, tenderness, juiciness and overall acceptability respectively (Fig.1). However, the mean sensory tasting score for produced beef luncheon in the next day post-processing were 7.0 for the product manufactured with plant oil, 6.80, 6.6, 6.7, 6.5, 6.85 and 6.69 for plant oil and alginate; 6.5, 6.4, 6.5, 6.4, 6.6 and 6.48 for plant oil, alginate and rice flour; and 6.5, 6.8, 6.8, 6.5, 6.9 and 6.7 for plant oil, alginate, rice flour and gum Arabic (Table 2). Also, turkey luncheon produced by different combinations of fat replacers before refrigeration had high significant sensory scales in comparison to market sample for color, flavor, taste, tenderness, juiciness and overall acceptability; 6.7, 7, 6.8, 6.9, 7 and 6.88; 6.6, 6.8, 6.7, 6.8, 6.8 and 6.74; 6.5, 6.8, 6.5, 6.75, 6.7 and 6.65 and 6.4, 6.9, 6.8, 6.8, 6.9 and 6.76 (Table 3).

Results of sensory analysis generally revealed pronounced improvement in the investigated parameters for experimentally produced beef and turkey luncheon manufactured with different combinations of fat replacers. Moreover, the products produced by incorporation of plant oil had the significantly highest sensory scores followed by those produced with plant oil, alginate, rice flour and

gum, then those produced by plant oil and alginate and finally the product produced with oil, alginate and rice flour (Fig. 2 and Fig. 3). The results also declared that the use of rice flour significantly lowered the color score of the experimentally produced products (Fig. 2 and Fig. 3). Also, the combination of oil, alginate, rice flour and gum (T4) enriched juiciness of beef luncheon (Table 2) and flavor, taste, tenderness and juiciness of turkey luncheon (Table 3).

Table (2) Sensory Panel Scores of Market and Produced Beef Luncheons with Different Fat Replacer

