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ORIGINAL PAPER

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The effect of various types of poultry pre- and post-rigor meats on emulsification capacity, water-holding capacity and cooking loss

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Abstract In this study, the relationship between various kinds of poultry meat (quail, partridge, chicken and turkey) on pH, emulsification capacity, water-holding capacity and cooking loss was investigated. The effect of rigor state on pH, emulsification capacity, water-holding capacity and cooking loss was also determined. To investigate these parameters, immediately after slaughter and deboning, meat parts were submitted to both pre- and post-rigor analyses. The results indicated that the emulsification capacity of quail and chicken meat was higher than the values for partridge and turkey meat. Quail meat showed the highest water-holding capacity value in the post-rigor stage. The lowest cooking loss value was found in partridge meat, in both pre- and post-rigor stages. The state of rigor had a significant ($P<0.05$; $P\leq 0.01$) effect on pH and cooking loss values, respectively.

Keywords Pre-rigor · Post-rigor · Emulsification capacity · Water-holding capacity · Cooking loss

Introduction

Determination of emulsification capacity (EC), water-holding capacity (WHC) and cooking loss (CL) of various kinds of meat is very important for fresh meat and further-processed products. In both cases, high yield and low cooking losses are desired. Consumers discriminate against packages of fresh meat showing free fluid surrounding the products and also against further-processed products showing exudate in the package [1]. In order to avoid these troubles, it is essential to know the parameters mentioned. However, the literature lacks adequate information on some of these parameters, e.g., EC and WHC of muscle from partridge, quail and turkey [2].

Meat emulsion systems have been studied to test physical, chemical and technological properties of the proteins. Such studies often lead to different conclusions and also have different alternative processing methods [3–6]. However, some emulsion studies have been conducted employing model systems, in addition to commercial meat systems, to test and compare emulsion properties of food proteins [7–9]. Model system studies have often been preferred because they are convenient, economical, require minimum time and are reproducible [10–14].

WHC is known to be one of the major quality characteristics of fresh meat, as it affects some major characteristics of the cooked meat such as potential drip loss, technological quality, appearance and sensory properties [15]. These quality characteristics are especially important in comminuted meats such as sausages [16]. Low WHC of meat is undesirable for both retail consumption and manufacturing [17]. High WHC is desired both by industry and by consumers [18, 19]. A useful way to determine quality changes in the post-rigor stage is to measure the WHC of muscles [20].

Exudation is an important quality parameter for the meat industry. Factors involving the degree of comminution, mechanical working and the quantity of NaCl can be used to help in the control of exudation levels. Differences between meat from the same species and even the same cut can affect exudation. [17].

Cooking of pre-rigor meat inactivates the glycolytic enzymes and fixes the pH. Rapid freezing of meat leads to ‘thaw rigor’ on defrosting [17].

CL is a very important factor for meat processors, as it directly affects eating quality and determines profitability [21]. CL is also affected by pH values of meat species and a high pH in muscle will improve the CL value [16].

The goal of the present study was to investigate the differences between various kinds of poultry meats with respect to pH, EC, WHC and CL parameters and to determine the effect of rigor state and meat types on these same parameters.

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Materials and methods

Materials

Four species of poultry (partridge, quail, chicken and turkey) were procured from the Animal Feeding Unit of the Department of Animal Science in Agriculture Faculty, Selcuk University (Konya, Turkey). Three animals of each species (12 carcasses in total) were slaughtered. After deboning, meat parts were separately ground through a 3.0-mm plate. Then, ground meats were separately mixed with a mixer for 3 min in order to acquire homogenous batches. These batches were pooled by replication (n=6), and placed in low-density polyethylene tubes to conduct pre- and post-rigor analyses. Pre-rigor analyses were conducted less than 90 min after the slaughtering and deboning processes. The remaining meat batches were held for 24 h at 2 °C for post-rigor analyses [22].

Proximate analyses and pH

Analyses of moisture, protein (Kjeldahl) and fat (ether extraction) were determined according to the methods of the AOAC [23]. For pH determination, the sample (10 g) was homogenized in 100 ml of distilled water. The pH was measured with a pH meter [24].

