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Full Length Research Paper

Effects of salt and phosphate levels on the emulsion properties of fresh and frozen hen meats

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Meat samples have been taken from 2 different parts of old hen carcasses in this research. The aim was to find the emulsion characteristics of these meat samples in fresh and after frozen stored and thawed at different phosphate (K_2HPO_4) and salt (NaCl) levels. It was observed that fresh meat samples generally had higher emulsion capacity (EC) and emulsion stability (ES) values than frozen meat samples, and breast meat had higher EC and ES values than thigh meat and mixed (breast meat : thigh meat, 1:1) meat. When general salt and phosphate levels were considered, the highest EC values were obtained at the combination level of 2.5% salt + 0.50% phosphate level.

Key words: Emulsion, emulsion capacity, emulsion stability, frozen, hen, meat.

INTRODUCTION

Animal protein sources are significant in nutrition. Therefore, better methods are necessary to use animal protein sources at maximum levels and make their usage more economical. Such emulsified meat products as salami and sausage have been produced and consumed extensively all over the world. In the production of salami and sausage, in addition to protein characteristics of mixed meats, some other factors such pH, temperature, cutter rate and oil types are also important. In order to have a good emulsion the optimization of these parameters are required (Webb et al., 1970; Haque and Kinsella, 1989; Karakaya, 1990; Gokalp et al., 1994; Kaya et al., 1999). Functional quality criteria of meat emulsions include emulsion capacity (EC), emulsion stability (ES), emulsion viscosity (EV), emulsion gel power, emulsion density and microscopic status (Gokalp et al., 1994; Zorba, 1995). In order to determine these quality criteria in different emulsions, laboratory type model systems have been used. Model system studies have often been preferred because they are convenient, economical, require minimum time and are reproductible. These model systems have been employed by several researchers (Gaska and Regenstein, 1982; Lyon et al., 1983; Haque and Kinsella ,1989; Karakaya, 1990; Zorba et al., 1993a,b; Karakaya and Bayrak, 1997; Kaya, 1997; Kurt and Zorba, 2005; Yapar et al., 2005). Both Lesiow and Skrabka (1984) and Karakaya (1990) concluded that EC and ES values of chicken meat were lower than beef meat. Smolinska et al. (1988) did not find any difference in breast and thigt parts of chicken in terms of EC values. However Lyon et al. (1984) concluded that EC values of breast of chicken were higher than these of thigh parts.

Phosphate added to meat products have significant effects on emulsion features. In emulsion technology, the use of phosphates are employed in order to increase pH of the emulsion. In addition, the use of phosphate in meat emulsions enhances the structural homogeneity of the product, provides better emulsification of oil and increases the stability (Gokalp et al, 1994). Zorba et al. (1993a,b) investigated the effect of phosphate (0.0, 0.25 and 0.50%) and salt (1.0, 1.5 and 2.5%) emulsion properties of frozen and fresh meat. They found that the EC value of frozen beef increased but the values of ES and EV decreased. They also found that EC was also elevated significantly with increasing phosphate and salt levels and the ES and EV were elevated significantly in the presence of phosphate when compared to the control.

Lesiow and Skrabka (1984) studied the emulsion features of frozen duck breast meat at –18 and –2^{0}C. They found that at both temperature levels, EC and ES values of the frozen breast meat were lower than those of fresh samples at both temperature levels. They argued that this was related to protein denaturation. Kurt and Zorba (2005) studied the effects of different concentrations (0.00, 0.25, 0.50%) of either non-fat dry milk (NFDM) or whey powder (WP) on EC and ES of beef, chicken and turkey meats . The EC and ES of chicken meat was higher than those found in beef and turkey meat.

In this study , meat samples taken from breast and thigh parts of old hen carcasses were used. Half of the samples were used as fresh, while the other half were frozen at $-25\pm^{o}C$ and stored at $-18^{o}C$ for two months. The effects of different salt and phosphate levels on the emulsion properties of fresh and frozen hen meats were investigated.