	Time (weeks)	*Sensory attributes*					
		Color	***Flavor***	***Taste***	***Tenderness***	***Juiciness***	***Overall acceptability***
Market		4.00^{k}	4.50^{j}	4.40^{j}	3.50^{g}	4.00^{i}	4.08^{k}
Sunflower (T_1)	***0***	7.00^{a}	7.00^{a}	7.00^{a}	7.00^{a}	7.00^{a}	7.00a
	2	6.80^{b}	7.00^{a}	6.90^{b}	7.00^{a}	$6.95^{a,b}$	$6.93^{a,b}$
	4	$6.70^{b,c}$	$6.90^{a,b}$	$6.90^{b,c}$	7.00^{a}	$6.95^{a,b}$	$6.89^{b,c}$
	6	6.60^{c}	6.85^{b}	$6.80^{c,d}$	6.90^{a}	$6.90^{a,b}$	6.81^{c}
	8	6.40^{d}	$6.80^{b,c}$	$6.80^{c,d}$	$6.90^{a,b}$	6.85^{b}	6.79^{c}
	10	6.20^{e}	$6.70^{c,d}$	6.70^{d}	6.80^{b}	$6.80^{b,c}$	6.64^{d}
	12	6.10^{e}	6.60^{d}	6.70^{d}	6.80^{b}	6.70^{c}	6.58^{d}
sunflower+ Alginate (T_2)	***0***	6.80^{b}	6.60^{d}	6.70^{d}	6.50^{c}	6.85^{b}	6.69^{c}
	2	$6.70^{b,c}$	6.60^{d}	6.70^{d}	6.50^{c}	$6.80^{b,c}$	6.66^{d}
	4	6.65^{c}	$6.60^{d,e}$	$6.60^{d,e}$	$6.40^{c,d}$	$6.80^{b,c}$	6.62^{d}
	6	6.50^{d}	$6.50^{e,f}$	6.50^{e}	$6.40^{c,d}$	6.75^{c}	6.53^{e}
	8	6.30e,^{f}	$6.40^{f,g}$	6.50^{e}	6.30^{d}	6.70^{c}	6.44^{e}
	10	6.10^{e}	6.30^{g}	$6.50^{e,f}$	6.30^{d}	$6.65^{c,d}$	6.37^{e}
	12	$6.00^{e,g}$	6.30^{g}	6.40^{f}	6.30^{d}	6.60^{d}	6.32^{e}
Sunflower+ alginate+ rice flour (T_3)	***0***	6.50^{h}	$6.40^{f,g}$	6.50^{e}	$6.40^{c,d}$	6.60^{d}	6.48^{f}
	2	6.40^{d}	$6.40^{f,g}$	6.50^{e}	$6.40^{c,d}$	6.60^{d}	6.46^{f}
	4	6.40^{d}	6.30^{g}	$6.40^{e,f}$	$6.40^{c,d}$	$6.50^{d,e}$	6.40^{f}
	6	$6.30^{e,f}$	$6.30^{g,h}$	$6.30^{f,g}$	6.30^{d}	$6.40^{e,f}$	$6.32^{f,g}$
	8	$6.00^{e,g}$	6.20^{h}	$6.30^{f,g}$	6.30^{d}	6.30^{f}	6.22^{g}
	10	5.90^{i}	6.10^{i}	$6.20^{g,h}$	6.30^{d}	$6.30^{f,h}$	6.16^{i}
	12	5.70^{j}	6.10^{i}	$6.10^{h,i}$	6.10^{e}	6.20^{h}	6.04^{j}
Sunflower+ alginate+ rice flour+ gum Arabic (T_4)	***0***	6.50^{h}	$6.80^{b,c}$	$6.80^{c,d}$	6.50^{c}	$6.90^{a,b}$	6.70^{c}
	2	$6.30^{e,f}$	$6.70^{c,d}$	$6.80^{c,d}$	6.50^{c}	$6.90^{a,b}$	6.64^{c}
	4	6.35e,^{f}	$6.70^{c,d}$	6.70^{d}	$6.40^{c,d}$	$6.80^{b,c}$	6.59^{e}
	6	6.10^{e}	$6.60^{d,e}$	6.70^{d}	6.30^{d}	$6.80^{b,c}$	6.50^{e}
	8	5.90^{i}	$6.55^{e,f}$	$6.60^{d,e}$	$6.30^{d,f}$	6.75^{c}	6.42^{f}
	10	5.80^{i}	$6.50^{e,f}$	$6.60^{d,e}$	6.20^{f}	6.70^{c}	$6.36^{f,g}$
	12	$5.70^{i,j}$	$6.50^{e,f}$	6.50^{e}	6.20^{f}	6.70^{c}	$6.32^{f,g}$

a-k Values with the different superscript within the same column differ significantly at P <0.5

Table (3) Sensory Panel Scores of Market and Produced Turkey Luncheon with Different Fat Replacers during Refrigeration Storage