Emulsification capacity

The EC was determined by using a model system described by Ockerman [24]. The end point was determined as described by Webb et al. [7]. A solution of NaCl (2.5%) and K_2HPO_4 (0.25%) in water was prepared. To measure EC, 25 g of meat sample and 100 ml of cold (2±2 °C) salt–phosphate solution (SPS) were placed into a blender jar and comminuted for 2 min at 13,000 rpm. The slurry obtained (12.5 g) and 37.5 ml of additional SPS were transferred to another blender jar and homogenized for 10 s at low speed (5,000 rpm). Then, 50 ml of corn oil was added. To detect the break point of the emulsions, electrodes were connected to an ohmmeter with a millivolt recorder. Oil was added at a speed of 1.0 ml s^{-1}. The blender rate during emulsifying was 13,000 rpm. The water-jacketed burette containing the oil was maintained at 11 °C. The emulsion break point was detected when the ohmmeter showed a sudden increase in resistance. At the break point, oil addition was stopped. The total amount of emulsified oil was measured and calculated by considering 50 ml of oil was initially added. EC was calculated as milliliters of oil per gram of protein after protein (Kjeldahl) contents of the meat samples had been determined [24].

Water-holding capacity

The method reported by Wardlaw et al. [25] was used to determine the WHC of meat batches. A meat sample (8 g) and 12 ml 0.6 M NaCl solution were put into a tube. The tubes were placed into a water bath (5 °C) for 15 min, and the tubes were centrifuged (4 °C) at 10,000 rpm for 15 min. The supernatant was obtained to determine the WHC (percent) of the meat batches.

Cooking loss

The meat sample (20 g) was placed in a polyethylene bag and heated in a water bath at 80 °C to achieve an internal temperature of 72 °C. During cooking, the temperatures at the center of the meat samples were monitored with a glass thermometer inserted into the center of the sample. The drip was drained from the sample. The cooked mass was cooled and subsequently weighted to determine weight loss [26].

Statistical analysis

The poultry meat samples were analyzed in both the pre-rigor and the post-rigor stages. The data were tested using one-way ANOVA as four meat kinds times three batches of each meat kind times two replicates with 23 degrees of freedom [27]. Significant treatment means were further analyzed using Duncan's multiple range test option [28]. A t-test was used to determine the effect of rigor state on poultry meat types for pH, EC, WHC and CL [27].

Results and discussion

Proximate analyses

The results shown in Table 1 demonstrate a significant (P<0.05) difference in proximate analyses of meat types with respect to fat values, moisture and protein. The results were similar to USDA results [29].

pH

The differences in pH between kinds of meat and pre- and post-rigor stages are shown in Table 2. Significant (P<0.05) differences were found with respect to pH in pre- and post-rigor stages. The quail meat had the highest pH value in both pre- and post-rigor stages. The pH value of turkey meat was the lowest in the post-rigor stage. It is also clear from Table 2 that the rigor state of poultry meats had a significant (P<0.05; P<0.01) effect on the pH value. This could be due to the glycolysis.

Emulsification capacity

There was a significant (P<0.05) difference with respect to EC values in pre- and post-rigor stages. The EC values for quail and chicken meat were higher than the values for partridge and turkey meat in both pre- and post-rigor stages (Table 2). These results were consistent with the information reported by Cheftel et al. [30], who stated that pH was one of the most important parameters to affect emulsion characteristics. Therefore, decreasing pH values in the post-rigor stage cause proteins to approach the isoelectric point where proteins show the lowest EC [31]. From this point, the high pH values of quail and chicken meats in the post-rigor stage could explain their higher EC values. Table 2 shows that, in relation to the

Table 1 Proximate analyses results of poultry meats. The values are means of two observations per treatment and their pooled standard deviation (*SD*).

Analyses	Species			
	Partridge	Quail	Chicken	Turkey
Moisture (%)	72.9±0.3	74.0±0.8	71.0±1.1	69.3±3.3
Protein (%)	21.8±0.0	21.1±1.6	19.6±0.4	20.6±0.2
Fat (%)[a]	3.3±0.7	2.2±0.0	5.6±1.3	6.6±1.6

[a] Significance using F test (P<0.05)

Table 2 The difference between poultry meat types and pre- and post-rigor stages with respect to pH, emulsification capacity (*EC*), water-holding capacity (*WHC*) and cooking loss (*CL*). The values are means of six observations per treatment and their pooled SD. Means within a column with no common *superscript* differ significantly by the Duncan's multiple range test ($P<0.05$). *Asterisks* indicate that there is a significant difference between pre- and post-rigor meat types using a *t*-test: *$P<0.05$; **$P\leq0.01$.

