Content is avaliable at SCOPUS

Meat Technology — Special Issue 64/2

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 637.514.9.05:636.5
637.54:636.5]:664.932

ID: 126687497

https://doi.org/10.18485/meattech.2023.64.2.84

Original scientific paper

Effects of replacing chicken meat with chicken liver on some quality characteristics of model system chicken meat emulsions

Berker Nacak[a*]

[a] *Uşak University, Engineering Faculty, Food Engineering Department, 64000, Uşak, Türkiye*

A R T I C L E I N F O

Keywords:
Chicken liver
Chicken meat replacer
Model system chicken meat emulsion
Technological properties
Quality characteristics

A B S T R A C T

The present study was set the purpose of investigating the effects of chicken liver as a chicken meat replacer on some quality characteristics of model system chicken meat emulsions. For this purpose, one control (100% chicken meat) and three different chicken liver treatments were formulated as follows: L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver). Chicken liver replacement ratios significantly affected moisture and protein contents and pH ($p<0.05$). The lowest emulsion stability and water holding capacity was observed in L75 ($p<0.05$). L75 also had the highest cooking loss among the emulsions ($p<0.05$). Chicken liver replacement ratio increments resulted in lower L* and b* values and higher a* values ($p<0.05$). Textural properties of emulsions were significantly affected by the presence of chicken liver in formulations, and softer emulsions were achieved with increasing chicken liver addition ($p<0.05$). The present study showed that chicken liver could be a good chicken meat replacer at up to 50%; however, this ratio could be increased by the addition of binders/fillers in meat products.

1. Introduction

Meat products are consumed world-wide in a variety of forms. They are among the foods that offer the best opportunity to deliver high amounts of protein, essential amino acids, minerals such as iron and selenium, vitamins and other nutrients (*Bolger et al.*, 2017). Different strategies have been used to change ingredients to improve the quality and presence of bioactive compounds in meat products (*Jiménez-Colmenero et al.*, 2001).

Chicken production and consumption have steadily increased globally. This implies that chicken edible by-products are also increasing day by day. Chicken liver, which is around 1.6–2.3% of a chicken's weight, is one of the main chicken by-products (*Ockerman & Basu,* 2004). According to *Ockerman and Basu* (2004) and *Seong et al.* (2015), chicken liver could be a good source of vitamins A, B_{12}, and some minerals, such as iron (Fe). Thus, using chicken liver in meat formulations could be a good strategy to provide novel products with high nutritional quality. However, using chicken liver in meat formulations could affect some quality characteristics, such as emulsion stability, water holding capacity (WHC), cooking loss, texture and color. For this reason, the replacement ratio becomes an important challenge for producing novel formulations.

***Corresponding author:** Berker Nacak, *berker.nacak@usak.edu.tr*

Paper received July 13th 2023. Paper accepted July 27th 2023.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia

With the aforementioned facts, it is clearly understandable that using chicken liver in chicken meat formulations could increase the functionality of the products. Hence, the present study was set the purpose of investigating the effects of chicken liver as a chicken meat replacer on some quality characteristics of model system chicken meat emulsions.

2. Materials and methods

2.1. Materials

Chicken meat, chicken liver and beef fat were purchased from a local butcher. Sodium tripolyphosphate and sodium chloride were purchased from Kimbiotek (İstanbul, Türkiye).

2.2. Production of emulsions

In each treatment, the total proportion of chicken meat and chicken liver was 68%, and four different treatments were produced by replacing chicken meat with chicken liver as follows: C (100% chicken meat+0% chicken liver), L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver). Chicken meat, chicken liver and beef fat were passed through a grinder with a 3mm plate (Arnica Meatchef, Türkiye). After homogenization of chicken meat, chicken liver and half of the ice (5%) for 1 minute in kitchen type blender (Fakir Mr Chef Quadro, Türkiye), beef fat (20%), salt (1.5%), sodium tripolyphosphate (0.5%), and rest of the ice (5%) were added to the blender and mixed to provide a uniform blend. After obtaining a uniform blend, portions of each emulsion (approximately 25 g) were placed in Falcon tubes (50 mL) and were hermetically sealed. The tubes were heated for 30 min in a 70°C water bath. Emulsions were cooled to room temperature and analyzed.

2.3. Methods

2.3.1. Chemical composition

Moisture, fat, protein and ash contents of the samples were determined according to *AOAC* (2005).

