Effects of modified atmosphere packaging on the shelf life of gutted rainbow trout (*Oncorynchus mykiss*) stored at 3 ºC

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Abstract— **The objective of this study was to find out the effect of modified atmosphere packaging on the shelf life of gutted rainbow trout and to determine the optimum composition of gas mixtures. Microbiological analysis, thiobarbituric acid reactive substance (TBARS), hardness values (maximum force of puncture test) and drip loss were determined in gutted rainbow trout stored at 3 ± 0.5 ºC under 5 different atmospheric conditions; T_1: 60% CO_2+40% N_2, T_2: 40% CO_2 +10% O_2+50% N_2, T_3: 60% CO_2+10% O_2+30% N_2, T_4: vacuum-packaged and T_5: air-packaged. Mesophilic, psychrotrophic and *enterobacteriacae* counts increased throughout the storage time and there were no significant differences among the groups. Counts of lactic acid bacteria (LAB) at the 0th day were about 1.4- 1.6 log Cfu/g which rose to 4.4-7.5 following fifteen days of storage. The highest and lowest LAB counts were belonged to the T1 and T2 groups, respectively. TBARS increased after 15 days of storage with the highest level for T_1 and T_2 compared to others experimental groups. Hardness values were also significantly decreased during 72 hours of storage, although the values were similar among all the groups. The highest drip loss was recorded in the T_4, which was succeeded by the T_1 and the lowest exudates was additionally found in the T_3. Results of the current study revealed that mixture of 60% CO_2+30% N_2+10% O_2 provided an appropriate atmospheric condition to elongate the shelf life of gutted rainbow trout which was still acceptable after 12 days of storage at 3 ºC.**

Keywords— **MAP, Rainbow trout, Packaging, Shelf-life.**

I. INTRODUCTION

Spoilage of fish results from changes brought about by biological reactions such as oxidation, autolysis and the metabolic activities of micro organisms [1, 2]. The rate of fish spoilage primarily depends on its initial quality as well as the storage conditions. The most important factors during storage are temperature, processing, and atmospheric conditions. Modification of the atmosphere within the package has significantly prolonged the shelf-life of perishable food products at chill temperatures [3].

Rainbow trout (O*ncorhynchus mykiss*) is economically and socially an important fish. It is also an interesting field for those working in aquaculture industries. Trout has a well- established market, and is a good candidate species for commercial aquaculture.

The objective of present study was to determine the effects of modified atmosphere packaging (MAP) with various gas mixtures and vacuum packaging in compare with air condition on microbiological, chemical, physical and sensory properties of gutted rainbow trout during storage at 3 ˚C.

II. MATERIALS AND METHODS

A. Packaging and storage condition

Fresh water rainbow trout with an average weight of 300g reared in 11 ˚C spring water in a local farm located in 80 km north of Shiraz, Iran, were caught using a dipping net and transferred to the laboratory on crushed ice within two hours. Fish were gutted and washed carefully using tap water, divided into five groups, and packaged under the following conditions using a packaging machine (Webomatic C 15-HLD, Germany):

Group 1: 60% CO_2 + 40% N_2
Group 2: 40% CO_2 + 10% O_2 + 50% N_2
Group 3: 60% CO_2 + 10% O_2 + 30% N_2
Group 4: vacuum
Group 5: air

Each fish was placed into a pouch individually. At least 99.9% of the air was removed by the packaging machine, and subsequently the appropriate gases were inserted into the pouch (except vacuum condition), which was then double heat-sealed. Packaging material consisted of a 15×30 cm polyethylene film bag (thickness: 85 micron, density: 1.1 g ml^{-1}, oxygen transmission rate: 36.5 ml m^{-2} day^{-1} atm at 20 ˚C, nitrogen transmission rate: 10 ml m^{-2} day^{-1} atm at 20 ˚C, carbon- dioxide transmission rate: 75.3 ml m^{-2} day^{-1} atm at 20 ˚C and water vapor transmission rate: 30 ml m^{-2} day^{-1} atm at 38 ˚C). The ratio of gas/product in all packages (except vacuum condition) was approximately 2:1 (v w^{-1}). All samples were stored at 3 ± 0.5 ˚C for 15 days and subjected to microbial, chemical, physical and sensory analyzes on the 0, 3, 6, 9, 12 and 15 days of the storage period.