Stages	Kind of meat	pH	EC (ml oil/g protein)	WHC (%)	CL (%)
Pre-rigor	Partridge	**$6.35^{b}\pm0.0$	**$198^{b}\pm1.4$	$39.6^{a}\pm3.8$	**$22.3^{b}\pm1.6$
	Quail	*$6.53^{a}\pm0.0$	$221^{a}\pm29.5$	$47.4^{a}\pm8.9$	**$24.9^{a}\pm1.3$
	Chicken	**$6.40^{b}\pm0.0$	$224^{a}\pm2.4$	$37.5^{a}\pm6.9$	**$25.4^{a}\pm1.3$
	Turkey	**$6.32^{b}\pm0.2$	$198^{b}\pm2.7$	$38.0^{a}\pm14.3$	**$26.1^{a}\pm0.5$
Post-rigor	Partridge	**$6.13^{b}\pm0.1$	**$205^{b}\pm1.7$	$35.9^{c}\pm2.6$	**$25.7^{c}\pm1.7$
	Quail	*$6.38^{a}\pm0.1$	$215^{a}\pm16.3$	$53.1^{a}\pm2.8$	**$27.9^{b}\pm1.1$
	Chicken	**$6.10^{b}\pm0.0$	$222^{a}\pm2.6$	$44.3^{b}\pm5.0$	**$27.5^{b}\pm1.0$
	Turkey	**$5.72^{c}\pm0.1$	$200^{b}\pm1.7$	$39.0^{bc}\pm7.5$	**$30.5^{a}\pm1.5$

rigor state, only partridge meat shows a significant ($P<0.01$) difference in EC value. These results are specific and informative because, as stated previously, little information is available on the EC of muscle from partridge, quail and turkey [2].

Water-holding capacity

As seen in Table 2, there was a significant ($P<0.05$) difference between meat types with respect to the WHC values in the post-rigor stage only. The influence of pH on WHC has been demonstrated by Warriss et al. [32]. The pH value of quail meat was the highest; therefore, the highest WHC value of quail meat in the post-rigor stage was attributed to its higher pH value when compared with the other meat types. The results were also in accordance with the results from an investigation performed on the myofibrillar system [33], where it was reported that the WHC is at a minimum at the isoelectric point, where the net charge of myosin and actomyosin are at a minimum. There was no effect on WHC of the rigor state for meat types (Table 2). This result did not agree with the information given by Offer and Knight [34], who have reported that post-rigor stages caused a decrease in muscle WHC. The discrepancy in the results may be attributed to the occurrence of proteolysis of meat samples at 24 h at 2 °C for post-rigor analyses. Thus, our results agree with the results of Kristensen and Purslow [35], who have recently shown that the WHC of pork meat first decreased and then increased during cold storage (24 h at 2 °C).

Cooking loss

It was found that there was a significant ($P<0.05$) difference between poultry meat types (Table 2). The partridge meat had the lowest CL value in both pre-rigor and post-rigor stages. Turkey meat had the highest CL value in the post-rigor stage. The rigor state of poultry meat types had a significant ($P\leq0.01$) effect on CL values. Accordingly, the CL value of each meat type in the post-rigor stage was higher than the CL value of each kind of meat in the pre-rigor stage. According to Lawrie [16], a pH fall will increase the CL. Hence, these results could be explained by lower pH levels of meat types in the post-rigor stage.

Conclusion

Quail and chicken meats show a higher EC compared with that of partridge and turkey meats in both pre- and post-rigor stages. Quail meat has the highest WHC value in the post-rigor stage. The use of quail and chicken meats should result in considerable advantages in the production of further-processed products, especially in the production of emulsion-type meat products. Partridge meat has the lowest CL value in both pre-rigor and post-rigor stages. This property makes it appropriate for use in meat products. Poultry meats in the pre-rigor stage are recommended, with respect to CL, for meat products that are to be processed further.

