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Protein and lipid oxidations in jerky chicken and consequences on sensory quality

Fábio A.P. Silva[a], Mario Estévez[b,*], Valquíria C.S. Ferreira[a], Samara A. Silva[a], Leanderson T.M. Lemos[a], Elza I. Ida[c], Massami Shimokomaki[d], Marta S. Madruga[a]

[a] Department of Food Engineering, Federal University of Paraiba, Joao Pessoa, CEP 58051-900, PB, Brazil
[b] IPROCAR Research Institute, University of Extremadura, CP 10003, Cáceres, Spain
[c] Department of Food Science and Technology, State University of Londrina, CEP 86057-970, PR, Brazil
[d] Department of Preventive Medicine, State University of Londrina, CEP 86057-970, PR, Brazil

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ABSTRACT

Four chicken charqui samples were prepared, namely, B-B (Broiler Breast charqui); B-T (Broiler Thigh charqui); H-B (Hen Breast charqui); H-T (Hen Thigh charqui), and analyzed for lipid and protein oxidation, instrumental color and texture and sensory properties for 120 days at 25 °C. Oxidative reactions were highly affected by chicken age, storage time and muscle type. Thiobarbituric acid-reactive substances increased up to 1.6 mg/kg in H-T samples at day 90 and subsequently decreased by the end of storage. H-T also appeared as the most sensitive towards oxidation and suffered loss of thiols (61%), tryptophan depletion (30%) and formation of protein carbonyls (up to 1.97 nmol/mg protein). "Grilled chicken" and "beef charqui" flavors, which were found to be linked to lipid oxidation, decreased over time in favor of rancid aroma. Shear-force increased over time (from 105 to 207 N in H-B samples) and that occurred concomitantly with intense protein oxidation in jerky chicken. This study provides scientific evidence of the impact of lipid and protein oxidation on the loss of quality during storage of a processed chicken product.

1. Introduction

Oxidative reactions have been considered as one of the most significant causes of quality deterioration in meat and meat products. The main targets of this type of redox reaction in meats are lipids and proteins. Lipid oxidation is a complex free radical chain reaction that involves the consumption of molecular oxygen and affects unsaturated lipids of meat products, leading to development of rancidity and degradation of sensory and nutritional value. The extent of lipid oxidation in muscle foods is affected by several factors such as metal catalysts, myoglobin, enzymes, water activity, fat composition, oxidative enzymes, processing and storage (Vieira, Zhang, & Decker, 2017; Chaijan & Panpitat, 2017, pp. 2–37). Proteins from muscle tissue are also susceptible to oxidative processes induced by reactive oxygen species (ROS) or by secondary byproducts of oxidative stress via free radical formation, which causes the production of various oxidation derivatives. These products have been related to pathological conditions in human organism due to its cytotoxic and mutagenic potential when exposed to the gastrointestinal tract and internal organs (Estévez & Luna, 2017). The mechanisms involved in protein oxidation (POX) of meat are particularly different from oxidative deterioration of lipids. In fact, protein carbonylation can occur even in absence of lipids and molecular oxygen (Estévez, 2011). During POX in meat, ROS may attack the side chain of amino acids and the peptide backbone, which leads to formation of carbonyl compounds, loss of essential amino acids and water-holding capacity (WHC), decreases in protein solubility and degradation of color and texture (Estévez, 2015; Soladoye, Juarez, Aalhus, Shand, & Estévez, 2015).

Charqui is a popular salted and dried jerky-type meat product traditionally made from beef and widely consumed in various South American countries. During charqui elaboration, a combination of heavy salting and drying (T < 45 °C) leads to a shelf stable meat product with a water activity of around 0.75 (Shimokomaki et al., 1998). Some studies have emphasized the use of chicken meat in charqui processing (Rocha Garcia et al., 2003; Silva et al., 2017), highlighting the market potential of this raw material in the Intermediate Moisture

* Corresponding author.
E-mail addresses: fabio@ct.ufpb.br (F.A.P. Silva), mariovet@unex.es (M. Estévez), valquiriacsf@gmail.com (V.C.S. Ferreira), samara.andrades@hotmail.com (S.A. Silva), leanderson_tulio@hotmail.com (L.T.M. Lemos), elida@uel.br (E.I. Ida), mshimo@uel.br (M. Shimokomaki), msmadruga@uol.com.br (M.S. Madruga).

