Journal of Animal and Veterinary Advances 9 (22): 2778-2783, 2010
ISSN: 1680-5593

The Effects of Salting on Chemical Quality of Vacuum Packed Liquid Smoked and Traditional Smoked Rainbow Trout (*Oncorhyncus mykiss*) Fillets During Chilled Storage

Zayde Alcicek and Hasan Huseyin Atar
Department of Fisheries and Aquaculture, Faculty of Agriculture,
Ankara University, 06110 Ankara, Turkey

Abstract: The study reports the effects of TS (Traditional Smoke) and LS (Liquid Smoke) smoking processes after performing chemical composition analyses using two different brining solutions on fillets of rainbow trout. The fillets were brined at 36 and 70% for 4 h at 4°C affected by each brining level. It was concluded that shelf life of TS1 and LS1 extended to 90 days while TS2 and LS2 were 120 days. The results of the study demonstrated that liquid smoking process is quite appropriate to the rainbow trout fillets and 70% brining provided longer shelf life.

Key words: Liquid smoke, traditional smoke, rainbow trout, shelf life, TS2, LS2

INTRODUCTION

The smoking process has been used as a method for meat and seafood preservation for many centuries. The preservative effects provide some antimicrobial (phenols, formaldehyde etc.) and antioxidant compounds in smoke gas and also provide special colour and flavour. The smoking process includes three important stages of salting, drying and smoking.

The salting is as important as the preservative effect of smoking on product's potential shelf life. Recent studies showed that the level and preservative effect of salt has direct proportion (Espe *et al*., 2001; Goulas and Kontaminas, 2005; Yanar *et al*., 2006). However, other studies report that high salt level trigger some health problems such as chronic heart disease, hypertension and NPC (Nasopharingeal carcinoma) (Yu *et al*., 1986; Shewmake and Huntington, 2009; Turk *et al*., 2009).

There are different salting methods: dry salting, brine salting and injection salting or their combinations which are used in the smoking industry for years. Several studies report on the effect of different salting techniques on shelf life of seafood reveal that brine salting is more effective compare to dry salting in relation to brining time and temperature (Cardinal *et al*., 2001; Goulas and Kontaminas, 2005; Bugueno *et al*., 2003).

The salmonids have commonly been used due to nutritional features. The usage of smoking techniques including hot and cold smoking as liquid smoking have been used since over 30 years (Hattula *et al*., 2001; Dimitridau *et al*., 2008). Although, traditional direct flue gas smoking have recently been replaced with some computerised smoking equipmentswhich cannot prevent contamination of product by some carcinogenic compounds such as PAHs (polyaromatic hydrocarbons) in smoke gas. On the contrary the liquid smoke flavouring do not contains PAHs (especially as an indicator Benzo (a) pyrene) due to removing of carcinogen compounds in smoke gas during readied liquid smoke flavour process. Therefore, use of liquid smoke flavouring can be evaluated as safe for health and also easily using, cheaper cost and friendly to environment (Phillips, 1999; Hattula *et al*., 2001; Martinez *et al*., 2004; Simon *et al*., 2005; Siskos *et al*., 2005, 2007; Hanne *et al*., 2007; Muratore *et al*., 2007).

The packaging and storage conditions are as important as salting and smoking methods to produce synergistic effects toward spoilage and to prolonged shelf-life as well. Vacuum and Modified Atmosphere (MA) packaging have widely been used by smoking industry. According to Muratore and Licciardello (2005), a smoke fish pack with MA has high percentage of CO_2 and N_2 and low levels of O_2 that provide long shelf-life due to some restrict microbiological spoilages however, low levels of O_2 retard some chemical reactions that reducing the TMAO into TMA.

While consumers always prefer to buy a specific product with attending salt level and shelf life information, this study aims to investigate the effects of different brining levels in the traditional smoking and liquid smoking processes on some physicochemical parameters of the vacuum packed rainbow trout fillets during chilled storage.

