INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 08 Issue 12 December 2025

DOI: 10.47191/ijmra/v8-i12-09, Impact Factor: 8.266

Page No. 6658-6662

Chemical Characteristics of Cold-Smoked and Non-Smoked Salmon Slices

I Wayan Agus Widyantara[1], I Gede Arie Mahendra Putra[1], I Wayan Widia[1]

[1]Program Magister of Food Technology, Faculty of Agricultural Technology, Udayana University, Badung, Bali, Indonesia, 80361

ABSTRACT: This study aimed to compare the chemical characteristics of salmon slices subjected to cold smoking with those of non-smoked salmon slices. Salmon fillets were cold-smoked at 10 °C for 1 hour in a modified standing chiller equipped with a coconut fiber burner, with a smoke source distance of approximately 30 cm from the product. Proximate composition (moisture, ash, protein, fat, and carbohydrate by difference) and energy value were determined using standard AOAC (2019) methods.

Non-smoked salmon contained 52.12% moisture, 3.63% ash, 20.68% protein, 23.18% fat, 0.39% carbohydrate, and an energy value of 292.9 kcal/100 g. Cold-smoked salmon showed higher moisture (56.33%) and slightly higher ash (3.68%), but lower protein (18.69%) and fat (21.24%) contents, with very low carbohydrate (0.06%) and a reduced energy value of 266.1 kcal/100 g. These results indicate that the cold-smoking treatment applied in this study acted as a mild process that primarily imparted smoke flavour and only moderately modified the chemical composition of the salmon slices.

Overall, both non-smoked and cold-smoked products retained the nutritional profile typical of salmon, characterized by high protein and fat and negligible carbohydrate. Cold-smoked salmon may therefore be positioned as a ready-to-eat product that offers characteristic smoke sensory attributes while maintaining favourable nutritional qualities and slightly lower energy density.

KEYWORDS: salmon, cold smoking, proximate composition, energy value, smoked fish products.

I. INTRODUCTION

Salmon (Salmo salar) is one of the most popular fish species worldwide due to its high nutritional content, particularly omega-3 fatty acids, proteins, and vitamin D, which offer significant health benefits for humans (Zhong et al., 2020). Processed salmon products, such as fillets or slices, are often subjected to various processing techniques, including smoking, to enhance sensory quality and extend shelf life. Among these, cold smoking is a widely used method that imparts distinctive colour, aroma, and flavour characteristics without causing significant degradation of the protein structure (Arvanitoyannis and Koutsoumanis, 2022). Cold smoking is typically performed at low temperatures (usually between 10–30°C) and produces products with physical and chemical properties that differ from those of fresh, unsmoked salmon. The smoking process not only provides the characteristic smoky flavour and aroma but also affects the colour, nutritional profile, and texture of the final product (Cardinal et al., 2023). In contrast, unsmoked salmon generally exhibits a lighter colour and a different nutritional composition, as it does not undergo interaction with volatile compounds from smoke (Poulter et al., 2021).

In the analysis of processed salmon products, key parameters commonly evaluated include proximate composition, colour, and sensory characteristics. Proximate analysis encompasses moisture, protein, fat, and ash content, which are essential indicators of the nutritional value and physical quality of the product (AOAC, 2019). Colour is also an important factor influencing consumer visual appeal, as smoking can enhance colour intensity through interactions between smoke constituents and the natural pigments of salmon (Zhong et al., 2020). Furthermore, sensory evaluation is conducted to assess consumer perceptions of taste, aroma, texture, and appearance, all of which play a crucial role in determining consumer preference for processed fish products (Arvanitoyannis and Koutsoumanis, 2022).

A comparative study on the effects of cold smoking versus non-smoking on salmon slices can provide deeper insights into the physical, chemical, and sensory changes that occur during processing. The findings of such research are expected to contribute to the fish processing industry by offering valuable information on the impact of cold smoking on salmon quality and serving as a reference for developing more innovative fish-based products that align with consumer preferences.

II. METODOLOGY

A. Research Design and Approach

This study employed an experimental design to compare the chemical characteristics of non-smoked salmon slices and coldsmoked salmon slices. Two treatments were defined: (1) salmon slices without smoking (control), and (2) salmon slices subjected to cold smoking under standardized conditions. Each treatment was prepared and analyzed in replicate, and the results were expressed as mean values of proximate composition and calculated energy per 100 g of product.

B. Research Location and Period

The experimental work was carried out at the Integrated Service Laboratory (Laboratorium Pelayanan Terintegrasi) on 12 November 2024.