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Meat Products (IMMP) formulations. In particular, the use of meat from spent hen for the manufacture of a charqui-like product seems to be a feasible strategy to produce high-quality protein commodities and to add value to meat from spent hens (Silva et al., 2017). According to Silva et al. (2017), chicken charqui presents high protein content (> 30%), low microbial counts and similar flavor to conventional beef charqui. However, the high percentage of unsaturated fatty acids in chicken meat compared to beef associated with the harsh conditions of charqui processing can promote high rates of lipid and protein oxidation in charqui prepared from poultry. No studies have been conducted on the effect of raw material source, muscle type and time of storage on lipid and protein oxidation parameters of charqui-like product made from broiler and spent hen meat. Considering the well-known impact of lipid and protein oxidation on the chemical safety and sensory quality of meat products, the aims of this work was i) to assess the oxidative reactions in charqui-like meat prepared from broiler and spent hen over 120 days of storage and ii) to evaluate the connection of such oxidative deterioration with the impairment of the sensory properties of the product.

2. Material and methods

2.1. Experimental design

A 2 × 2 x 5 factorial completely randomized design (CDR) was used. The effect of the type of raw material (broiler vs. spent hen meat), muscle type (breast vs. thigh) and time of storage (1, 30, 60, 90 and 120 days) on the oxidative reactions and sensory traits of chicken charqui was performed. Charqui-like samples were prepared in two independent batches, totaling 40 experimental units. Chemical and sensory analysis were conducted on whole charqui in triplicate.

2.2. Chemicals

Ellman's reagent (5,5′-Dithio-bis-nitrobenzoic acid – DTNB) and 1,1,3,3 tetraethoxypropane (TEP) were supplied from Sigma-Aldrich (São Paulo, Brazil). Ethylenediaminetetraacetic acid (EDTA) and sodium phosphate were obtained from Merck (Merck, São Paulo, Brazil). L-cysteine was supplied by Synth (Synth®, São Paulo, Brazil). N-acetyl-L-tryptophan amide (NATA) was provided by Sigma-Aldrich (Barcelona, Spain). All other chemicals were purchased from Panreac (Panreac Química, S.A., Barcelona, Spain). The water used in HPLC analysis was purified by passage through a Milli-Q system (Millipore Corp., Bedford, MA, USA).

2.3. Raw material

Frozen broiler and spent hen carcasses (−20 °C) were collected in two batches on different days from a commercial slaughterhouse located in the city of Nazaré da Mata (Pernambuco, Brazil). Chicken meat was stored at −20 °C for seven days until elaboration of charqui-like samples. Before processing, frozen-stored broiler and spent hen carcasses were thawed at 4 °C for 24 h and manually deboned to separate breast and thigh meat.

2.4. Production of chicken charqui (jerky chicken)

Chicken charqui samples were elaborated according to Silva et al. (2017) procedures. A total of 14 kg of breast (*pectoralis major*) and thigh (*biceps femoris*) meat from broiler (1.85 kg live weight and 5 weeks-old) and spent hen (3.90 kg live weight and 66 weeks-old) Cobb® birds were dry-salted for 72 h at 14 °C using 1 kg of coarse marine salt per kg of chicken and 50 mg/kg of sodium nitrite. The meat pieces were stacked into piles separated from each other by layers of coarse marine salt. In this first stage, the meat pieces were repositioned at each 24 h during 3 days to ensure that all meat was completely salted. After this stage, the excess of salt was rinsed from the meat surface with distilled water. Subsequently, samples were dried in a drying chamber with circulation and air exchange (SL 102/221, SOLAB, São Paulo, Brazil) at 45 ± 2 °C during approximately 24 h until the moisture and water activity levels reached values below 0.5 kg/kg and 0.75, respectively. Finally, the salted and dried breast and thigh chicken meats were cut into rectangular shape pieces (15 × 10 × 5 cm) and subsequently pressed in a conventional manual press (4.90 × 10^6 Pa) for 24 h under refrigeration (15 ± 2 °C). In due course, dried and pressed samples were packaged (500–700 g) in trays and covered with an oxygen permeable low-density polyethylene film (20 μm of thickness). Four chicken charqui samples were prepared, namely, B-B (Broiler Breast charqui); B-T (Broiler Thigh charqui); H-B (Hen Breast charqui); H-T (Hen Thigh charqui), which were stored at room temperature (25 ± 2 °C) during 120 days.