Corresponding Author: Zayde Alcicek, Department of Fisheries and Aquaculture, Faculty of Agriculture, Ankara University, 06110 Ankara, Turkey

MATERIALS AND METHODS

Fish samples: The fresh rainbow trout individually weighing 230±20 g (*Oncorhyncus mykiss*) were obtained from a commercial Turkish fish processing plant localized in Kemer Dam lake at Aydin in Western Turkey. After harvesting, the fish were placed on ice for transport to the laboratoryand then on the day of processing, the fish were eviscerated and cleaned. Ultimately these fillets were vacuum packed and stored at +4°C after brining and smoking processes till analysis on 15, 30, 45, 60, 75, 90, 105 or 120th days. The study was conducted in trough using three replicates. Each replicate per treatment contained 30 fish.

Liquid smoke flavouring: Commercial liquid smoke flavouring agent (Red Arrow, SmokEz-M-10, Mesquite wood based smoke) purchased from a trade food company to smoke the fillets.

Brining and smoking processes

Brining and treatment: The fillets were grouped into five groups; two of which were appropriated by liquid smoke process and two other fillet groups were appropriated by traditional hot smoke process according to two different brining levels shown in Fig. 1. Last group was used as control group without application of any process:

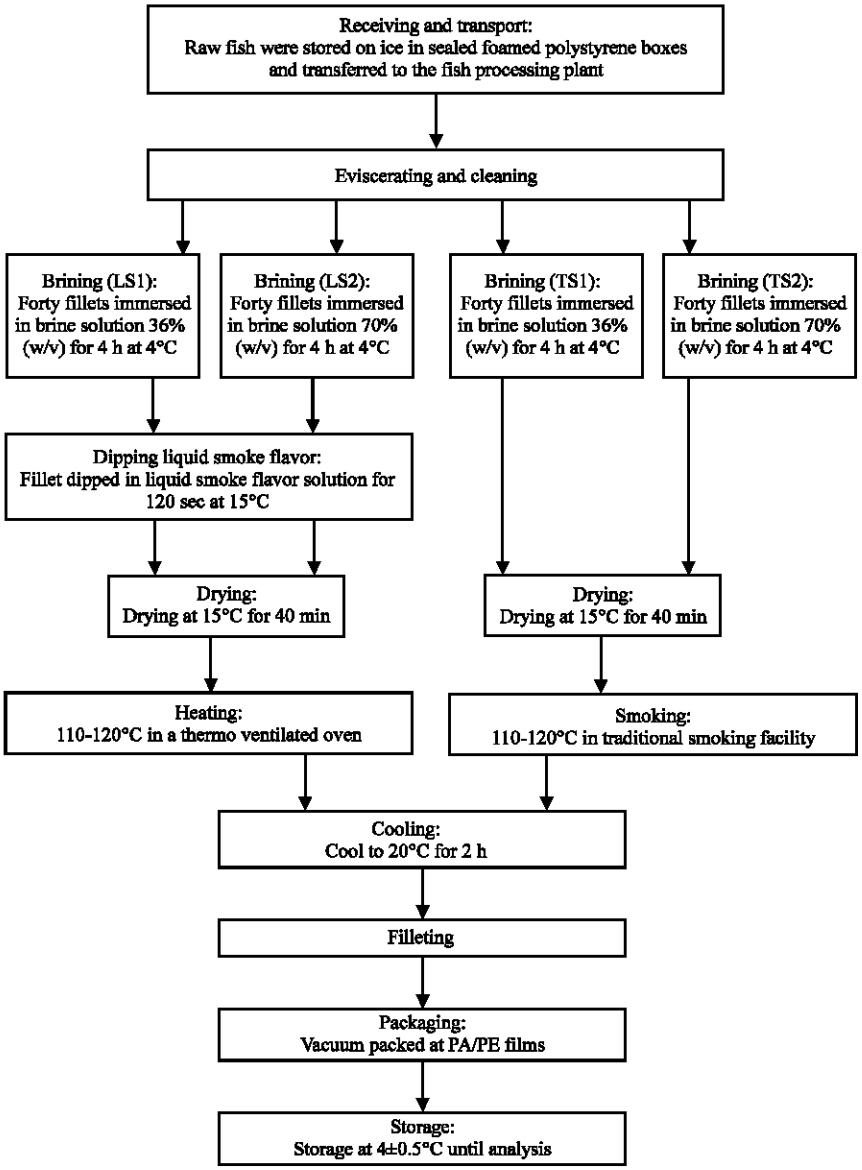

Fig. 1: Flow diagram of the production of traditional hot smoked and liquid smoked rainbow trout

- 36% brined fillets-Traditional Smoking (TS1)
- 70% brined fillets-Traditional hot Smoking (TS2)
- 36% brined fillets-Liquid Smoking (LS1)
- 70% brined fillets-Liquid Smoking (LS2)
- Control Group (Raw rainbow trout) (CG)

The fillets were brined for 4 h and the brine temperature was kept +4°C in order to minimize microbiological contamination. Consequently, these fillets were kept in the cooling room at +20°C for 2 h.