2.3.2. Emulsion stability, water holding capacity and cooking loss

Emulsion characteristics of treatments in terms of total expressible fluid (TEF) and WHC were determined according to *Hughes et al*. (1997). Cooking loss (CL) was calculated according to sample weight difference before and after cooking. Total expressible fat (TFAT) was calculated with a modified procedure of *Hughes et al*. (1997) as follows:

2.3.3. pH

The pH of raw and cooked emulsions was measured using a pH meter (Hanna Instruments Inc., USA) on a homogenate of 10 g sample in 90 ml of distilled water.

2.3.4. Color

Lightness (L*), redness (a*) and yellowness (b*) parameters of treatments were determined by using a portable colorimeter (Chromameter CR400, Minolta, Japan). Emulsions were cut in half and color was determined on the inside cut surfaces.

2.3.5. Textural properties

Texture profile analysis (TPA) of cooked emulsions was performed using a texture analyzer (CT3-4500; Brookfield Engineering Laboratories, USA) with TA4/1000 probe. Samples (10 mm length, 20 mm diameter cylinder) were taken and compressed to 50% of their original height with a crosshead speed of 1 mm/s and 4500 g load cell. Texture Expert version 1.0 software (Stable Micro Systems, England) was used to collect and process the data.

2.3.6. Statistical analysis

All analyses were carried out in triplicate and one-way analysis of variance (ANOVA) was applied in order to observe the effect of using chicken liver as chicken meat replacer. Significant differences that had an effect were further analyzed by Duncan's multiple range test at 95% confidence level using SPSS for Windows statistical package program (version 23, IBM, USA).

3. Results and discussion

The chemical composition of emulsions is shown in Table 1. Moisture, fat, protein and ash contents of samples ranged between 58.97–61.15%, 19.82–20.80%, 16.48–17.29%, and 2.61–2.80%, respectively. According to the results, fat and ash contents of the emulsions were similar ($p>0.05$). However, significantly lower protein content and higher moisture content was found L75 than in the

Table 1. Chemical composition and pH of emulsions

	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	pH	
					Raw	Cooked
C	59.41±0.64^{b}	20.16±0.37	17.07±0.31^{a}	2.77±0.05	6.16±0.01^{d}	6.24±0.01^{d}
L25	59.14±0.18^{b}	20.06±0.17	17.29±0.25^{a}	2.61±0.14	6.29±0.01^{c}	6.41±0.01^{c}
L50	58.97±0.94^{b}	19.82±0.86	17.01±0.63^{a}	2.78±0.32	6.46±0.01^{b}	6.52±0.01^{b}
L75	61.15±1.00^{a}	20.80±0.43	16.48±0.13^{b}	2.80±0.33	6.57±0.01^{a}	6.61±0.01^{a}

$^{a–b}$ Means in a same column with different letters are significantly different (p<0.05). C (100% chicken meat+0% chicken liver), L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver).

other emulsions (p<0.05). Similar to our results, *Wijayanti et al.* (2013) stated that chicken liver addition ratio could decrease protein contents of broiler nuggets.

The pH of raw and cooked emulsions was between 6.16–6.57 and 6.24–6.61, respectively. Similar to previous reports (*Dourou et al*., 2021), in the present study, the pH of fresh chicken liver was 6.60±0.02. Thus, with respect to chicken liver ratio, the pH of raw and cooked emulsions was increased (p<0.05).

WHC, emulsion stability (total expressible fluid and total expressible fat), and cooking loss are presented in Table 2. WHC, total expressible fluid, total expressible fat and cooking loss were between 74.43–83.19%, 1.13–6.41%, 0.23–5.22%, and 3.89–7.03%, respectively. Using chicken liver as chicken meat replacer at up to 50% did not affect the emulsion stability (p>0.05). However, using chicken liver at more than 50% significantly degraded the emulsion stability and WHC, and increased the cooking loss of the emulsion (p<0.05). Even though the pH of L75 was higher than in other emulsions, L75's emulsion stability was the lowest (p<0.05). Protein provides good emulsifying ability in emulsions (*Tamnak et al.*, 2016). For this reason, lower protein content and higher moisture content could be the result of lower emulsion stability in L75 (p<0.05). Cooking loss is associated with fat and water retention of products. *Afshari et al. (2017)* stated that high fat and moisture losses resulted in higher cooking losses in meat products. Thus, lower total expressible fluid and total expressible fat caused higher cooking loss in L75 (p<0.05).

