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Evaluation of the quality of chilled and frozen African catfish (*Clarias gariepinus* Burchell, 1822) fillets

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Abstract: The quality of chilled and frozen African catfish fillets was compared. The experiment was performed on 20 individuals of *Clarias gariepinus* aged < 1 year, with estimated body weight of 1 kg. A total of 40 right and left fillets were subjected to pre-treatment. Chilled right fillets (20) and left fillets (20) stored for 8 months in the freezer were subjected to quantitative and qualitative laboratory analyses. Chilled African catfish fillets had a lower of moisture content, higher of total protein, fat and crude ash, and higher energy value than frozen samples. Chilled fillets had also higher water-holding capacity, lower cooking loss and higher tenderness.

Keywords: african catfish; chemical composition; chilled and frozen filets; physicochemical properties

African catfish (*Clarias gariepinus*) inhabits the entire African continent and the Middle East, with Turkey marking the northern boundary of its geographic range (Goda *et al.* 2007; Chwastowska-Siwiecka *et al.* 2016). The African catfish is also bred outside its native range, mainly because it is characterised by a higher growth rate than other species of the genus *Clarias*. Catfish are also more tolerant of adverse environmental conditions than other fish species, and they are facultative air-breathers due to specific gill morphology (Goda *et al.* 2007). The meat of African catfish has high total protein content (16.91–17.90%) and relatively low fat content (3.95–7.57%) (Polak-Juszczak 2007; Chwastowska-Siwiecka *et al.* 2016; Paleckaitis *et al.* 2018). According to Polish Standard PN-A-86770:1999, the African catfish with a fat content of up to 7% can be classified as medium-fat fish. The African catfish is highly valued for the quality and flavour of its meat which is well suited for processing, including freezing, cooking, frying, grilling, smoking and soup preparation (Rosa *et al.* 2007; Aderolu *et al.* 2009).

The quality of fish meat is significantly affected by the applied preservation methods, namely freezing, freezer storage and thawing. The maximum shelf life of frozen fish and frozen fillets is limited mainly by adverse microbiological, physical, chemical and biochemical changes in the lipid profile. Fish and fish products should be stored at a temperature of –30°C. The shelf life of frozen fish is twice longer at –30°C than at –18°C. The shelf life of fish freezed at –20°C is 15 months for lean fish and 16 months for fatty fish (Skałecki 2012). According to Polish Standard PN-A-07005:2006, the shelf life of medium-fat fish and their products stored in closed packaging is 6 months at a temperature from –22.1°C to –30°C and 8 months at temperatures below –30°C. The shelf-life of chilled fish stored at + 1 to + 2°C is approximately 7 days, and may vary across species (Samcik *et al.* 2018). In view of the above, the aim of

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this study was to compare the quality of chilled and frozen African catfish fillets.

MATERIAL AND METHODS

Material. The experiment was performed on 20 randomly selected African catfish (*C. gariepinus*) aged < 1 year, with estimated body weight of 1 kg. Fish were obtained in fall and winter from a farm in northern Poland which specializes in the production of freshwater fish. On the farm, catfish were reared in an intensive system and were kept in a concrete pool with a volume of 9000 l, water temperature of 25 ± 1°C and a closed recirculating system. Fishes were manually fed with farm-made pelleted feed every 3 hours. Feed composition (per 100 kg) was as follows: 17.8 kg of fish meal, 44.6 kg of soybean meal, 14.9 kg of wheat grain, 7.4 kg of maize grain, 11.9 kg of rapeseed cake, 2.4 l of fish oil, and 1 kg of vitamin-mineral premix. The nutrient content of feed was determined at the Laboratory of the Department of Animal Nutrition and Feed Science of the University of Warmia and Mazury in Olsztyn) according to standard methods (AOAC 2005). The content of dry matter, total protein, crude fat, crude ash and crude fibre was 89.49, 33.57, 5.82, 6.45 and 3.80%, respectively, and energy value was 17.229 MJ/kg.