Traditional hot smoking: The smoking was done wood chips using temperature was kept 110-120°C using. At the first step of traditional hot smoking process, the fillets was dried to in the oven for 40 min at 20-40°C. In the second step of the process, the fish trolley equipments were laid on the oven shelf. Thereafter, the temperature was gradually increased to 110-120°C followed by ejection of the fillets to cool when internal temperature of fillet reached 70-80°C until the samples were vacuum packed.

Liquid smoking: The liquid smoke was threatened to brined fillets by dipping them in a water solution (100-150 g L^{-1}) for 120sec according to the instruction of Red Arrow Company. Thereafter, the samples were heated in a thermoventilated oven at 120-130°C until internal temperature of fillet reached 70-80°C. The drying and cooling treatments were similar to those of traditional hot smoking. The fillets were then vacuum packed and stored at 4°C until analyses.

Physicochemical analyses: Physicochemical composition of the fish samples were analyzed by standard methods (AOAC, 1995). Determination of the protein was analyzed according to the Kjeldahl method (N ×6.25) and ash by incineration at 550°C in a muffle furnace. The moisture content was calculated on 3 g of sample, dried in a thermoventilated oven at 105°C until it attained a constant weight. Lipid was extracted from the fish samples with cyclohexane, 2-propanol and water (Smedes and Thomasen, 1996). The pH of fish samples was measured by using a pH-meter at ambient temperature. NaCl content in fish samples was determined by Mohr method (Treadwell and Hall, 1928). The salt content was calculated as percentage of the sample. TVB-N level was determined according to Goulas and Kontaminas (2005). All of those chemical determinations were carried out in triplicate.

Statistics: The significant effects of different brining levels in the traditional smoking and liquid smoking processes on the physicochemical status of vacuum packed rainbow trout fillets during chilled storage were determined to determine differences between samples by one-way Analysis Of Variance (ANOVA) method using the statistical programme SPSS for Windows, version 15.0 (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

Table 1 shows the moisture, protein, lipid, pH, TVB-N and salt contents of raw rainbow trout samples (CG). Similar findings have previously been by Kolsarici and Ozkaya (1998) in *Salmo gairdneri*.

Results of moisture content were TS1 65.23±0. 015% and LS1 65.33±0.14% and TS2 45.60±0.297% and LS2 46.30±0.17% after smoking processes (TS and LS) while 72.2±0.03% moisture content of CS. Moisture was decreased after smoking processes TS and LS due to the applied brining and heating. But no significant differences were recorded between TS1-LS1 and TS2-LS2 during chilled storage (Fig. 2).

Figure 3 shows protein results in which the protein contents did not show significant differences between the same brining concentration groups (TS1-LS1 and TS2-LS2) during storage time. But protein results of the different brining concentration groups showed statistically significant differences after smoking processes (Fig. 3). This decrease explains effects of salt on the fish muscle fibres and reduction of moisture content.

The initial lipid of the untreated fillets was 4.01±0.08. The lipid contents in all samples ranged 4.14-4.15 after smoking processes. These increases in lipid were probably due to reduction of moisture content. However, the increased lipid content in TS and LS cannot only be

Table 1: Approximate composition (w/w %) of raw rainbow trout (CG)

Sample content	Raw rainbow trout (CG)
Moisture	72.2±0.030
Protein	20.00±0.02
Lipid	4.01±0.08
pH	6.13±0.05
Salt	0.09±0.03