2.5. Analytical methods

2.5.1. Determination of thiobarbituric acid-reactive substances (TBARs)

TBARs values of breast and thigh chicken charqui were determined using the 2-thiobarbituric acid (TBA) method of Rosmini et al. (1996) and calculated from a standard curve of 1,1,3,3 tetraethoxypropane (TEP). The results were expressed as mg of TBARs per kg of charqui.

2.5.2. Free thiols (SH) determination

The content of free SH groups in chicken charqui samples was measured according to the method of Ellman (1959) using Ellman's reagent (5,5′-Dithio-bis-nitrobenzoic acid – DTNB, Sigma-Aldrich, São Paulo, Brazil). Briefly, samples (2.0 g) were homogenized in 50 mL of 0.1 mol/L phosphate + 1 mmol/L ethylenediaminetetraacetic acid (EDTA) buffer (pH 8.0) using an Ultra Turrax™ (T25, IKA, Rio de Janeiro, Brazil) at 13500 rpm for 30 min. Homogenate was centrifuged at 10000 × *g* for 20 min at 4 °C and filtered in a Whatman No. 1 filter. Aliquots (250 μL) of filtered homogenate were mixed with 50 μL of Ellman's reagent and Free thiol content was measured by absorbance at 412 nm using a standard curve of L-cysteine (Synth, São Paulo, Brazil). Protein concentration of the homogenate was determined at 280 nm using bovine serum albumin (BSA) as standard. The results were expressed as nmol of L-cysteine per mg of protein.

2.5.3. Tryptophan fluorescence measurements

Fluorescence spectroscopy was used to assess the loss of natural tryptophan fluorescence in charqui samples. Sample homogenization was carried out according to the process described by Utrera and Estévez (2012, 2013). Emission spectra of tryptophan was recorded from 300 to 400 nm with the excitation wavelength established at 283 nm (LS 55 Perkin Elmer luminescence spectrometer, Waltham, MA, USA). Tryptophan content was calculated from a standard curve of N-acetyl-L-tryptophan amide (NATA, Sigma-Aldrich, Barcelona, Spain) and the results were expressed as mg of NATA per 100 g of charqui.

2.5.4. Determination of α-aminoadipic (AAS) and γ-glutamic (GGS) semialdehydes

The procedure described by Utrera and Estévez (2013) was followed to determine the AAS and GGS. Briefly, samples (1.0 g) were derivatized with 0.5 mL of 50 mmol/L aminobenzoic acid (ABA) and subsequently hydrolyzed with 1.0 mL of 6 mol/L HCl (Utrera, Morcuende, Rodríguez-Carpena, & Estévez, 2011). Hydrolysates were dried *in vacuo*, reconstituted in Milli-Q water and filtered through a Polyvinylidene difluoride (PVDF) syringe filter (0.45 μm pore size, Pall Corp., New York, USA). Injection was performed in a HPLC using a Cosmosil (Phenomenex, Torrance, California, USA) C18-AR-II RP-HPLC column (5 μm, 150 × 4.6 mm) and a guard column (10 × 4.6 mm) filled with the same material. The Shimadzu "Prominence" HPLC apparatus (Shimadzu Corp., Kyoto, Japan) was equiped with a quaternary solvent delivery system (LC-20 AD), a DGU-20AS online degasser, an

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