B. Drip loss

The exudates in the packages during storage were measured gravimetrically and reported as g/100g of initial weight [4].

C. Microbial analysis

A sample was taken from the flesh of the belly muscle of each fish. Mesophilic and psychrotrophics counts were determined using Plate Count Agar. *Enterobacteriacea* and Lactic acid bacteria (LAB) counts were determined in VRBG-agar and MRS-agar, respectively. All counts were expressed as log cfu/g.

C. Thiobarbituric acid reactive substances

Lipid oxidation, measured as thiobarbituric acid reactive substances (TBARS) values, was determined according to the method proposed by Botsoglu et.al [5].

D. Textural analysis

The texture of the fish muscle samples were evaluated with a texture analyzer (Stevens-Lfra, England) using a cylindrical puncture probe with the diameter of 10 mm at 25 ˚C. The travelling speed of the probe and the puncture distance of all tests were 0.5 mm/s and 5 mm, respectively. The slope of forces (g) versus time (sec.) were extracted and reported as indications of the hardness of the fish muscle texture.

II. RESULTS AND DISCUSSION

Drip loss

The results show that high pressure in vacuumed packages makes a high drip loss. The highest drip loss belong to vacuumed packages with a meaningful difference ($P<0.05$), and group one (O_2 free) was in second position. The lowest exudates belong to group 3 (Fig 1).

Increased exudates formation could relate to the package rigidity/flexibility and thus, the under pressure developed exudates formation in vacuumed packaged Increased CO_2 levels in the MAP can also increase exudates formation in MAP packaged products [6, 7].

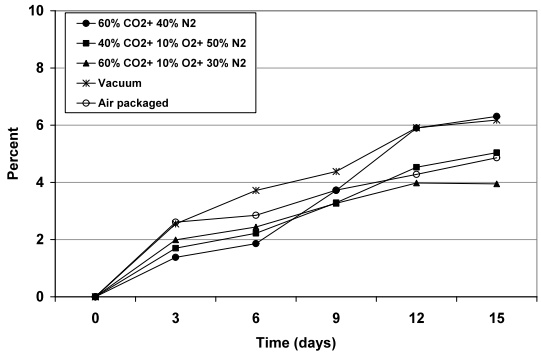

Fig. 1. Changes in drip loss in rainbow trout fillets stored in different atmospheres at 3º C.

Microbiological analysis

Throughout the storage period changes of the numbers of mesophilic bacteria were not different between all groups ($P>0.05$, Fig 2A). Counts of psychrotrophs increased from 1.8 log cfu/g at the 0^{th} day to 6.5-7.9 log cfu/g at the 15^{th} day. There was no significant difference between groups throughout the storage ($P>0.05$, Fig 2B). *Enterobacteriacae* counts were less than 6 bacteria in one gram of sample, but