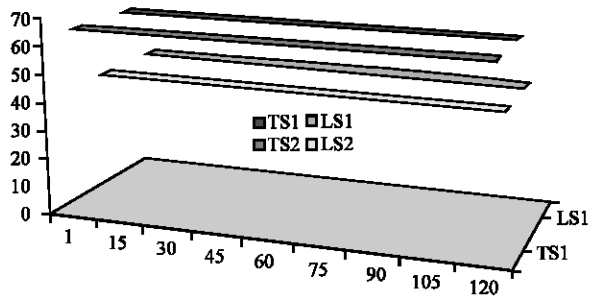

Fig. 2: Moisture content of the samples

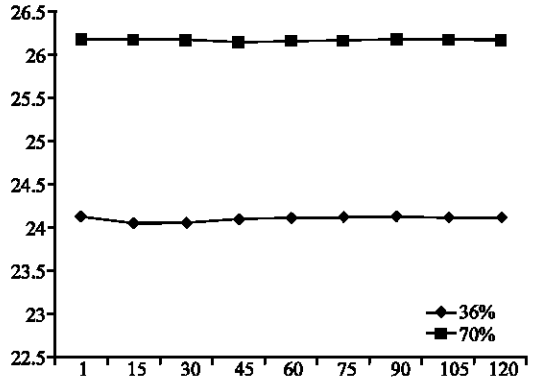

Fig. 3: Protein content of the samples

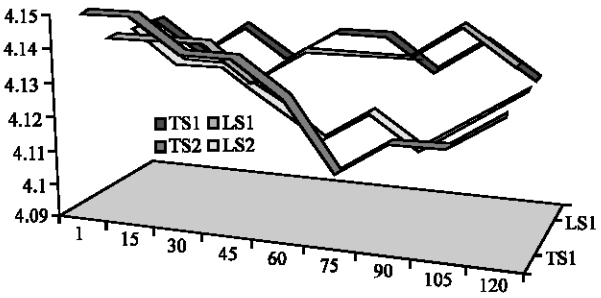

Fig. 4: Lipid content of the samples

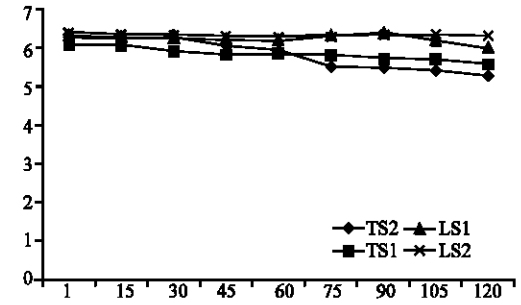

Fig. 5: pH content of the samples

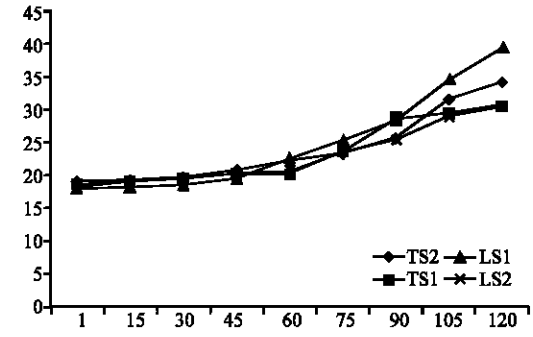

Fig. 6: TVB-N content of the samples

explained by reduction of moisture content without ruling out brining and heating processes. The lipid content of the samples were not significantly influenced by different smoking and brining processing conditions during storage (Fig. 4).

The changes in lipid content are in agreement with Birkeland *et al.* (2004), Dimitridau *et al.* (2008) and Alcicek (2010).

The changes in the pH of rainbow trout fillets are shown in Fig. 4. The initial pH of CS was 6.13. This pH value is in agreement with that of Martinez *et al.* (2004) who reported a pH value of 6.14 for fresh salmon before treatment. No significant differences ($p<0.05$) were observed between fillet samples smoked by the TS and LS after treatment (Fig. 5).

The significant lower ($p<0.01$) pH of smoked versus TS1 and TS2 samples were found at 75th storage day. With similar differences Goulas and Kontaminas (2005) reported that salt concentration of samples influenced pH during storage time. All of those confirm our data for TS1 and TS2 samples.