C. Data Handling

For each treatment, proximate analysis was conducted in replicate, and the resulting data were compiled to obtain representative values for non-smoked and cold-smoked salmon slices. The comparison between treatments focused on changes in moisture, ash, protein, fat, carbohydrate by difference, and calculated energy value, in order to describe the overall impact of cold smoking on the chemical characteristics of salmon slices.

III. RESULTS AND DISCUSSION

Table I. Proximate Analysis of Non-Smoked and Smoked Salmon

No	Sample Code	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrates by Difference (%)	Calories (kcal/100 g)
1.	NonSmoked Salmon	52.1168	3.63354	20.6762	23.1833	0.3902	292.915
2.	Smoked Salmon	56.3348	3.67989	18.6851	21.2378	0.0625	266.1303

A. Discussion

This study compared the chemical characteristics of salmon slices without smoking and salmon slices subjected to cold smoking at approximately 10 °C in a modified standing chiller equipped with a coconut-fiber burner. The smoking process lasted 1 hour, with a smoke source distance of 30 cm from the fish surface. Proximate analyses (moisture, ash, protein, fat, and carbohydrate by difference) and energy calculation were conducted using AOAC (2019) methods, which are widely applied in fish composition studies and allow comparison across research using standardized procedures (AOAC,2019). Overall, cold smoking produced a product with slightly higher moisture and lower protein, fat, and energy per 100 g, while ash content remained almost unchanged, indicating that the process behaved as a mild treatment that primarily imparted smoke flavour and caused only moderate changes in composition (Birkeland & Bjerkeng, 2005; Messina et al., 2021).All title and author details must be in single-column format and must be justified.

B. Validity of the Analytical Methods

The use of AOAC (2019) methods for moisture (drying to constant mass), ash (high-temperature incineration), protein (Kjeldahl), and fat (solvent extraction) is considered the reference standard for proximate analysis of fish and fish products. These methods have been extensively used to characterize both fresh and processed fish, ensuring reproducible data and comparability among studies (AOAC, 2019). Therefore, the differences observed between non-smoked and cold-smoked salmon can plausibly be attributed to the smoking process rather than to analytical variability.

C. Effect of Cold Smoking on Moisture Content

Non-smoked salmon in this study contained about 52% moisture, whereas cold-smoked salmon contained about 56%. Many hot-smoking and drying processes reduce moisture and concentrate solids (protein, fat, and ash), as water is substantially removed (Sokamté et al., 2017; Rybicka et al., 2022). By contrast, the present cold smoking was performed at only around 10 °C for 1 hour, with a relatively large distance between the smoke source and the fillet. Under these conditions, the intensity of dehydration is low, and the process functions primarily as a smoke exposure rather than a drying step (Birkeland & Bjerkeng, 2005).

The modified chiller with a coconut-fiber burner likely created a humid atmosphere, especially when water vapour condensed inside the chamber. High relative humidity limits moisture loss from muscle tissue and can, in some cases, promote limited reabsorption of surface water. In addition, several studies on cold-smoked salmon have shown that pre-salting and brining conditions modulate water-holding capacity and final moisture content (Gallart-Jornet et al., 2007; Birkeland & Skåra, 2008;

Messina et al., 2021). If brining or similar treatments were applied before smoking, they could have increased the capacity of muscle proteins to bind water, partially explaining the higher moisture content of smoked samples on a wet-weight basis.

D. Effect of Cold Smoking on Ash Content

Ash contents of non-smoked and cold-smoked salmon differed only marginally. This agrees with observations that short coldsmoking treatments, in the absence of very high salt additions, do not markedly change the total mineral fraction. Previous work has indicated that ash levels in smoked fish are more strongly affected by salt and seasoning formulations and by the extent of drying than by smoke itself (Krzynowek & Murphy, 1987; Sokamté et al., 2017). In hot-smoked fish with marked moisture loss, ash content may increase due to concentration of minerals (Rybicka et al., 2022), whereas the relatively gentle and humid coldsmoking conditions in this study understandably resulted in only minimal changes.

E. Effect of Cold Smoking on Protein Content

The protein content of non-smoked salmon was approximately 20–21%, while cold-smoked salmon contained about 18–19% protein. These values fall within the typical range reported for fatty fish such as salmon, which usually contain around 18–22% protein (Shearer, 1994; Ulleberg et al., 2023). The decrease in protein percentage in the smoked product is contrary to what is sometimes observed in hot-smoked fish, where intense dehydration can increase apparent protein concentration. However, in this mild cold-smoking process, several factors likely contributed to the lower protein percentage.