	Time (weeks)	*Sensory attributes*					
		Color	*Flavor*	*Taste*	*Tenderness*	*Juiciness*	*Overall acceptability*
Market		5.40^{g}	5.40^{g}	5.40^{f}	5.50^{e}	5.00^{h}	5.34^{h}
Sunflower (T_1)	***0***	6.70a	7.00a	6.80^{a}	6.90^{a}	7.00^{a}	6.88^{a}
	2	6.70a	7.00a	6.80^{a}	6.90^{a}	6.90^{a,b}	6.86^{a}
	4	6.65^{a}	6.90^{a,b}	6.80^{a}	6.90^{a}	6.80^{b,c}	6.81^{a,b}
	6	6.60^{a}	6.90^{a,b}	6.60^{b,c}	6.80^{a,b}	6.80^{b,c}	6.74^{b,c}
	8	6.60^{a}	6.85^{b}	6.60^{b,c}	6.70^{b}	6.70^{c,d}	6.69^{c,d}
	10	6.40^{b,c}	6.80^{b,c}	6.55^{c}	6.70^{b}	6.50e,f	6.59^{d,e}
	12	6.30^{c}	6.70^{c,d}	6.50^{c}	6.70^{b}	6.40^{f,g}	6.52^{e}
Sunflower+ Alginate (T_2)	***0***	6.60^{a}	6.80^{b,c}	6.70^{a,b}	6.80^{a,b}	6.80^{b,c}	6.74^{b,c}
	2	6.60^{a}	6.70^{c,d}	6.60^{b,c}	6.75^{b}	6.70^{c,d}	6.67^{b,c}
	4	6.60^{a}	6.70^{c,d}	6.55^{c}	6.75^{b}	6.70^{c,d}	6.66^{c,d}
	6	6.50^{b}	6.60^{d,e}	6.50^{c,d}	6.70^{b}	6.60^{d,e}	6.58^{e}
	8	6.40^{b,c}	6.60^{d,e}	6.50^{c,d}	6.70^{b}	6.50^{e,f}	6.54^{e}
	10	6.40^{b,c}	6.50^{e,f}	6.40^{d,e}	6.60^{b,c}	6.50^{e,f}	6.40^{f}
	12	6.20^{d}	6.40^{f}	6.30^{e}	6.50^{c,d}	6.30^{g}	6.34^{f}
Sunflower+ alginate+ rice flour (T_3)	***0***	6.50^{b}	6.80^{b,c}	6.50^{c,d}	6.75^{b}	6.70^{c,d}	6.65^{d}
	2	6.40^{b,c}	6.70^{c,d}	6.50^{c,d}	6.70^{b}	6.55$^{d.f}$	6.57^{d,e}
	4	6.30^{c,d}	6.60^{d,e}	6.45^{c,d}	6.60^{b,c}	6.50$^{e.f}$	6.49^{f}
	6	6.20^{d,e}	6.50^{e,f}	6.40^{d,e}	6.55^{c}	6.50^{e,f}	6.43^{f}
	8	6.20^{d,e}	6.50^{e,f}	6.40^{d,e}	6.55^{c}	6.40^{f,g}	6.41^{f}
	10	6.10^{e,f}	6.40^{f}	6.30^{e}	6.50^{c,d}	6.40^{f,g}	6.34^{f}
	12	6.00^{f}	6.40^{f}	6.30^{e}	6.40^{d}	6.35^{e,f}	6.29^{g}
Sunflower+ alginate+ rice flour+ Arabic gum (T_4)	***0***	6.40^{b,c}	6.90^{a,b}	6.80^{a}	6.80^{a,b}	6.90^{a,b}	6.76^{b,c}
	2	6.40^{b,c}	6.80^{b,c}	6.70^{a,b}	6.80^{a,b}	6.80^{b,c}	6.70^{b,c}
	4	6.35^{c,d}	6.80^{b,c}	6.60^{b,c}	6.70^{b}	6.70^{c,d}	6.63^{d}
	6	6.30^{c,d}	6.70^{c,d}	6.50^{c,d}	6.65^{b,c}	6.70^{c,d}	6.53^{e}
	8	6.30^{c,d}	6.70^{c,d}	6.50^{c,d}	6.60^{b,c}	6.50^{e,f}	6.52^{e}
	10	6.20^{d,e}	6.60^{c,d}	6.40^{d,e}	6.55^{c}	6.40^{f,g}	6.43^{f}
	12	6.20^{d,e}	6.60^{c,d}	6.40^{d,e}	6.50^{c,d}	6.30^{g}	6.40^{f}

a-k Values with the different superscript within the same column differ significantly at P <0.5

