LWT - Food Science and Technology 64 (2015) 1123–1129

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

High CO_2-modified atmosphere packaging for extension of shelf-life of chilled yellow-feather broiler meat: A special breed in Asia

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ARTICLE INFO

Article history:
Received 23 April 2015
Received in revised form
11 July 2015
Accepted 15 July 2015
Available online 17 July 2015

Keywords:
Yellow-feather chicken
Half-carcass
MAP
Shelf-life

ABSTRACT

This work evaluated the effect of air- and modified atmosphere-packaging (MAP) on the shelf life of chilled yellow-feather chicken, which is a special breed in China. Fresh half-carcasses were stored in air and under modified atmosphere packaging (M-H: 80% CO_2/20% N_2 and M-L: 30% CO_2/70% N_2) at 4 °C for up to 12 days. Microbiological, physico-chemical and sensory attributes were measured. The results showed that total viable counts (TVC) reached the limiting value (7.0 log CFU/g) after 4, 10 and 8 days of storage under aerobic, M-H packaging and M-L packaging conditions, respectively, while the sensory values (odor and surface slime data) and the percentage of drip loss were in good agreement with the trend for TVC. During the storage, the total volatile basic nitrogen (TVB-N) content of broiler meat in MAP packaging was lower than that in air-packaging, however, the M-H group had the highest storage losses. In conclusion, high CO_2 (80%) concentration packaging prolonged the shelf-life by at least 6 days when stored at 4°C. Our results provide practical information to extend the shelf-life of chilled yellow-feather broiler meat, which will benefit the poultry industry by reducing unnecessary waste.

1. Introduction

Chicken meat, having high protein and low fat contents, and being of relatively low cost, is very popular worldwide and its consumption has been increasing over the last few decades. China is the second largest chicken consuming country, accounting for 15.10 percent of the total world-wide consumption in 2014 (FAS/USDA, 2014). As a special species in Asia, meat from yellow-feather broilers has a more distinctive flavor than many other commercial broilers such as Arbor Acres and Cobb500 (Chumngoen & Tan, 2015; Jayasena et al., 2015a, b). For this reason it is favored by consumers, especially in Asian countries. Traditionally, live broilers have been sold and slaughtered in wet markets, where the environmental conditions are usually poor. Such retail procedures increased the likelihood of serious cross-contamination and the spread of animal influenza. The common method of consumption of these broilers has been to prepare a soup from the whole-carcass by a stewing process. However now, live poultry markets have been restricted in the majority of cities in China, including Beijing and Shanghai, in order to reduce the ongoing outbreaks of animal influenza, particularly the H7N9 strain in 2013. Thus, the original means of distribution has changed. Consumers now buy fresh chilled chicken meat, which originates from slaughter plants, through shops and supermarkets. The demand for these products has increased markedly.

As chicken meat provides a highly nutrient source for growth of spoilage bacteria, meat deterioration can occur even in a short time under chilled conditions (Meredith et al., 2014; Patsias, Badeka, Savvaidis, & Kontominas, 2008). Therefore, because of the need to distribute large volumes of these products through the supply chain to the consumer over a longer time period, there is a need to provide optimal packaging to ensure product safety and quality. For this reason we have investigated possible preservation technologies for the extension of chilled meat from yellow-feather chicken.

Modified atmosphere packaging (MPA) is considered as an effective method for packaging various fresh meat and related products including chicken meat in order to extend the shelf life of the products (Al-Nehlawi, Saldo, Vega, & Guri, 2013; Meredith et al., 2014; Patsias et al., 2008). The use of optimal mixture of gases (CO_2,

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http://dx.doi.org/10.1016/j.lwt.2015.07.039
0023-6438/

N_2 and O_2) in food packaging containers has been proved to effectively inhibit the microbial flora of various fresh perishable food, such as poultry meat (Gill, 1996; Jeremiah, 2001; Meredith et al., 2014). The presence of CO_2 is the main factor responsible for inhibiting microbial growth, although oxygen inhibits the growth of anaerobic bacteria. The primary function of N_2 is to prevent package collapse. A minimum CO_2 concentration range of 20%–30% is required for an inhibitory effect, therefore the poultry industry typically uses 40–100% CO_2 balanced with N_2 (Meredith et al., 2014). Regarding raw chicken meat preservation under modified atmosphere conditions, it has been established that the higher the concentration of CO_2, the greater the inhibition of microbial growth (Economou, Pournis, Ntzimani, & Savvaidis, 2009; Meredith et al., 2014; Patsias et al., 2008).

To date, limited information has been reported on the application of MAP for prolonging the shelf-life of chilled yellow-feather chicken carcasses and products, although many studies have been presented on the preservation of chilled chicken meat and products using MAP (Al-Nehlawi et al., 2013; Meredith et al., 2014). Some of these have been in a combination with other methods including treatment with oregano essential oil (Chouliara, Karatapanis, Savvaidis, & Kontominas, 2007), freeze chilling treatment (Patsias et al., 2008), irradiation (Chouliara, Badeka, Savvaidis, & Kontominas, 2008), high hydrostatic pressure treatment (Rodríguez-Calleja, Cruz-Romero, O'Sullivan, García-López, & Kerry, 2012) and chitosan treatment (Latou, Mexis, Badeka, Kontakos, & Kontominas, 2014). The objective of our study was to investigate the effect of MAP including air-packaging on shelf-life of chilled yellow-feather chicken stored at 4 °C.