First, the higher moisture content of the smoked samples dilutes protein when expressed on a wet-weight basis. The absolute amount of protein may not have changed substantially, but the increased water fraction reduces its percentage per 100 g. Second, smoke vapour and condensate can solubilise water-soluble protein fractions at the muscle surface, which may then be lost with dripping condensate. Third, reactive smoke constituents such as phenols and aldehydes can interact with protein side chains and may slightly affect extraction efficiency during analysis (Birkeland & Bjerkeng, 2005; Messina et al., 2021). Despite this reduction, the smoked salmon remains a high-quality animal protein source.

F. Effect of Cold Smoking on Fat Content and Energy Value

The fat content of non-smoked salmon was about 23%, whereas cold-smoked salmon contained around 21% fat. Both values confirm that the products are fatty fish rich in long-chain n-3 polyunsaturated fatty acids, including EPA and DHA, as commonly reported for salmon (Shearer, 1994; Krzynowek & Murphy, 1987). In hot-smoked products, reduced moisture often leads to an increase in relative fat content. Under the short and mild cold-smoking conditions of the present study, however, small fat losses and higher moisture appear to have lowered the fat percentage.

Superficial fat may partially soften and migrate to the surface, adhering to trays or chamber walls, and thus slightly reducing the amount retained in the muscle. Additionally, the increased water fraction dilutes fat content on a wet-weight basis. Together with the decrease in protein, this contributes to the lower energy value of smoked salmon (approximately 266 kcal/100 g) compared with non-smoked salmon (approximately 293 kcal/100 g). From a nutritional standpoint, this indicates that coldsmoked salmon remains a good source of essential fatty acids and protein while having a modestly lower energy density (Bland et al., 2021).

G. Carbohydrate by Difference

As expected for fish, carbohydrate values calculated by difference were very low for both treatments. The classical proximate system quantifies moisture, ash, fat, protein, and sometimes crude fibre, while carbohydrate is estimated as the residual fraction (FAO, 2003). This approach is sensitive to small analytical errors in the other components; consequently, minor differences in calculated carbohydrate between non-smoked and smoked salmon are more likely to represent analytical variability than real differences in sugar or glycogen content. Marine fish are generally reported to consist of 96–98% water, protein, fat, and ash, with carbohydrates contributing only a very small proportion (Krzynowek & Murphy, 1987; Bland et al., 2021).

H. Technological Implications and Product Quality

Viewed holistically, both non-smoked and cold-smoked salmon produced in this study exhibit nutritional profiles consistent with fresh salmon, namely high protein and beneficial fat contents with negligible carbohydrate (Shearer, 1994; Ulleberg et al., 2023). Cold smoking at 10 °C for 1 hour resulted in only moderate compositional changes and did not markedly reduce key nutrients. Thus, under the conditions used, cold smoking appears to function more as a flavouring step than as a strong preservative based on water activity reduction (Birkeland & Bjerkeng, 2005).

To achieve greater extensions of shelf life, smoking is commonly combined with additional preservation hurdles, such as higher salt levels, extended drying, and vacuum or modified-atmosphere packaging (Messina et al., 2021; Rybicka et al., 2022). The present findings may therefore serve as a baseline for developing ready-to-eat cold-smoked salmon slices that retain desirable nutritional attributes while offering characteristic smoke flavour, with further optimisation focusing on microbiological safety and storage stability.

I. Limitations and Future Research

This work is limited to basic chemical parameters measured at a single time point and does not yet include full statistical treatment of the data. Information such as the number of replicates, standard deviations, and significance testing would strengthen conclusions regarding differences between treatments. In addition, no measurements of pH, colour, texture, or microbiological quality were carried out, although these are critical for assessing the impact of cold smoking on safety and consumer acceptance. Sensory data are also absent, even though colour, smoke aroma, flavour, and texture are key determinants of preference for smoked fish (Frangos et al., 2010; Birkeland & Bjerkeng, 2005).

IV. CONCLUSION

This study evaluated the chemical characteristics of non-smoked and cold-smoked salmon slices processed at 10 °C for 1 hour in a modified standing chiller with a coconut-fiber smoke source positioned 30 cm below the product. Proximate composition (moisture, ash, protein, fat, and carbohydrate by difference) and energy value were determined using AOAC (2019) methods.

Non-smoked salmon slices contained 52.12% moisture, 3.63% ash, 20.68% protein, 23.18% fat, 0.39% carbohydrate, and an energy value of 292.9 kcal/100 g. Cold-smoked salmon slices exhibited higher moisture (56.33%) and slightly higher ash (3.68%), but lower protein (18.69%) and fat (21.24%) contents, with very low carbohydrate (0.06%) and a reduced energy value of 266.1 kcal/100 g.