Fig. (1) Sensory panel scores of the market samples of beef and turkey luncheon

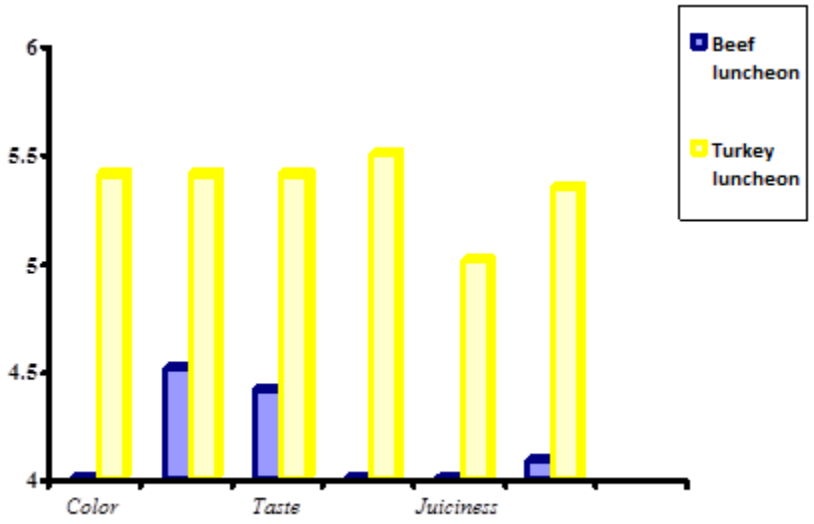


Fig. (2) Changes in sensory panel scores of chicken luncheon produced with different fat replacers *during refrigeration storage*