Samples preparation. Fish were caught and transferred to a separate pool on the farm 48 h before slaughter. They were physiologically cleaned, stunned and slaughtered in line with the provisions of Council Regulation (EC) No. 1099/2009. Fish were manually eviscerated and decapitated, and fins and fillets were removed.

The experimental material comprised 40 skinned right and left fillets that had been chilled for 24 h in the Frost chilling chamber at relative air humidity of 85% to achieve a temperature of 4 ± 1°C. Chilled left fillets (20) were subjected to analyses at the Laboratory for Meat Quality Assessment of the Department of Commodity Science and Animal Raw Material Processing, University of Warmia and Mazury in Olsztyn. Right fillets (20) were placed in individual PET PVdC/CCP heat shrinkable bags made of non-oriented polypropylene film with high gas barrier properties. The bags were sealed in the Tepro PP-15 single-chamber vacuum packing machine with 98% attainable vacuum (Tepro S.A., Poland). Fish were frozen at –30°C and stored in the Cheminst freezing chamber for 8 months. At the end of the freezer storage period, fillet samples were thawed for 24 h under exposure to atmospheric air in the Frost chilling chamber at a temperature of 4 ± 1°C. Thawed fillets were subjected to quantitative and qualitative analyses.

Chemical composition. An analysis of the proximate chemical composition of fish meat included the determination of moister content (PN-ISO 1442:2000), total protein content – by the Kjeldahl method (PN-A 04018:1975/Az3:2002) in the FOSS Tecator Kjeltec 2200 System I, crude fat content by Soxhlet extraction (PN-ISO 1444:2000) in the FOSS Tecator Soxtec™ Avanti 2050 extractor, and crude ash content (PN-ISO 936:2000). The hydroxyproline content of fish meat was measured and converted into total collagen content using a conversion factor of 7.25 (Palka 1999; PN-ISO 3496:2000). Oxidative changes in intramuscular lipids were determined by measuring the content of thiobarbituric acid-reacting substances (TBARS), as described by Rak and Morzyk (2002). The absorbance of fish meat samples was measured using the Analytik Jena AG Specord 40 spectrophotometer (wavelength of 532 nm), and was expressed in mg of malondialdehyde per kg of meat. The energy value of meat was calculated using conversion factors of 16.78 kJ/g for protein and 37.62 kJ/g for fat (Jeszka 2010).

The acidity of muscle tissue was measured 24 h *post mortem* in chilled left fillets and in meat homogenates (pH_u) (1:1 m/v ratio of meat to redistilled water) using the 340i pH-meter equipped with the WTW TFK 150/E temperature sensor and a Hamilton Double Pore combination glass electrode. Before measurements, the pH-meter was calibrated against buffers with known pH (PN-ISO 2917:2001/Ap1:2002).

Cooking loss. To determine cooking loss, fish meat samples weighing approximately 50 g were packaged in polyethylene (*PE*) string bags and pasteurised in a water bath at a temperature of 75°C for 50 minutes. Then the samples were cooled for 30 min under cold running water, dried and weighed within an accuracy of 0.001 g. Cooking loss was calculated as the difference between sample weights before and after heat treatment (Honikel 1998).

Water-holding capacity. The water-holding capacity of fish meat was determined by the Grau and Hamm method (van Oeckel *et al.* 1999). A sample of minced meat (approx. 300 mg) was placed on Whatman filter paper No. 1. The sample on filter paper was placed between two glass plates and subjected to a load of 5 kg for 5 minutes. The meat area and the expressed juice area were outlined and scanned.

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Both areas were planimetered by computer image analysis using Multi Scan software (Computer Scanning System III, Poland). The difference between the areas, converted to 0.3 g, was a measure of forced drip (higher value – lower water-holding capacity; cm^2).

The fish meat samples used for estimating cooking loss were wrapped in aluminium foil, stored at 4 ± 1°C for 24 h, and cut into cylinders (at least three) with a diameter of approximately 1.27 cm and a height of 2 cm. The maximum shear force required to cut meat samples across the grain was measured using a Warner-Bratzler head (500 N, speed 100 mm/min.) attached to the INSTRON 5542 universal testing machine.