Color is one of the main factors affects the consumer preference. The addition of non-meat ingredients could result in undesirable color changes (*Serdaroğlu et al.,* 2018)P2 (2% PM. Interior color parameters of the emulsions are presented in Table 3. L*, a*, and b* values ranged between 56.78–73.79, 3.64–14.83, and 10.95–13.84, respectively. Chicken liver replacement ratio increments resulted in darker, redder and less yellow products due to the characteristic color differences between chicken meat and chicken liver (p<0.05). These color differences might be the result of minerals, such as iron and zinc (*Permatasari et al.*, 2020). *Seong et al*. (2015) stated that chicken liver has higher levels of trace elements than most edible by-products and muscle tissues.

Table 2. Water holding capacity (WHC), total expressible fluid (TEF), total expressible fat (TFAT), and cooking loss (CL) of samples

	WHC (%)	TEF (%)	TFAT (%)	CL (%)
C	83.19±1.81^{a}	1.22±0.03^{b}	0.30±0.02^{b}	3.89±.041^{b}
L25	82.93±2.06^{a}	1.22±0.06^{b}	0.23±0.13^{b}	4.24±1.02^{b}
L50	82.45±1.98^{a}	1.13±0.06^{b}	0.64±0.31^{b}	3.98±0.45^{b}
L75	74.43±1.97^{b}	6.41±0.29^{a}	5.22±0.33^{a}	7.03±1.29^{a}

$^{a–b}$ Means in a same column with different letters are significantly different (p<0.05). C (100% chicken meat+0% chicken liver), L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver).

Table 3. Color of emulsions

	L*	a*	b*
C	73.79±0.85[a]	3.64±0.19[d]	13.45±0.23[a]
L25	65.64±0.36[b]	10.34±0.54[c]	13.84±0.29[a]
L50	61.52±0.46[c]	13.04±0.40[b]	12.82±0.13[b]
L75	56.78±1.58[d]	14.83±0.40[a]	10.95±0.42[c]

[a–b] Means in a same column with different letters are significantly different (p<0.05). C (100% chicken meat+0% chicken liver), L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver).

Table 4. Textural properties of samples

	Hardness (g)	Springiness (mm)	Cohesiveness (mJ)	Gumminess (g)	Chewiness (g)
C	4605.00±718.00[a]	3.23±0.24[a]	0.70±0.01[a]	3217.50±467.50[a]	102.84±22.19[a]
L25	2420.55±258.54[b]	3.11±0.32[b]	0.66±0.01[ab]	1594.92±173.65[ab]	49.07±10.29[b]
L50	1286.00±146.00[c]	2.74±0.28[c]	0.58±0.07[bc]	725.20±30.00[bc]	19.49±2.00[c]
L75	557.77±59.94[d]	2.60±0.08[c]	0.50±0.09[c]	272.29±52.18[c]	6.97±2.38[c]

[a–b] Means in a same column with different letters are significantly different (p<0.05). C (100% chicken meat+0% chicken liver), L25 (75% chicken meat+25% chicken liver), L50 (50% chicken meat+50% chicken liver), and L75 (25% chicken meat+75% chicken liver).

Textural properties of the emulsions are shown in Table 4. Chicken liver addition affected the texture of samples significantly (p<0.05). Due to the softer texture of chicken liver, incremental addition of chicken liver resulted in softer samples (p<0.05). Similar results were observed by *Amertaningtyas et al.* (2023) and *Wijayanti et al.* (2013). *Amertaningtyas et al.* (2023) stated that increasing the chicken liver substitution ratio could result in softer products, since chicken liver does not have muscle fibers. All textural properties of L75 were similar to those of L50 (p>0.05), except the hardness. However, these two emulsions had significantly lower textural properties than the control (p<0.05).

4. Conclusion

The main aim of this study was to investigate effects of using chicken liver as a chicken meat replacer on some quality characteristics of model system chicken meat emulsions. The chicken liver replacement ratio significantly affected moisture and protein contents of the emulsions as well as the pH values (p<0.05). The lowest emulsion stability, WHC, and the highest cooking loss was observed in L75 (p<0.05). However, using chicken liver as a chicken meat replacer at up to 50% did not affected the emulsion stability (p>0.05). With respect to chicken liver replacement ratio increments, lower L* and b* values and higher a* values were observed (p<0.05). Textural properties of emulsions were significantly affected by the presence of chicken liver in the formulations (p<0.05). The present study showed that chicken liver could be a good chicken meat replacer at up to 50%; however, this ratio could be increased by the addition of binders/fillers. Thus, further studies should be conducted to determine the effects of using chicken liver as a chicken meat replacer in meat products such as sausages, nuggets etc.