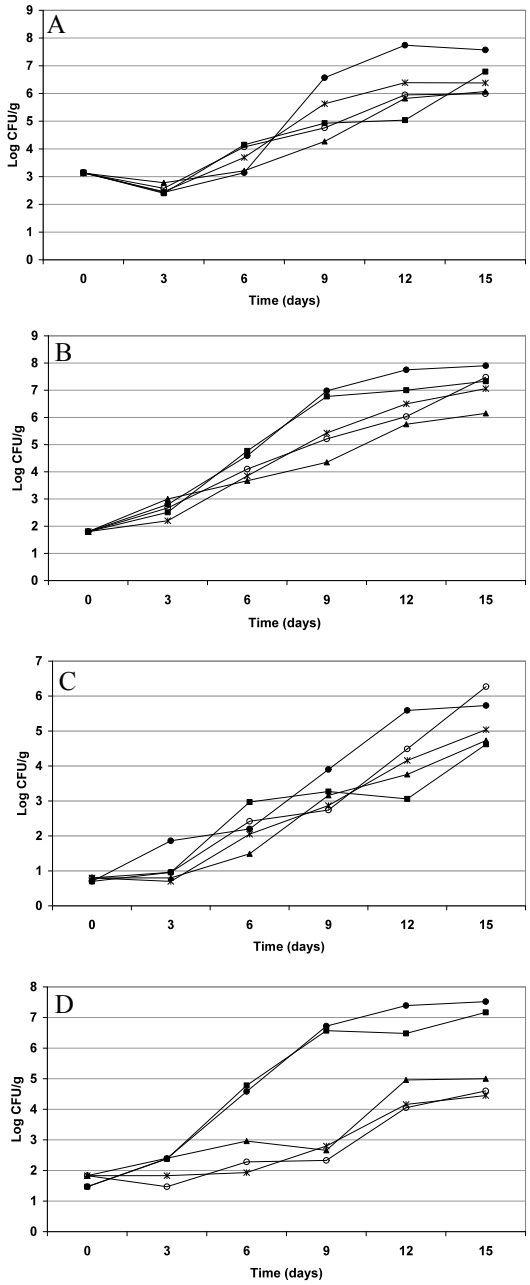

Fig. 2. Mesophilic (A), Psychrophilic (B), enterobacter-iaceae (C) and Lactic acid bacteria (D) counts (Log CFU g^{-1}) in rainbow trout fillets stored in different atmospheres at 3º C.

-●-: MAP (60% CO_2+ 40% N_2); -■-: MAP (40% CO_2+ 10% O_2+ 50% N_2); -▲-MAP (60% CO_2+ 10% O_2+ 30% N_2); -*-: Vacuum; -○-: Air packaged

increased during 15 days of storage. The changes in all groups were not different (P>0.05, Fig 2C). Lactic Acid Bacteria counts at the 0th day were about 1.4-1.6 log cfu/g and after 15 days reached to 4.4-7.5. Group 1 had the highest count and group 2 had the lowest count of LAB (Fig 2D).

Lipid oxidation

The MDA value was 0.86 mg/kg at the 0th day of experiment. This value increased during the storage times and reached 2.86, 2.42, 1.64, 1.69 and 1.02 mg/kg in the treatment groups, respectively. Higher MDA value was obtained in group 1 and 2 than others (Fig 3). Oxidative rancidity of poly unsaturated fatty acids (PUFA) in some fish may become a problem in modified atmosphere with O_2 if higher levels of oxygen are used [8, 9].

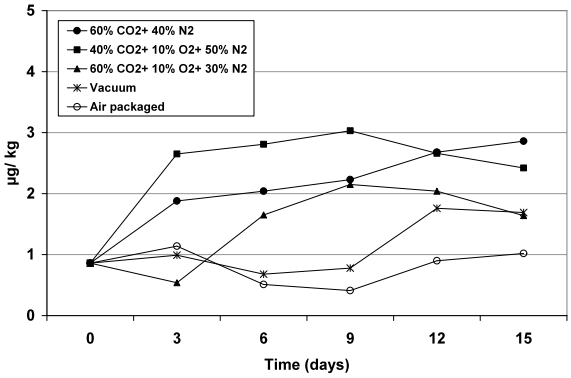

Fig. 3. Changes in mallondialdehyde counts in rainbow trout fillets stored in different atmospheres at 3º C.

Textural analysis

Hardness values (maximum force of puncture test) of the samples during storage (0 to 15 days) are presented in Fig.4. It reveals that during 72 hours of storage hardness of the samples decreased for all treatments significantly (P< 0.05). However, after 72 hours of storage the hardness of all treated samples was almost similar (P> 0.05).

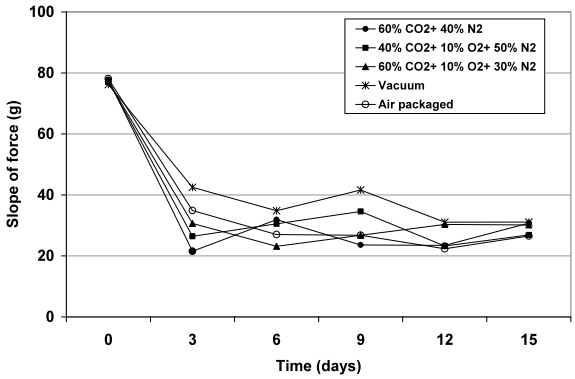

Fig 4. Changes in texture hardness in rainbow trout fillets stored in different atmospheres at 3º C.

IV. CONCLUSION

Results of the current study revealed that mixture of 60% CO_2+30% N_2+10% O_2 provided an appropriate atmospheric condition to elongate the shelf life of gutted rainbow trout which was still acceptable after 12 days of storage at 3 ºC.

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