Meat colour was determined based on the values of CIELAB coordinates L^*, a^* and b^* (CIE 1978) measured three times by the reflectance method using a HunterLab MiniScan XE Plus spectrocolorimeter (Germany) at the same points over the internal (ventral) and external surfaces. Saturation/chroma (C^*) and hue angle ($h°$) were calculated using the formulas proposed by Hunt *et al.* (1991): $C^* = \sqrt{a^2 + b^2}$, $h° = \tan^{-1}(b/a)$. Standard illuminant D_{65} and a 10° standard observer angle were used. Measurements were performed on fillets chilled at 4 ± 1°C for 30 minutes. Before each measurement, the spectrocolorimeter was calibrated against white and black standards.

The results were analysed statistically (mean values ± sd), and the significance of differences between means was determined by Student's t-test using licensed Statistica ver. 13.1 software (StatSoft 2017).

RESULTS AND DISCUSSION

An analysis of the chemical composition of chilled and frozen African catfish fillets (Table 1) revealed a significantly ($P \leq 0.01$) higher content of total protein (17.37%), fat (5.11%) and crude ash (1.09%) chilled samples. Rosa *et al.* (2007) reported similar values in chilled fish muscles, where the average content of total protein was determined at 16.80%, fat content – at 5.70%, and crude ash content – at 1.00%. In our study, the fat content of the fresh meat of *C. gariepinus* was 1.47% higher, ash content was 0.41% higher and protein content was 0.48% lower than in the experiment performed by Yanar (2007). In a study by Goda *et al.* (2007), the meat of African catfish administered standard feed contained 15.96% protein. The cited authors reported a considerably higher ash content (3.71%) and a lower fat content (4.60%) in the muscle tissue of African catfish relative to our study. In comparison with the results reported by Ekpenyong and Ibok (2012) in catfish fillets deep-frozen for 7 days, the frozen fillets in our study had higher total protein content (by 6.33%) and a lower content of fat (by 10.73%) and crude ash (by 13.96%). Significant differences ($P \leq 0.05$) were observed in the total collagen content of chilled and frozen meat which was 0.19 mg/g lower in frozen samples (0.66 mg/g). In the present study, TBARS values (Table 1) were low in both chilled (0.29 mg MDA/kg) and frozen (0.24 mg MDA/kg) fillets, which points to the high oxidative stability of lipids in chilled and frozen meat of African catfish. In a study by Yanar (2007), the average TBARS values of *Clarias gariepinus* were determined at 0.45 mg MDA/kg in fresh meat. In the work of Kamkar *et al.* (2014), the MDA content of silver carp increased from 0.54 mg MDA/kg in fresh meat to 3.75 mg MDA/kg after 30 days of storage at a temperature of –3°C. Higher TBARS values in silver carp fillets stored at 4°C for 35 days were reported by Fan *et*

Table 1. Chemical composition and energy value of chilled and frozen African catfish (*Clarias gariepinus)* fillets

Specification	Fish meat samples (n = 20)		P
	chilled fillets	frozen fillets	
Moisture content (%)	75.99^{B} ± 0.41	76.99^{B} ± 0.88	≤ 0.001
Total protein (%)	17.37^{A} ± 0.67	16.38^{B} ± 0.67	≤ 0.001
Crude fat (%)	5.11^{a} ± 0.82	4.52^{b} ± 0.50	0.030
Crude ash (%)	1.09^{B} ± 0.07	2.54^{A} ± 0.21	≤ 0.001
Total collagen (mg/g fresh tissue)	0.85^{a} ± 0.23	0.66^{b} ± 0.14	0.025
TBARS value (mg malondialdehyde per kg of fish meat)	0.29 ± 0.12	0.24 ± 0.07	0.300
Energy value (kJ/100 g)	483.31^{A} ± 33.09	444.96^{B} ± 17.37	≤ 0.001

^{a,b}mean values followed by different superscript letters in a row differ significantly ($P \leq 0.05$); ^{A,B}mean values followed by different superscript letters in a row differ significantly ($P \leq 0.01$); values are a mean ± sd

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al. (2008). In their study, TBARS concentration after 13 days of storage approached the threshold value of 2 mg MDA/kg which is indicative of undesirable flavour and aroma.