MATERIALS AND METHODS

Meat

Hen meats was taken from animals of 1.5 - 2 years old. They were cut, and breast and thigh parts were seperated, and ground using a lab style grinder with a 3 mm plate. Three different parts of meat; breast meat, thigh meat and their mixture (1:1 ratio) were employed in this study. In order to get a homogenenous mixture they were mixed using a kitchen robot for 20 min. The blended meat samples were divided into two portions, one of which was used as the fresh meat treatment while the other was frozen $-25\pm^{o}C$. The frozen hen meat samples were placed into polyethylene bags and stored at $-18^{o}C$ for two months. Analytical grade K_2HPO_4, NaCl and refined corn oil were used in the emulsion preparation. In the experiments, the effects of three different NaCl additions (1.0, 1.5 and 2.5%) and three different K_2HPO_4 additions (0.00, 0.25 and 0.50%) on the frozen breast, thigh and mixed meats were determined. The salt and K_2HPO_4 were weighed and the combined mixture was dissolved in distilled water and used as the salt-phosphate solution (SP) in this experiment. The experiment was replicated three terms for ES and EC.

Chemical composition

The solid content, total protein, of the samples were determined by the methods as decribed in (AOAC (1990) pH value was determined according to the the method of Gokalp et al. (1993).

The fat content was determined using the Babcock method (Gokalp et al., 1993).

Determination of emulsion capacity (EC)

EC of the samples was determined by using a model system described by Ockerman (1985) and modified by Zorba et al. (1993a). In the EC calculation, the determination of the final point was realized by ohm-meter (electrical conductivity measurement) developed by Webb et al. (1970). For this aim, 100 ml salt phosphate solution (SP) was added to 25 g sample an then mixed for 3 min using a blender (Waring Commercial Laboratory Blender, USA). Then, 12.5 g homogenate and 37.5 ml of additional SP solution were transferred into blender and homogenized for 15 s at low speed (~5000 rpm), and 50 ml of corn oil was added. To detect the end point of the emulsions, electrodes were connected to an ohm meter (Bew BE-360 TR Bultiester). Corn oil was added at rate of 0.6 - 0.8 ml/s. The emulsion end point was determined when the ohm meter connected to a millivolt recorder (Perkin Elmer Model 56) showed a sudden increase in resistance. At the end point, oil addition was stopped, and the amount of oil emulsified including the first 50 ml added was recorded. EC was calculated as milliliter oil/gram protein utilizing the Kjeldahl protein content of the samples (AOAC, 1990).

Determination of emulsion stability (ES)

ES determination was calculated using the method developed by Inklaar and Fortuin (1969) and Ockerman (1985). This method was modified by Zorba et al. (1993b). The sample was prepared as in EC determination. Corn oil was added at rate of 0.6 - 0.8 ml/s and total oil consumed was 80 ml. Then, a 10 g of emulsion was weighed into centrifuge tube. The samples were placed into water of $80^{o}C$ for 30 min. Any seperation of water and oil was observed during this process. In order to determine this, sample tubes were centrifuged at 2000 rpm for 15 min and both the amount of oil (ml) and of water (ml) were measured. Using these values, the amount of water (ES_1), the amount of oil (ES_2) and ES values were calculated as follows:

ES_1(%) = the amount of water (ml)*10
ES_2(%) = the amount of oil (ml)*d*10 (for corn oil d = 0.91 g/ml)
ES (%):100-(ES_1+ES_2)

Emulsion pH

The pH of the prepared emulsions were measured by a pH meter (Jenway 3010) as outlined by Ockerman (1985).

Emulsion density

The emulsion density is one of the simplest methods of determined emulsion properties. The emulsion density of the prepared emulsions was determined by using the picnometer according to Kurt et al. (1993).