There was no statistically different pH of LS smoked samples during storage. This point can be explained by using thermo ventilated oven for LS samples while using smoke house for TS samples. TVB-N increased from initial values of 17.61 mg N/100 g to 18.90±0.298, 18.54±0.263, 18.02±0.021 and 18.06±0.032 for TS1, TS2, LS1 and LS2 after treatment, respectively (Fig. 6). Both smoking processes influenced positively TVB-N level of all samples. As results indicate, TVB-N level increased gradually through storage. The increase was significantly lower in the TS2 and LS2 than TS1 and TS2 samples which can be attributed to the preservative effect of sodium chloride (Dondero *et al.*, 2004; Goulas and Kontaminas, 2005; Yanar *et al.*, 2006, Muratore *et al.*, 2007).

The TVB-N level of TS and LS samples ranged 30.40±0.197 to 39.43±0.239 after 90th days of storage. According to Lopez Cabellero *et al.* acceptability of the TVB-N level is 25-30 mg N/100 g. As a consequence, it was revealed that shelf life of TS1 and LS1 were 90 days while TS2 and LS2 were 120 days.

The salt content of raw rainbow trout was 0.09±0.03% while sometimes consumers prefer to buy a smoke product with attending salt level. The effects of salt level were lower activity of water and provide longer shelf life by limiting microbial activities on smoked samples (Goulas and Kontaminas, 2005; Muratore *et al.*, 2007).

Salt is also essentially used in processed seafood to promote flavourand improve emulsifying capacity. There was no statistical differences ($p<0.05$) between TS and LS

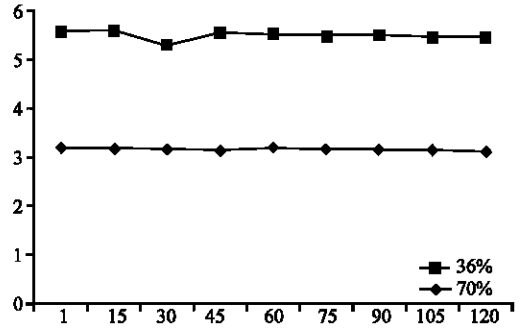

Fig. 7: Salt content of the samples

treatment (Fig. 7). Similar differences have been previously reported by Goulas and Kontaminas (2005) and Muratore *et al.* (2007) for smoked swordfish. But we could not identify statistically significant differences between 36 and 70% brining concentration level during storage.

CONCLUSION

In this study, some chemical features were determined for different brining levels of TS and LS samples. As a result, the chemical features of LS samples were determined as similar to TS samples. But different brining level groups (TS1-LS1 and TS2-LS2) had differences due to the effects of salt level and heating process on water content.

ACKNOWLEDGEMENTS

The research was supported by Ankara University under the BIYEP, Project Number: 2005K 120 14. The researcher acknowledge the fish processing plant, ALBA Fish Aydin, Western Turkey for the smoking of fish. The researchers also acknowledge help of Assoc. Prof. Dr. Khalid Mahmood Khawar, Department of Field Crops, Ankara University, Ankara, Turkey for preparing of manuscript.

REFERENCES

AOAC, 1995. Official Methods of Analysis of the Association of Official Analytical Chemist. 16th Edn., AOAC International, Arlington, VA., USA.

Alcicek, Z., 2010. comparative investigate of using hot smoking and liquid smoking techniques of fillets of rainbow trout (*Oncorhynchus mykiss*) during vacuum pack and chilled storage with different salting techniques. Ph.D. Thesis, Ankara University.

Birkeland, S., B.M.A. Rora, T. Skara and B. Bjerkeng, 2004. Effects of cold smoking procedures and raw material characteristics on product yield and quality parameters of cold smoked Atlantic Salmon (*Salmo salar* L.) fillets. Food Res. Int., 37: 273-286.

Bugueno, G., I. Escriche, N. Martinez-Navarrete, M. del Mar-Camacho and A. Chiralt, 2003. Influence of storage conditions on some physical and chemical properties of smoked salmon (*Salmo salar*) processed by vacuum impregnation tecniques. Food Chem., 81: 85-90.

Cardinal, M., C. Knockaert, O. Torrissen, S. Sigurgisladottir and T. Morkore *et al.*, 2001. Relation of smoking parameters to the yield, color and sensory quality of smoked Atlantic salmon (*Salmo salar*). Food Res. Int., 34: 537-550.

Dimitridau, D., A. Zotos, D. Petridis and A.K.D. Taylor, 2008. Improvement in the production of smoked trout fillets (*Salmo gairdnerii*) steamed with liquid smoke. Food Sci. Technol. Int., 14: 67-77.