In this study, chilled and frozen African catfish fillets differed significantly ($P \leq 0.01$) in energy value (Table 1). The energy value of chilled fillets was 38.35 kJ/100 g higher relative to frozen fillets. The higher energy value of chilled meat can be attributed to lower weight loss and, consequently, lower loss of nutrients, including total protein and crude fat, relative to frozen meat. Rosa *et al.* (2007) reported similar energy value of fresh catfish meat at 457.90 kJ per 100 g. The gross energy value of *C. gariepinus* meat was determined at 560.61 kJ/100 g by Goda *et al.* (2007).

The pH of chilled and frozen African catfish meat was determined at 6.29 and 6.34, respectively, 24 h *post mortem* (Table 2). The pH of muscle homogenates measured 48 h *post mortem* was higher in chilled meat (pH_u = 6.57) than in frozen meat (pH_u = 6.35) and the observed difference was statistically significant ($P \leq 0.01$). According to Marx *et al.* (1997), the threshold value of pH_{24} in fresh meat is 6.5. In a study by Skałecki *et al.* (2013), the average pH values of rainbow trout muscles decreased from 7.25 to 6.68 after 48 h, regardless of the rearing system.

In the present study, despite a significant difference ($P \leq 0.05$), forced drip was satisfactory in both chilled (6.82 cm^2) and frozen (7.96 cm^2) fillets, which points to the high water-holding capacity of catfish meat. Our results confirm that the meat of *C. gariepinus* is highly suited for processing and cooking. In a study by Paleckaitis *et al.* (2018), the water-holding capacity of African catfish fillets was determined at 64.25% in fish administered feed with the addition of feather meal and at 61.25% in fish administered feed with the addition of feather and pig bristle meal. In the cited study, catfish meat was characterised by low cooking loss at 17.74%, whereas cooking loss in control fish was similar to that noted in chilled fillets at 21.98%. In our experiment, the shear force of chilled and frozen African catfish meat, was determined at 5.62 and 7.09 N, respectively (Table 2), which is indicative of high tenderness.

Table 2. Physicochemical properties of chilled and frozen African catfish (*Clarias gariepinus)* fillets

Specification	Fish meat samples (n = 20)		P
	chilled fillets	frozen fillets	
pH_{24}	6.29 ± 0.10	6.34 ± 0.13	0.462
$pH_{u\ (ultimate)}$	6.57^{A} ± 0.16	6.35^{B} ± 0.13	≤ 0.001
Water holding capacity (cm^2)	6.82^{b} ± 0.82	7.96^{a} ± 0.47	0.044
Cooking loss (%)	21.21^{B} ± 0.96	24.93^{A} ± 0.97	≤ 0.001
Shear force value (N)	5.62^{B} ± 0.40	7.09^{A} ± 0.66	≤ 0.001

$^{A, B}$mean values followed by different superscript letters in a row differ significantly at $P \leq 0.01$; values are a mean ± sd

Table 3. Colour parameters of chilled and frozen African catfish (*Clarias gariepinus)* fillets

Specification	Fish meat samples (n = 20)		P
	chilled fillets	frozen fillets	
External surface L^*	41.91^{B} ± 0.82	44.00^{A} ± 0.64	≤ 0.001
a^*	15.52^{A} ± 0.72	11.54^{B} ± 0.72	≤ 0.001
b^*	11.66 ± 0.95	11.90 ± 0.78	0.488
C^*	19.43^{A} ± 0.81	16.58^{B} ± 0.92	≤ 0.001
h°	36.84^{B} ± 0.85	45.85^{A} ± 0.83	≤ 0.001
Internal surface L^*	47.42^{B} ± 0.94	49.24^{A} ± 0.93	≤ 0.001
a^*	10.87 ± 0.88	11.29 ± 0.82	0.194
b^*	15.52^{B} ± 0.99	17.77^{A} ± 0.67	≤ 0.001
C^*	18.98^{B} ± 0.80	21.07^{A} ± 0.72	≤ 0.001
h°	54.98^{B} ± 0.97	57.58^{A} ± 0.86	≤ 0.001