Statistical analyses

All the statistical analyses were conducted using the SPSS (Version 10.0) commercial statistic program. Significant treatment and interaction means were further analyzed using multiple comparisons by Duncan Tests (Ozdamar, 2004).

RESULT AND DISCUSSION

Chemical composition

The solid content, total protein, fat content and pH values of the samples are given in Table 1. It was found that breast meat had less solid and fat contents in contrast to thigh meat. On the other hand, the amount of protein in breast meat was found to be higher than in thigh meat. The chemical composition of frozen meat is very similar to that of fresh meat.

Emulsion pH values

As seen in Table 2, the pH values of the frozen meat were significantly ($P<0.05$) higher than fresh hen meat. The pH values of breast meat were much lower than

Table 1. Chemical composition of hen meat samples.

Condition	Meat	Solid content (%)	Protein (%)	Fat (%)	pH
Fresh	Breast Meat(B)	33.58	20.26	9.66	5.92
	Thigh Meat(T)	38.84	16.87	20.66	6.25
	Mixture (B:T, 1:1)	35.75	18.48	15.33	6.09
Frozen	Breast Meat(B)	33.55	20.39	9.50	6.04
	Thigh Meat(T)	38.50	16.50	20.80	6.34
	Mixture (B:T, 1:1)	36.02	18.90	15.50	6.14

Table 2. pH of fresh and frozen hen meat with different salt and phosphate levels

			K_2HPO_4 level (%)		
Condition	Meat	Salt (%)	0.00	0.25	0.50
Fresh	Breast (B)	1.0	5.99	6.88	7.00
		1.5	6.03	6.80	7.05
		2.5	6.04	6.91	7.06
	Thigh (T)	1.0	6.39	7.10	7.20
		1.5	6.30	7.12	7.30
		2.5	6.18	7.11	7.42
	Mixture (B:T, 1:1)	1.0	6.07	7.02	7.20
		1.5	6.28	7.04	7.09
		2.5	6.04	6.97	7.32
Frozen	Breast (B)	1.0	6.00	6.90	7.03
		1.5	6.05	6.90	7.09
		2.5	6.10	7.06	7.27
	Thigh (T)	1.0	6.30	7.23	7.60
		1.5	6.61	7.33	7.49
		2.5	6.40	7.25	7.46
	Mixture (B:T, 1:1)	1.0	6.25	7.19	7.37
		1.5	6.25	7.04	7.28
		2.5	6.39	7.12	7.29

those of thigh meat and mixture ($P<0.05$). Phosphate addition significantly affected pH of the emulsions. The highest emulsion pH was observed for the sample containing 2.5% salt and 0.50% phosphate (Zorbal et al 1993a) . The addition of salt slightly changed the pH of the emulsion. The influence of those treatments on pH was probably as a result of a combination of alkaline K_2HPO_4 presence and the meat's buffer capacity (Zorba et al., 1993a). The results of the present study were similar to those of Karakaya (1990) and Zorba et al. (1993a).

Emulsion capacity

The EC of samples given in Table 3. The EC value of breast meat was much higher than those of thigh meat and mixture ($P<0.05$). Lyon et al. (1984) concluded that the EC value of breast meat was higher in contrast to that of thigh meat. However, this difference was not statistically significant. Smolinska et al. (1988) stated that the ability to extract protein of breast meat and to bind water and fat is higher than that of thigh meat. The EC values in the present study were similar to the results reported by Lesiow ve Skrabka (1984) for duct breast. Lyon et al. (1983) argued that the EC values of thigh meat decrease to a statistically significant level as a result of freezing process. They also stated that the amounts of water and oil increase in this process. Meat parts, salt and phosphate levels effects on the EC of fresh and frozen meat are given in Figures 1 and 2.