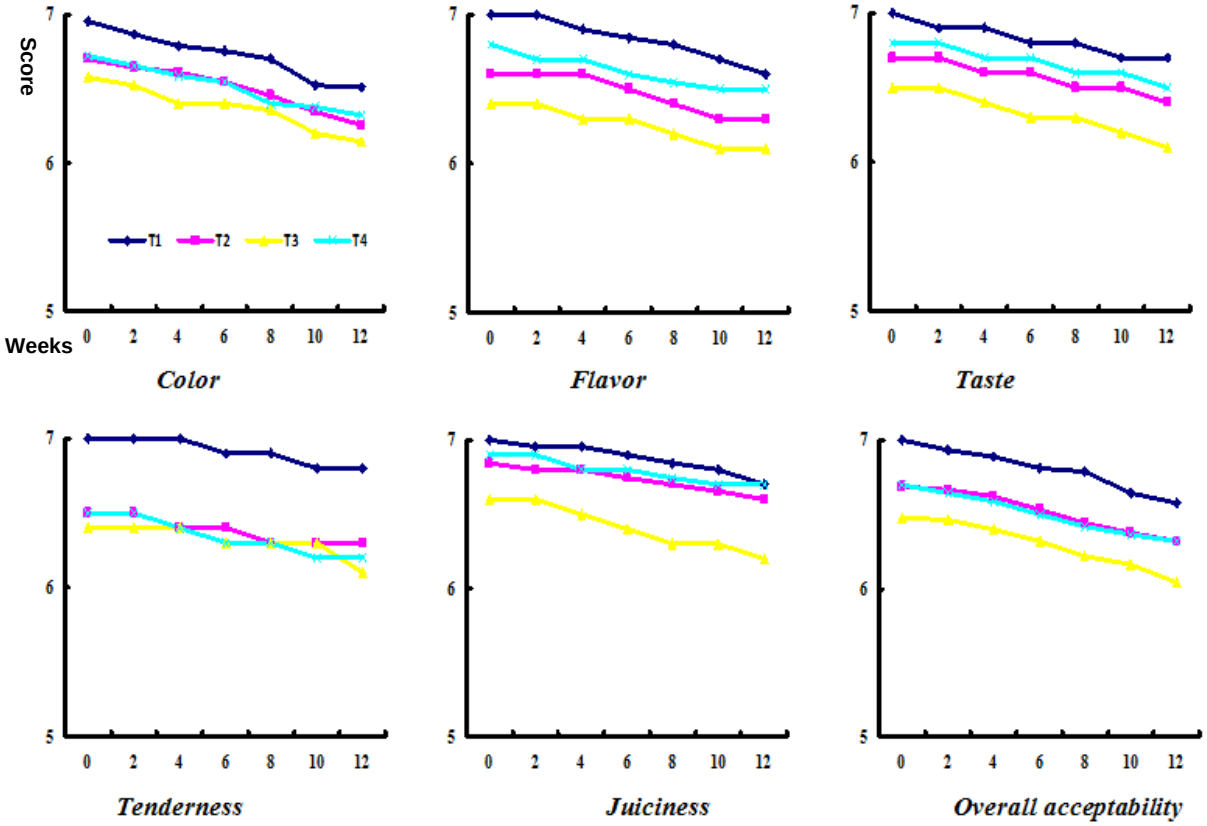
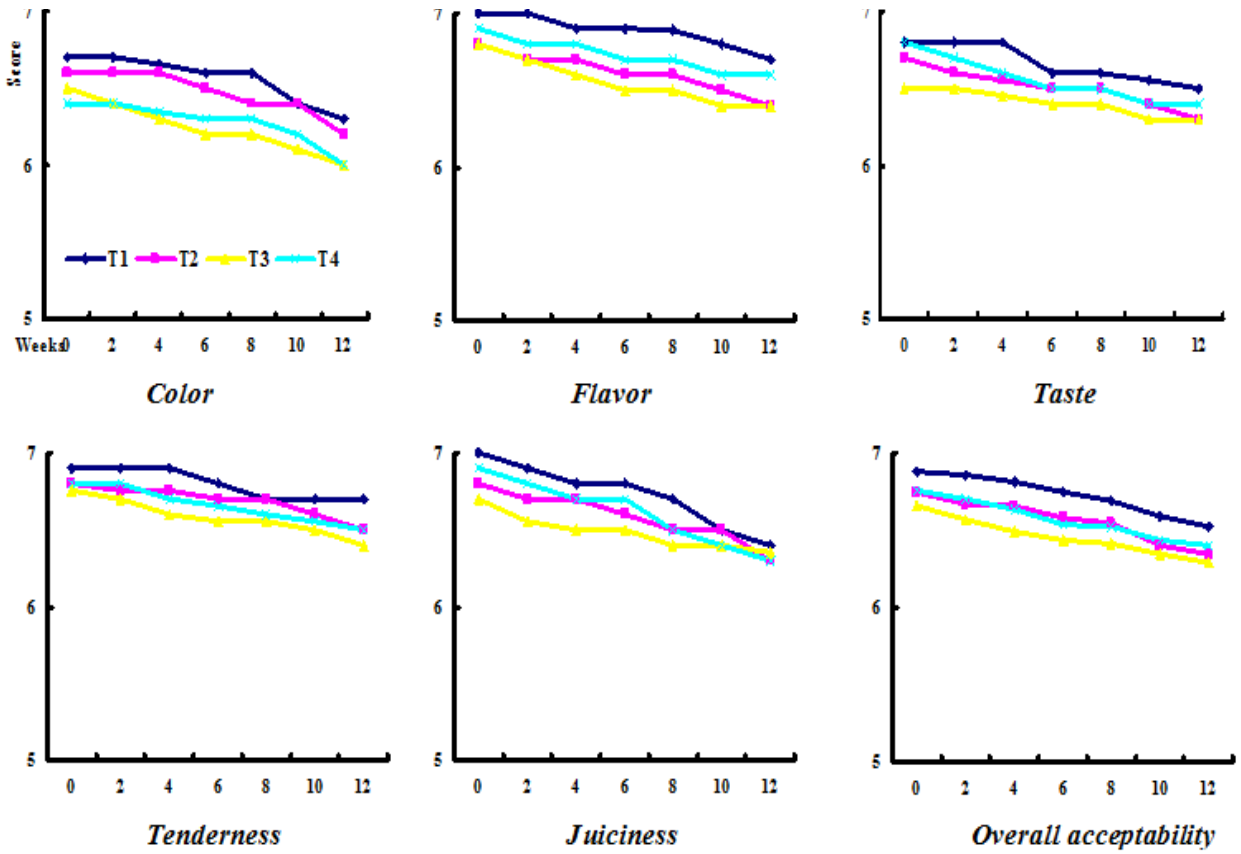


Fig. (3): ***Changes in sensory panel scores of turkey luncheon produced with different fat replacers during refrigeration storage.***