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References

1. Barbut S (2002) Poultry products processing, an industry guide. CRC Press, Boca Ratan, FL 548pp
2. Swift CE, Lockett C, Frayer AJ (1961) Food Technol 15:468
3. Smith GC, John H, Carpenter L, Maatil KF, Carter CM (1973) Food Sci 38:849–855
4. Lauck RM (1975) Food Sci 40:736–740
5. Sofos JN, Noda I, Allen CE (1977) Food Sci 42:879–884
6. Ensor SA, Mandigo KW, Calkins CD, Quint LN (1987) Food Sci 52:1155–1158
7. Webb NB, Ivey JF, Craip HB, Jones VA, Monroe RJ (1970) Food Sci 35:501–504
8. Kato A, Fujishige T, Matsudomi N, Kobayashi K (1985) Food Sci 50:56, 58, 62
9. Haque Z, Leman J, Kinsella JE (1988) Food Sci 53:1107–1110
10. Huang YT, Kinsella JE (1987) Food Sci 52,1684–1688
11. Parks LL, Carpenter JA (1987) Food Sci 52:271–274, 278
12. Paulson AT, Tung MN (1988) Food Sci 53:817–825
13. Haque Z, Kinsella JE (1988) Food Sci 53:416–420
14. Haque Z, Kinsella JE (1989) Food Sci 54:39–44
15. Oeckel MJ, Warnanats N, Boucque CV (1999) Meat Science 51: 313–320
16. Lawrie RA (1991) Meat science, 5th edn. Pergamon, Oxford, 293pp
17. Varnam AH, Sutherland JP (1995) Meat and meat products, 1st edn. Chapman & Hall, London, 430pp

18. Offer G, Trinick J (1983) Meat Sci 8:245–281
19. Fennema OR (1990) Muscle Foods 1:363–381
20. Olsson GB, Olsen RL, Carlehög M, Ofstad R (2003) Aquaculture 217:191–205
21. Aaslyng MD, Bejerholm C, Ertbjerg P, Bertram HC, Andersen HJ (2003) Food Quality Preference 14:277–288
22. Dzudie T, Okubanjo A (1999) Food Engineering 42:103–107
23. AOAC. (2000) Official methods of analysis 17th edn. Official Methods of Analysis of AOAC International, Gaithersburg, MD
24. Ockerman HW (1985) Quality control of post-mortem muscles tissue 13th edn. The Ohio State University, Colombus, OH
25. Wardlaw FB, McCaskill LH, Acton JC (1973) Food Sci 38:421–423
26. Kondaiah N, Anjaneyulu ASR, Keseva Rao V, Sharma N, Joshi HB (1985) Meat Sci 15:183–192
27. MINITAB (1991) Minitab Reference Manual, Release 7.1 Minitab Inc., State Coll., PA
28. MSTAT C (1986) Version 4.00. Michigan State University East Lansing, MI
29. USDA (1999) Nutrient database for standard references, Release 13. US Department of Agriculture, Washington, DC
30. Cheftel JC, Cuq JL, Lorient D (1986) Amino acids, peptides, and proteins. In: Fennema OR (ed) Food chemistry, 2nd edn. Marcel Dekker, New York, pp 246–369
31. Gökalp HY, Kaya M, Zorba Ö (1997) Meat process engineering Ataturk University Publ. no. 786. Ataturk University, Erzurum, 561pp
32. Warriss PD, Wilkins LJ, Knowles TG (1999) The influence of ante-mortem handling on poultry meat quality. In: Richarson RI Mead GC (eds) Poultry meat science. Poultry meat symposium series Vol 25. CABI Publishing Wallingford, UK, pp 217–230
33. Hamm R (1986) Functional properties of the myofibrillar system and their measurement. In: Muscle as food. Academic, New York, pp 135–199
34. Offer G, Knight P. (1988) The structural basis of water-holding in meat. In: Lawrie R (ed) Developments in meat science, vol 4. Elsevier Applied Science, London, pp 63–243
35. Kristensen L, Purslow PP (2001) Meat Sci 58:17–23