The results of analysis of varience of the effect of the kind of meat, the part of meat, NaCl and K_2HPO_4 levels on EC values are summarised in Table 4. It is observed that all emulsions prepared from frozen and thawed thigh meat were broken during the heating process. Thus no stable emulsion can be produced. The EC is the maximum amount of oil that can be emulsified by proteins. It

Table 3. Emulsion capacity (EC)* of fresh and frozen hen meat with different meat parts, salt and phosphate levels

Condition	Meat	Salt (%)	K_2HPO_4 levels (%)		
			0.00	0.25	0.50
Fresh	Breast (B)	1.0	255.4	257.1	254.8
		1.5	251.7	255.2	254.4
		2.5	249.7	244.2	265.6
	Thigh (T)	1.0	242.6	238.4	233.1
		1.5	240.8	239.6	251.4
		2.5	276.2	262.5	306.0
	Mixture (B:T, 1:1)	1.0	243.1	239.5	247.9
		1.5	243.6	243.1	244.7
		2.5	247.9	245.3	257.8
Frozen	Breast (B)	1.0	218.7	218.7	228.1
		1.5	236.2	223.8	243.9
		2.5	238.2	238.3	246.7
	Thigh (T)	1.0	142.7	137.4	144.3
		1.5	142.3	136.7	167.1
		2.5	188.2	159.2	213.9
	Mixture (B:T, 1:1)	1.0	195.4	206.6	201.5
		1.5	208.7	212.4	212.5
		2.5	241.2	237.3	247.4

* Values are in ml oil/g protein

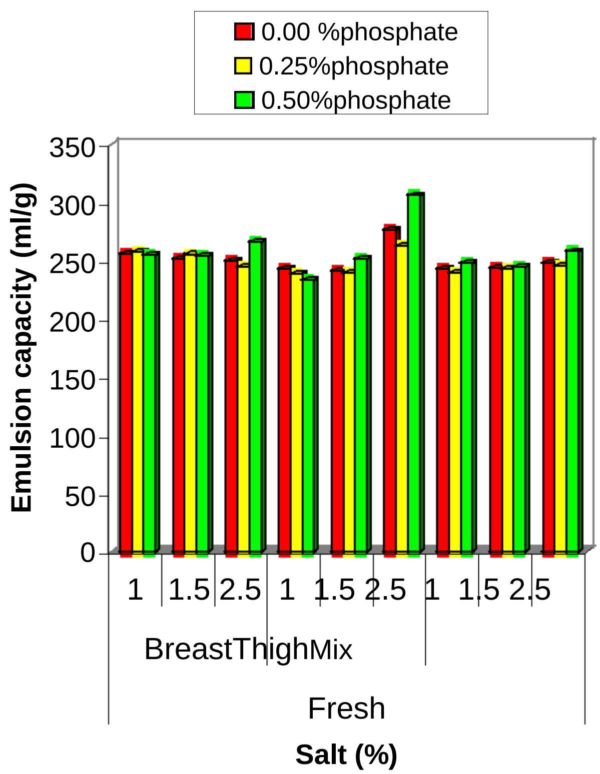

Figure 1. Effect of salt and phosphate levels on the capacity (EC) of fresh hen meat.