Dondero, M., F. Cisternas and L. Carvajal, 2004. Changes in quality of vacuum-packed cold smoked salmon (*Salmo salar*) as a function of storage temperature. Food Chem., 87: 543-550.

Espe, M., R. Nortvedt, O. Lie and H. Hafsteinsson, 2001. Atlantic salmon (*Salmo salar* L.) as raw material fort he smoking industry. I: Effect of different salting methods on the oxidation of lipids. Food Chem., 75: 411-416.

Goulas, A.E. and M.G. Kontaminas, 2005. Effect of salting and smoking method on the keeping quality of chub mackerel (*Scomber japonicus*): Biochemical and sensory attributes. Food Chem., 93: 511-520.

Hanne, L., K.N. Jensen, G. Hylding, H.H. Nielsen and J. Nielsen, 2007. Changes in liquid-holding capacity, water distribution and microstructure during chill storage of smoked salmon. J. Sci. Food Agric., 87: 2684-2691.

Hattula, T., K. Elfving, U.M. Mroueh and T. Luoma, 2001. Use of liquid smoke flavouring as an alternative to traditional flue gas smoking of rainbow trout fillets (*Oncorhynchus mykiss*). Lebensm.-Wiss. Technol., 34: 521-525.

Kolsarici, N. and O. Ozkaya, 1998. Gokkusagi alabaligi (*Salmo gairdneri*) nin raf omru uzerine tutsuleme yontemleri ve depolama sicakligi nin etkisi. Turk. J. Vet. Anim. Sci., 22: 273-284.

Martinez, O., J. Salmeron, M.D. Guilen and C. Casas, 2004. Texture profile analysis of meat products treated with commercial liquid smoke flavourings. Food Control, 15: 457-461.

Muratore, G. and F. Licciardello, 2005. Effect of vacuum and modified atmosphere packaging on the shelf-life of liquid-smoked Swordfish (*Xiphias gladius*) slices. Food Chem. Toxicol., 70: C359-C363.

Muratore, G., A. Mazzaglia, C.M. Lanza and F. Licciardello, 2007. Effect of process variables on the quality of swordfish fillets flavored with smoke condensate. J. Food Process. Preservat., 31: 167-177.

Phillips, D.H., 1999. Polycyclic sromatic hydrocarbons in the diet. Mutat. Res., 443: 139-147.

Shewmake, R.A. and M.K. Huntington, 2009. Nutritional treatment of obesity. Prim. Care Clin. Office Pract., 36: 357-377.

Simon, R. B. la Calle, S. Palme, D. Meier and E. Anklam, 2005. Composition and analisis of liquid smoke flavouring primary products. J. Sep. Sci., 28: 871-882.

Siskos, I., A. Zotos and K.D.A. Taylor, 2005. The effect of drying, pressure and processing time on the quality of liquid-smoked trout (*Salmo gairgneii*) fillets. J. Sci. Food Agric., 85: 2054-2060.

Siskos, I., A. Zotos, S. Melidou and R. Tsikritzi, 2007. The effect of liquid smoking of fillets of trout (*Salmo gairdnerii*) on sensory, microbiological and chemical changes during chilled storage. Food Chem., 101: 458-464.

Smedes, F. and T.K. Thomasen, 1996. Evaluation of the bligh and dyer lipid determination method. Mar. Pollut. Bull., 32: 681-688.

Treadwell, F.P. and W.T. Hall, 1928. Analytical Chemistry. 7th Edn., John Wiley and Sons, Inc., New York.

Turk, M., P.K. Tuite and L.E. Burke, 2009. Cardiac health: Primary prevention of heart disease in women. Nurs. Clin. North Am., 44: 315-325.

Yanar, Y., M. Celik and E. Akamca, 2006. Effects of brine concentration on shelf-life of hot-smoked tilapia (*Oreochromis niloticus*) stored at 4°C. Food Chem., 97: 244-247.

Yu, M.C., J.H.C. Ho, S. Lai and B.E. Henderson, 1986. Cantonese-style salted fish as a cause of nasopharyngeal carcinoma: Report of a case-control study in Hong Kong. Cancer Res., 46: 956-961.