Clear, steady and significant reduction in scores of all sensory characteristics was observed with increase in storage weeks in all treatments of the experimentally produced beef and turkey luncheons as illustrated in Fig.2 and Fig 3, respectively. However, the sensory panel scores still acceptable and higher than that of market samples even after 3 months of refrigeration storage (Tables 2, 3)

DISCUSSION

In the last decades, the development of sensory evaluation of meat products as a science has undergone tremendous expansion. The sensory panel of manefactured meat products is recommended to measure meat tenderness and consumer evaluation.The low sensory panel scores of the market samples may be due to incorporation of other non-meat ingredients such as chicken skin as source of fat, mechanically recovered poultry meat, and high starch content (Nouman et al., 2001; Emara and Nouman, 2002a) especially in the traditional Egyptian beef and chicken luncheon as a method of cost reduction, which ultimately deteriorates the sensory quality of such products and lowers its overall acceptability.

Recently, consumers have demanded meat products that are safe, nutritious and attractive. This encourages awareness of meat products manufacturing to use new technologies which lead to beneficial effects on health (Desmond, 2006; Kemi et al., 2006). Some of these modifications of meat products may affect its quality (Ruusunen and Puolanne, 2005) but others improve sensory quality of the products and produce healthier products (Schirle- Keller et al., 1992). Fats in meat products play important role in stabilizing meat emulsions, reducing cooking loss, improving water holding capacity and providing juiciness and hardness (Carballo et al., 1995; Pietrasik and Duda, 2000; Yoo et al. 2007). Hughes et al., 1997

have also found that fats have considerable effects on the binding and structural properties of meat products. Additionally, (Giese, 1996) reported that fat in meat products forms stable emulsions which interact with other ingredients and control the sensory quality of products as texture, , juiciness and flavor. However, reduction of a significant amount of fat from meat products results in various technological problems such as rubbery and dry texture, soft mushy interiors, excessive purge and changes in flavor and mouth feel (Hatchwell, 1994). Therefore, reducing fat in meat products has adverse effect on appearance, flavor and texture and consumer acceptability (Tokusoglu and Unal, 2003; Vandendriessche, 2008), as well as cooking loss, and palatability (Lamkey, 1998; Chin et al., 2004). Increase cooking loss may decrease the yield of products leading to increase economic loss. Therefore, fat replacers must be added in order to improve the functional and textural properties caused by fat removal, (Chin and Chung, 2002;).

Fat replacers are ingredients that replace a certain amount of fats and contribute a minimum of calories to formulated meats products without alter flavor, juiciness, viscosity, mouth feel or processing properties dramatically. Many fat replacers are used for partial replacement of the fat (Keeton, 1994). Fat replacers, such as hydrocolloids, non-meat proteins, plant oil and gums are used to reduce the fat content in meat products (Choi and Chin, 2002; Keeton, 1994) to provide minimum calories without changing palatability.

This study reported significant decrease in scores of all sensory characteristics by increasing in storage period in all treatments of the experimentally produced products as well as high sensory panel scores of market samples even after 3 months of refrigeration storage (Tables 2-3). This was observed by (Reddy and Rao, 1997).

Tenderness of meat products has been shown to have relationship with addition of vegetable oils (Marquez et al., 1989). Though, addition of vegetable oils to meat products has considerable changes in their color and flavor (Swern, 1964), which may affect the quality characteristics of meat products. In the present study the use rice flour as fat replacer decreased color score significantly. This result agreed with Vickery and Rogers, 2002 who suggested that rice-based fat substitute can mimic fat mouth feel and texture perception. Also, (Alexander, 1995) who reported the same result and attributed it as the modified starch can form gel that adversely affecting on meat product sensory quality.

CONCLUSION

Results of this study can be concluded that replacement of the animal fat upgraded the sensory quality of cooked meat products and this will satisfy the needs of the consumer with low-fat as well as high palatable meat products

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Ayman Nasr Mahmoud Khalil, Herbert W.Ockerm were responsible for the design and conduct of the experiment including laboratory analysis. Ayman Nasr Mahmoud Khalil wrote the manuscript. and responsible for the statistical analysis of data.

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