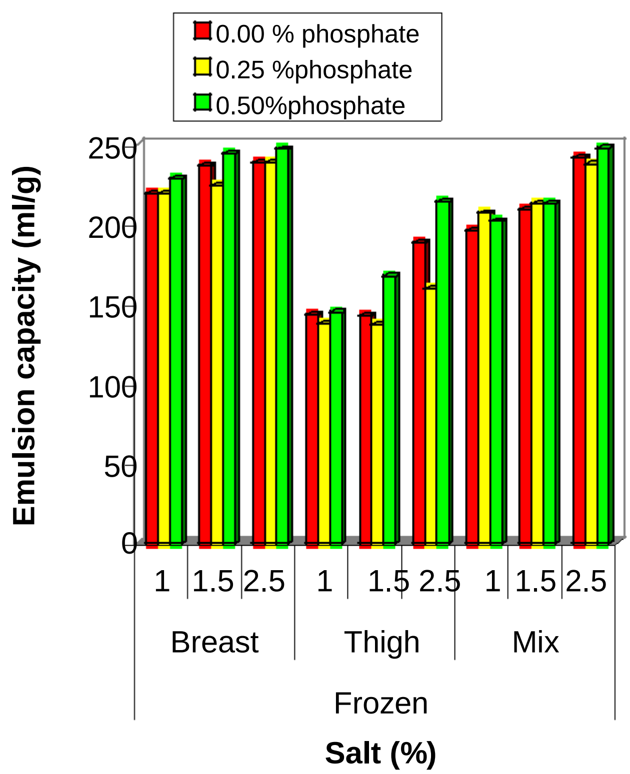

Figure 2. Effect of salt and phosphate levels on the capacity (EC) of frozen hen meat.

Table 4. Analysis of variance of the effect of the condition of meat, the part of meat, NaCl and K_2HPO_4 levels on capacity (EC) values.

Sources of variation	Degrees of freedom	Mean Square	F value
Corrected Model	53	4167.651	10.741
Intercept	1	8384103.005	21607.296
Condition of meat (CT)	1	93874.445	241.931*
Part of meat (PS)	2	18966.437	48.880*
Salt level (S)	2	9893.452	25.497*
Phosphate level (P)	2	2319.677	5.978*
CTxP	2	100.851	0.26
CTXPS	2	22716.834	58.545*
CT xS	2	1316.344	3.392*
PSxS	4	1915.721	4.937*
PSxP	4	421.667	1.087
SxP	4	663.088	1.709
CTxPSxS	4	366.824	.945
CTxPS xP	4	106.688	.275
CTxSxP	4	82.913	.214
PS xSxP	8	210.222	.542
CTxPSxSxP	8	59.312	0.153
Error	108	388.022	
Total	**162**		

*P<0.05 Significance level.

is strictly related to protein content and protein solubility (Kurt and Zorba, 2005). Therefore, the reason for higher EC value of breast meat can be explained by the higher protein values of breast meat.

There is no statistically significant difference at 1.0% and 1.5% salt levels in terms of the EC values. But at the 2.5% salt level, the EC value increased to a statistically significant level (Table 3). It was also observed that the EC value increases in parallel to the increase in the level of salt. It may be a result of the increase in the ability of proteins to emulsify fats (Heinevetter et al., 1987). As seen in Table 5, the EC of the fresh meat was significantly (P<0.05) higher than that of frozen hen meat. Table 5 also shows that EC values with 0.50% phosphate additions were higher than those without phosphate and those with 0.25% phosphate.

NaCl and phosphates have been reported to increase protein solubility, causing an increase in the EC of meat proteins (Zorba et al., 1993a). The authors concluded that the EC values increase when the levels of phosphate increases. They stated that pH is an importont factor in the increase of EC. The highest EC values in breast thigh meat and mixture were observed at the salt and phosphate levels of 2.5% and 0.50%, respectively (Table 3).

Emulsion stability (ES)

The ES of frozen meats was significantly lower than fresh meat. Freezing can cause a structural deformation of the muscle tissue and partial denaturation of the hen meats proteins so that the water may have been more easily released, causing a less stable emulsification for frozen meat. The ES of fresh and frozen meat with different meat parts, phosphate and salt levels are summarised in Table 6. Higher ES values was observed in breast meat in comparison to other two conditions of meat. It was observed that all emulsions prepared from frozen thigh meat were broken during the heating process. Lyon et al. (1983) indicated that fat level of meat and its pH level are very influential on the ES level and that the ES value is negatively affected by high levels of fat, low pH value and high amounts of water/protein. They also reported that chicken thigh meat binds less water and fat as a result of freezing. The pH value, fat level and water/protein ratio of breast meat were found to be lower in contrast to those in mixed and thigh meat.