These findings indicate that the cold-smoking treatment applied in this research acted as a mild process that primarily imparted smoke flavour and aroma while only moderately modifying the chemical composition of the salmon slices. Both non-smoked and cold-smoked products retained the typical nutritional profile of salmon, characterized by high protein and fat contents and negligible carbohydrate, with the smoked product offering a slightly lower energy density.

Overall, cold-smoked salmon slices can be positioned as ready-to-eat products that combine desirable smoke sensory attributes with favourable nutritional quality. Future work should integrate statistical analysis, sensory evaluation, and microbiological assessment to more comprehensively define product quality and shelf-life under different processing and storage conditions.

ACKNOWLEDGMENT

The author would like to express sincere gratitude to the staff and technicians of the Integrated Service Laboratory (Laboratorium Pelayanan Terintegrasi) for providing facilities and technical assistance during the experimental work conducted on 12 November 2024. Appreciation is also extended to colleagues and academic advisors for their constructive input, encouragement, and guidance throughout the research and manuscript preparation. Finally, the author acknowledges the support of all parties who contributed, directly or indirectly, to the completion of this study.

REFERENCES

1) AOAC (2019). Official Methods of Analysis of AOAC INTERNATIONAL. 21st Edition. AOAC International.
2) Arvanitoyannis, I. S., & Koutsoumanis, K. (2022). Processing of smoked fish and safety issues. In Advances in Food Processing (pp. 35–52). Springer.
3) Bland, J. M., Grimm, C. C., Bechtel, P. J., Deb, U., & Dey, M. M. (2021). Proximate composition and nutritional attributes of ready-to-cook catfish products. Foods, 10(11), 2716. https://doi.org/10.3390/foods10112716
4) Birkeland, S., & Bjerkeng, B. (2005). The quality of cold-smoked Atlantic salmon as affected by salting method, time and temperature. International Journal of Food Science & Technology, 40(8), 963–976.
5) Birkeland, S., & Skåra, T. (2008). Cold smoking of Atlantic salmon fillets with smoke condensate – An alternative processing technology for the production of smoked salmon. Journal of Food Science, 73(8), S326–S332.
6) Cardinal, M., et al. (2023). Effects of cold-smoking on the physico-chemical properties of salmon slices. Food Science & Technology, 110(5), 435–442.
7) FAO. (2003). Food energy – Methods of analysis and conversion factors (FAO Food and Nutrition Paper No. 77). Food and Agriculture Organization of the United Nations.
8) Frangos, L., Pyrgotou, N., Giatrakou, V., Ntzimani, A., & Savvaidis, I. N. (2010). Combined effects of salting, oregano oil and vacuum-packaging on the shelf-life of refrigerated trout fillets. Food Microbiology, 27(1), 115–121. https://doi.org/10.1016/j.fm.2009.09.002
9) Gallart-Jornet, L., Rustad, T., Barat, J. M., Fito, P., & Escriche, I. (2007). Effect of superchilled storage on the freshness and salting behaviour of Atlantic salmon (Salmo salar) fillets. Food Chemistry, 103(4), 1268–1281.
10) Krzynowek, J., & Murphy, J. (1987). Proximate composition, energy, fatty acid, sodium, and cholesterol content of finfish, shellfish, and their products (NOAA Technical Report NMFS 55). U.S. Department of Commerce.

11) Messina, C. M., Arena, R., Ficano, G., La Barbera, L., Morghese, M., & Santulli, A. (2021). Combination of freezing, low sodium brine, and cold smoking on the quality and shelf-life of sea bass (Dicentrarchus labrax L.) fillets as a strategy to innovate the market of aquaculture products. Animals, 11(1), 185. https://doi.org/10.3390/ani11010185
12) Arvanitoyannis, I. S., & Koutsoumanis, K. (2022). Processing of smoked fish and safety issues. In Advances in Food Processing (pp. 35-52). Springer.
13) Cardinal, M., et al. (2023). Effects of cold-smoking on the physico-chemical properties of salmon slices. Food Science & Technology, 110(5), 435-442.
14) Poulter, R. G., et al. (2021). Nutritional comparison of fresh and smoked fish products: A proximate analysis approach. Journal of Fishery Technology, 49(2), 102-110.
15) Zhong, Q., et al. (2020). Impact of different smoking methods on fish quality. Journal of Marine Foods Research, 16(3), 225-233.