$^{A, B}$mean values followed by different superscript letters in a row differ significantly ($P \leq 0.01$); values are a mean ± sd

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According to Wedekind (1995), the fillets of *Clarias gariepinus* have a distinctive red colour, and the meat is lean and cohesive. In this study, an analysis of the colour profile on the surface of catfish fillets (Table 3) revealed that chilled samples were significantly ($P \leq 0.01$) darker (L^* values lower by 2.09) and were characterised by significantly higher values of redness a^* (by 3.98) and saturation C^* (by 0.72). The hue angle $h°$ was significantly ($P \leq 0.01$) higher in frozen fillets at 45.85. A statistical analysis of colour profile values revealed that frozen fillets were significantly ($P \leq 0.01$) lighter on the internal surface. The contribution of yellowness, saturation and hue higher ($P \leq 0.01$) in frozen than in chilled fillets by 2.25, 2.09 and 2.60, respectively. Frozen and chilled fillets did not differ in the contribution of yellowness on the external surface or the contribution of redness on the internal (ventral) surface, and the average values reached 11.78 and 11.08, respectively, in both groups. In a study by Skałecki *et al.* (2015), common carp, bighead carp and silver carp fillets did not differ significantly in lightness L^*, but considerable variations in L^* values were noted in bighead carp. The cited authors also observed significant differences in the values of colour parameters a^* and b^* between the examined fish species. Common carp fillets were characterised by the highest contribution of redness (16.31) and yellowness (3.68). The lowest value of a^* was reported in silver carp fillets (10.54), whereas negative values of b^* were noted in bighead carp (–0.95) and silver carp (–1.09) fillets, which points to a predominance of the blue component.

CONCLUSIONS

Chilled African catfish fillets had a lower content of moisture, higher of total protein, fat, crude ash and total collagen, and higher energy value than frozen samples. Frozen storage contributed to an increase in the colour lightness L^* of fillets. Chilled fillets were characterised by higher values of redness and saturation, and a darker colour on the external surface than frozen samples. The contribution of yellowness, saturation and hue were significantly higher on the internal surface of frozen fillets. Chilled fillets had higher water-holding capacity, lower cooking loss and higher tenderness than frozen fillets.

References

Aderolu A.Z., Akinremi O.A. (2009): Dietary effects of coconut oil and peanut oil in improving biochemical characteristics of *Clarias gariepinus* Juvenile. Turkish Journal of Fisheries and Aquatic Sciences, 9: 105–110.

Chwastowska-Siwiecka I., Skiepko N., Pomianowski J.F., Kondratowicz J. (2016): Pomiary morfometryczne i ocena jakości mięsa suma afrykańskiego. Medycyna Weterynaryjna, 72: 102–109.

Ekpenyong E., Ibok C.O. (2012): Effect of smoking, salting and frozen-storage on the nutrient composition of the African catfisch (*Clarias gariepinus*). Journal of Food, Agriculture & Environment, 10: 64–66.

Fan W., Chi Y., Zhang S. (2008): The use of a tea polyphenol dip to extend the shelf life of silver carp (*Hypophthalmicthys molitrix*) during storage in ice. Food Chemistry, 108: 148–153.

Goda A.M., El-Haroun E.R., Kabir Chowdhury M.A. (2007): Effect of totally or partially replacing fish meal by alternative protein sources on growth of African catfish *Clarias gariepinus* (Burchell, 1822) reared in concrete tanks. Aquaculture Research, 38: 279–287.

Honikel K.O. (1998): Reference methods for the assessment of physical characteristics of meat. Meat Science, 49: 447–457.