The difference could be related to the difference in composition and pH value. The highest ES value was observed. Emulsion capacity and stability are significantly affected by increased ionic strength and pH of the solution (Hegarty et al., 1963; Zorba, 1993b). In fresh and

Table 5. Mean capacity (EC) values showing the effect of the condition of meat, the part of meat and and levels of K_2HPO_4 and NaCl.

Variables		Mean values of EC (ml oil/g protein)
Condition of meat (n:81)		
	Fresh meat	251.5 [a]
	Frozen meat	203.2 [b]
	SE	2.189
Part of meat (n:54)		
	Breast meat (B)	243.0 [c]
	Thigh meat (T)	232.0 [b]
	Mixed Meat (B:T, 1:1)	206.0 [a]
	SE	2.681
NaCl levels (n:54)		
	1.0%	217.0 [a]
	1.5%	222.0 [a]
	2.5%	242.0 [b]
	SE	2.681
Phosphate level (n:54)		
	0.00%	225.0 [a]
	0.25%	221.0 [a]
	0.50%	234.0 [b]
	SE	2.681

SE: Standarr error; n: Number of observations. The mean values with the same letters within a group for a variable are not significantly different ($P>0.05$) from each other.

Table 6. Emulsion stability (ES) of fresh and frozen hen meat with different meat parts, salt and phosphate levels

				K_2HPO_4 (%)	
Condition	**Meat**	**Salt(%)**	**0.00**	**0.25**	**0.50**
Fresh	Breast (B)	1.0	63.0	55.7	58.4
		1.5	59.4	58.0	59.3
		2.5	60.3	63.6	61.7
	Thigh (T)	1.0	Broken	55.1	49.7
		1.5	Broken	54.7	59.1
		2.5	61.0	56.2	58.1
	Mixture (B:T,1:1)	1.0	56.3	55.1	56.4
		1.5	59.1	56.4	54.9
		2.5	59.0	56.5	63.0
Frozen	Breast (B)	1.0	55.4	56.0	61.5
		1.5	57.0	59.0	59.4
		2.5	57.4	57.4	63.0
	Thigh (T)	1.0	Broken	Broken	Broken
		1.5	Broken	Broken	Broken
		2.5	Broken	Broken	Broken
	Mixture (B:T, 1:1)	1.0	54.6	47.8	51.6
		1.5	50.2	53.8	54.6
		2.5	55.3	46.3	57.3

frozen mixed samples and in frozen breast emulsions, 2.5% salt + 0.50% phosphate level had the highest ES value. In fresh breast emulsions, as seen in Table 6, the addition of salt and phosphate increase ES values. At the 2.5% level of salt addition, 2.5% salt + 0.25% phosphate level also had the highest ES value. In fresh thigh emulsions, 2.5% salt + 0.00% phosphate level had the highest ES.

Emulsion density (ED)

The emulsion density of sample prepared with fresh breast, thigh and mixed hen meats were determined to be 0.945, 0.930 and 0.938 g/cm^3, respectively. The emulsion density of sample prepared with frozen breast, thigh and mixed hen meats were 0.939, 0.930 and 0.935 g/cm^3, respectively. The ED of thigh was lower than breast meat. The difference could be related to the difference in composition.

Conclusıons

The ES and EC of fresh meat were higher than in frozen meat. The difference could be related to the structural deformation or partial denaturation of the frozen meat proteins. Both EC and ES values of thigh meat were lower than those of breast meat and mixed meat. The ES value of breast meat was found to be higher than those of thigh meat and mixed meat. It was also found that those emulsions prepared from thigh meat were broken during the heating process. In general, the addition of salt and phosphate positively affected the emulsion properties. The EC of the sample with 2.5% salt and 0.50% phosphate was higher than those of the other groups. The result indicates under these conditions, especially the breast meat and/or its suitable mixes, the hen carcasses could be used in the processing of emulsion type products.

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