2. Materials and methods

2.1. Sample preparation

Eighty-four fresh half-carcass samples of chilled yellow-feather chickens were obtained from a local poultry processing plant in Anhui Province, China. The half-carcasses were considered to be convenient for consumers and more suitable for MAP compared with the whole carcass. The samples were packaged in aseptic bags and placed on ice and transported to the laboratory within 3 h. For this work, the chicken samples were randomly distributed and packaged in three different atmospheres: A (air) and two modified atmospheres (MAs), namely M-H (high CO_2-packaged, 80%/20%, CO_2/N_2) and M-L (low CO_2-packaged, 30%/70%, CO_2/N_2). All chicken samples were kept at 4 ± 0.1 °C (Compressor-Cooled Incubator ICP260, Memmert, Germany) for up to 12 days. The M-H and M-L samples were packaged in 25 μm thickness low-density polyethylene/polyamide/low-density polyethylene (LDPE/PA/LDPE) barrier pouches (1 fillet/pouch), having an oxygen permeability of 24 $cm^3/(m^2.day.atm)$ at 0% RH/23 °C, CO_2 permeability of 78 $cm^3/(m^2.day.atm)$ at 0% RH/23 °C and water vapor permeability of 44 $g/(m^2.day)$ at 100% RH/38 °C. Air samples were packaged in polyethylene film having an oxygen permeability of 14483 $cm^3/(m^2.day.atm)$, a CO_2 permeability of 63683 $cm^3/(m^2.day.atm)$ and a water vapor permeability of 54 $g/(m^2.day.atm)$. Samples were analyzed at predetermined time intervals, namely, 0, 2, 4, 6, 8, 10 and 12 days (n = 4 for each time per treatment).

2.2. Microbiological analysis

Total viable counts (TVC) were determined according to the China National Food Safety Standard methods–Food microbiological examination (GB 4789.2-2010). TVC were determined using Plate Count Agar (PAC, Land Bridge, Beijing, China) after incubation for 2 days at 37 °C. *Pseudomonas* and LAB were determined according to the method proposed by Chouliara et al. (2007). *Pseudomonas* was determined on cetrmide fusidin cephaloridine agar (Oxoid code CM 0559, supplemented with SR 103, Basingstoke, UK) after incubation at 25 °C for 2 days. LAB were inoculated using MRS ager (Oxoid code CM 0361) after incubation for 3 days at 25 °C.

2.3. Determination of weight loss on storage

Storage loss was measured according to the method of Duun and Rustad (2008) with slight modifications. Briefly, the initial weight of samples were weighed and recorded. After the designated storage period, drip was wiped from each sample surface and the samples were re-weighed. Weight loss on storage was calculated as 100 × ((final weight of sample - initial weight of sample)/initial weight of sample).

2.4. TVB-N measurement

Total volatile basic nitrogen (TVB-N) was determined according to the China National Food Safety Standard methods - Method for analysis of hygienic standard of meat and meat products (GB/T 5009.44-2003). TVB-N contents were expressed as mg of TVB-N per 100 g of chicken.

2.5. Biogenic amine determination

The value of BAs was determined according to the method by Lu et al. (2010), and analyzed by using a high-performance liquid chromatography (Agilent 1100 system, Agilent, USA). The separation was carried out on a C_{18} column (Spherisorb 2.5 μm ODS. 250 cm × 4.6 mm internal diameter) and peaks were detected at 254 nm using a diode array detector. The chromatography conditions were as follows: a flow rate of 1 mL/min, an injection volume 20 μL, a column temperature of 20 °C. A gradient elution program was used with acetonitrile as solvent A and with water as solvent B (Table 1). Standards for biogenic amines (namely, putrescine and cadaverine) were purchased from Sigma (USA).

2.6. pH measurement

A measure of pH was done determined according to the method described of Wang, Li, Xu, and Zhou (2013). Briefly, 1 g of chicken breast sample was homogenized (Ultra Turrax T25, IKA, Germany) at 6000 rpm for 2 × 15 s, with a 5 s break, in 10 mL of ice-cold buffer (pH 7.0) containing 5 mmol/L sodiumiodoacetate and 150 mmol/L potassium chloride. The pH value was measured with a Microprocessor pH meter (Hanna HI9025c, Portugal).

2.7. Sensory evaluation

Sensory evaluation was determined according to the method used by Patsias, Chouliara, Badeka, Savvaidis, and Kontominas (2006a; b). The samples were evaluated by five experienced panelists who participated in the sensory tests from National Center of Meat Quality and Safety Control of China trained by professional

Table 1
Gradient elution program for the separation of biogenic amines by HPLC.

Elution time (min)	Mobile phase A (%)	Mobile phase B (%)
0.0	35.0	65.0
5.0	30.0	70.0
20.0	0.0	100.0
24.0	0.0	100.0
25.0	35.0	65.0
30.0	35.0	65.0