Hunt M.C., Acton J.C., Benedict R.C., Calkins C.R., Cornforth D.P., Jeremiah L.E., Olson D.G., Salm C.P., Savell J.W., Shivas S.D. (1991): Guidelines for meat color evaluation. Appendix to Proceeding and the Reciprocal Meat Conference, 9–12 June, 1991, Kansas State University, USA: 1–17.

Jeszka J. (2010): Energia. In: Gawęcki J. (ed.): Żywienie Człowieka. Podstawy Nauki o Żywieniu. T. 1, Warszawa, Państwowe Wydawnictwo Naukowe: 133–146.

Kamkar A., Jebelli Javan A., Nemati G., Falahpour F., Partovi R. (2014): Effects of *Mentha pulegium* water extract dipping on quality and shelf life of silver carp (*Hypophthalmichthys molitrix*) during superchilled storage. Iranian Journal of Fisheries Sciences, 13: 341–353.

Marx H., Brunner B., Wenzierl W., Hoffmann R., Stolle A. (1997): Methods of stunning freshwater fish: impact on meet quality and aspects of animal welfare. Zeitschrift für Lebensmittel-Untersuchung und -Forschung, 204: 282–286.

van Oeckel M.J., Warnants N., Boucqueé Ch.V. (1999): Comparison of different methods for measuring water holding capacity and juiciness of pork versus on-line screening methods. Meat Science, 51: 313–320.

Paleckaitis M., Buckiūnienė V., Trepenaitienė R., Klementaviciūtė J., Racevičiūtė-Stupelienė A., Šašytė V., Kudlinskienė I.

https://doi.org/10.17221/330/2018-CJFS

(2018): Effect of different extruded compound feed on african catfish (*Clarias gariepinus*) productivity, meat chemical and technological parameters. Veterinarija ir Zootechnika, 76: 66–70.

Palka K. (1999): Changes in intramuscular connective tissue and collagen solubility of bovine *m. semitendinosus* during retorting. Meat Science, 53: 189–194.

Polak-Juszczak L. (2007): Chemical characteristics of fishes new to the Polish market. Acta Scientiarum Polonorum, Piscaria, 6: 23–32.

Rak L., Morzyk K. (2002): Chemiczne Badanie Mięsa. Wrocław, Wydawnictwo Akademi Rolniczej we Wrocławiu: 139–141.

Rosa R., Bandarra N.M., Leonor Nunes M. (2007): Nutritional quality of African catfish *Clarias gariepinus* (Burchell 1822): a positive criterion for the future development of the European production of Siluroidei. International Journal of Food Science and Technology, 42: 342–351.

Samcik K., Kaliniak A., Hawryluk S., Dmoch M., Siemiński G., Skałecki P., Wolanciuk A. (2018): Effect of refrigerated storage on the quality of rainbow trout carcasses. Journal of Animal Science, Biology and Bioeconomy, 36-: 33–45.

Skałecki P. (2012): Mięso i przetwory mięsne. In: Litwińczuk Z. (ed.): Towaroznawstwo Surowców i Produktów Zwierzęcych z Podstawowymi Przetwórstwa. Warszawa, Powszechne Wydawnictwo Rolnicze i Leśne: 439–470.

Skałecki P., Florek M., Litwińczuk A., Zaborowska A. (2013): Wartość użytkowa i jakość mięsa pstrągów tęczowych (*Oncorhynchus mykiss*) z uwzględnieniem masy ryb. Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego, 9: 69–73.

Skałecki P., Florek M., Staszowska A., Kalniak A. (2015): Wartość użytkowa i jakość mięsa ryb karpiowatych (*Cyprinidae*) utrzymywanych w polikulturze. ŻYWNOŚĆ. Nauka. Technologia. Jakość, 1 (98): 75–88.

Wedekind H. (1995): Dietary influences on product quality in African catfish (*Clarias gariepinus*). Journal of Applied Ichthyology, 11: 347–353.

Yanar Y. (2007): Quality changes of hot smoked catfish (*Clarias gariepinus*) during refrigerated storage. Journal of Muscle Foods, 18: 391–400.

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