Disclosure statement: No potential conflict of interest was reported by authors.

References

Afshari, R., Hosseini, H., Mousavi Khaneghah, A. & Khaksar, R. (2017). Physico-chemical properties of functional low-fat beef burgers: Fatty acid profile modification. *LWT — Food Science and Technology*, 78, 325–331, https://doi.org/10.1016/j.lwt.2016.12.054

Amertaningtyas, D., Evanuarini, H., Mutia, S. H. & Zahra, L. L. (2023). The effect of the addition of skim milk powder to broiler liver nuggets on physicochemical and organoleptic quality. *Jurnal Ilmu dan Teknologi Hasil Ternak*, 18(1), 50–63, https://doi.org/10.21776/ub.jitek.2023.018.01.6

AOAC, (2005). Official Method of Analysis. 18th Edition. Association of Official Analysis Chemists International Press, Maryland, USA.

Bolger, Z., Brunton, N. P. & Monahan, F. J. (2017). Effect of mode of addition of flaxseed oil on the quality characteristics of chicken sausage containing Vitamin E and omega 3 fatty acids at levels to support a health claim. *Food and Function*, 8(10), 3563–3575, https://doi.org/10.1039/c7fo00929a

Choe, J., Kim, G. W. & Kim, H. Y. (2019). Effects of green tea leaf, lotus leaf, and kimchi powders on quality characteristics of chicken liver sausages. *Journal of Animal Science and Technology*, 61(1), 28–34, https://doi.org/10.5187/jast.2019.61.1.28

Dourou, D., Grounta, A., Argyri, A. A., Froutis, G., Tsakanikas, P., Nychas, G.-J. E., Doulgeraki, A. I., Chorianopoulos, N. G. & Tassou, C. C. (2021). Rapid Microbial Quality Assessment of Chicken Liver Inoculated or Not With Salmonella Using FTIR Spectroscopy and Machine Learning. *Frontiers in Microbiology*, 11, https://doi.org/10.3389/fmicb.2020.623788

Hughes, E., Cofrades, S. & Troy, D. J. (1997). Effects of fat level, oat fibre and carrageenan on frankfurters formulated with 5, 12 and 30% fat. *Meat Science*, 45(3), 273–281, https://doi.org/10.1016/S0309-1740(96)00109-X

Jiménez-Colmenero, F., Carballo, J. & Cofrades, S. (2001). Healthier meat and meat products: their role as functional foods. *Meat Science*, 59(1), 5–13, https://doi.org/10.1016/S0309-1740(01)00053-5

Ockerman, H. W. & Basu, L. (2004). By-products| Edible, for Human Consumption. In *Encyclopedia of Meat Sciences,* (pp. 104–112), Elsevier, https://doi.org/10.1016/B0-12-464970-X/00046-5

Permatasari, N., Angkasa, D., Dhyani, P., Melani, V. & Purwara, L. (2020). Pengembangan Biskuit MPASI Tinggi Besi dan Seng dari Tepung Kacang Tunggak (Vignia unguiculata L.) dan Hati Ayam. *Jurnal Pangan Dan Gizi*, 10(02), 33–48.

Seong, P. N., Cho, S. H., Park, K. M., Kang, G. H., Park, B. Y., Moon, S. S. & Ba, H. Van. (2015). Characterization of chicken by-products by mean of proximate and nutritional compositions. *Korean Journal for Food Science of Animal Resources*, 35(2), 179–188, https://doi.org/10.5851/kosfa.2015.35.2.179

Serdaroğlu, M., Kavuşan, H. S., İpek, G. & Öztürk, B. (2018). Evaluation of the quality of beef patties formulated with dried pumpkin pulp and seed. *Korean Journal for Food Science of Animal Resources*, 38(1), 3–13, https://doi.org/10.5851/kosfa.2018.38.1.001

Tamnak, S., Mirhosseini, H., Tan, C. P., Ghazali, H. M. & Muhammad, K. (2016). Physicochemical properties, rheological behavior and morphology of pectin-pea protein isolate mixtures and conjugates in aqueous system and oil in water emulsion. *Food Hydrocolloids*, 56, 405–416, https://doi.org/10.1016/j.foodhyd.2015.12.033

Wijayanti, D., Hintono, A. & Yoyok, B. P. (2013). The protein content and tenderness of chicken nuggets with various level of broiler livers substitution. *Animal Agriculture Journal*, 2(1), 295–300.