Journal of Food Engineering xxx (2017) 1–8

Contents lists available at ScienceDirect

Journal of Food Engineering

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

Development of a novel smoke-flavoured trout product: An approach to sodium reduction and shelf life assessment

Arantxa Rizo, Ana Fuentes*, Isabel Fernández-Segovia, José M. Barat

Departamento de Tecnología de Alimentos, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 21 December 2016
Received in revised form
20 April 2017
Accepted 25 April 2017
Available online xxx

Keywords:
Smoke flavouring
Trout
NaCl
KCl
Water vapour permeable bags
Shelf life

ABSTRACT

This work aimed to develop a reduced sodium smoke-flavoured trout product with similar physico-chemical traits and sensory quality to commercial smoked trout. In a first phase, a reduced sodium smoke-flavoured trout product was developed by a novel smoke-flavouring process using water vapour permeable bags. In a second phase, the obtained product's microbial and physico-chemical quality was evaluated for 42 cold storage days. A smoke-flavoured trout product with similar physico-chemical characteristics and sensory acceptance to commercial smoked trout was achieved through smoke-flavouring with water vapour permeable bags. Partial substitution of NaCl for KCl led to a 42% sodium reduction in the smoke-flavoured trout and did not affect its physico-chemical traits, sensory attributes and hygienic quality throughout the storage. During shelf life study, no sample exceeded the limits of acceptance proposed for physico-chemical and microbial parameters, except for mesophilic bacteria, which limited the product shelf life to 1 month.

1. Introduction

Fish smoking techniques involve a salting step prior to smoking, which is essential in preservation, texture and product flavour terms. However, processed foods like “ready-to-eat” fish products are considered important contributors to dietary salt intake, which is linked to increased risk of cardiovascular disease. Some countries have implemented control measures, such as mandatory labelling for such products as “highly salted” to promote consumer awareness (WHO, 2009). Health authorities' efforts to encourage low-sodium diets and increase fish intake render the development of less salty fish products is a relevant issue.

To achieve this goal, the food industry is attempting to reformulate recipes to reduce the sodium of its products, while maintaining food safety and consumer acceptance. The main strategy to adopt in order to reduce the sodium in these foodstuffs consists in the partial replacement of NaCl with other salts (KCl, $CaCl_2$, $MgCl_2$, K-lactate, etc.). Partially substituting NaCl for KCl is the best alternative to reduce sodium content, but the main limitation of using KCl is the bitter and metallic flavour that it confers foods if used at high levels (Toldrá and Barat, 2012), and 50:50 NaCl/KCl blends are the common practical industrial limit. However, this limit can vary depending on the type of food and presence of other ingredients, such as spices or smoke flavours, which can mask the residual flavours associated with using KCl. Hence the sodium substitution level in smoked products could be higher than in other kinds of food matrices (Fuentes et al., 2012; Mitchell et al., 2011).

In this context, a new methodology to obtain smoke-flavoured salmon based on a controlled salted process and the use of water vapour permeable (WP) bags has been developed (Rizo et al., 2015a). The process was found to effectively reduce handling, brine waste and processing steps without affecting the smoke-flavoured fish's sensory acceptance and the physico-chemical quality (Rizo et al., 2016a, 2016b).

Rainbow trout (*Oncorhynchus mykiss*) is one of the most produced aquacultured fish in Europe (FAO, 2014). Lower stable market prices, and its smaller whole “easy-to-handle” fillets, make trout a more profitable raw material for smoking than Atlantic salmon, especially given the close resemblance between the commercial smoked products of both species (Salán et al., 2006).

Thus we considered that a combined approach that would integrate partial NaCl replacement into the described smoke-flavouring process would provide high added value to smoke-flavoured trout products, which could meet the needs of both consumers and producers, who demand healthier fish products and improved process yields.

* Corresponding author.
E-mail address: anfuelo@upvnet.upv.es (A. Fuentes).

http://dx.doi.org/10.1016/j.jfoodeng.2017.04.031
0260-8774/

The objectives of this study were to: (a) develop a reduced sodium smoke-flavoured trout product by the new smoke-flavouring process; (b) evaluate the obtained product's physico-chemical and microbial quality during storage.

2. Material and methods

2.1. Materials

Aquacultured trout (*Oncorhynchus mykiss*) were obtained from Piscifactorias Andaluzas, S.A (Granada, Spain). Fish specimens (commercial weight 300–700 g) were transported to the laboratory in polyspan boxes with ice and then stored at 4 °C until processing were purchased from a local market in the city of Valencia (Spain) Trout were headed and gutted, and fillets were trimmed to remove bones before processing. Eighty-six trout fillets (average weight 111 ± 25 g) were employed for the complete test (38 for the first phase and 48 for the second).

NaCl and KCl salts were supplied by Panreac Química, S.A. (Barcelona, Spain) and natural liquid smoke HARDWOOD AFS 10 was provided by Amcan Ingrédients Ltd., Le Chesnay, France). The water vapour permeable bags (WP) used for smoking-salting were supplied by TUB-EX ApS (Taars, Denmark) (polyamide mix; size: 200 × 300 × 0.04 mm; water vapour transmission rate: 5.0 g/50 μ/m^2/24 h (38 °C/50% RH).

Two smoked trout batches of three different brands were analysed to establish the target smoke-flavoured trout's physico-chemical parameters (moisture, salt content and a_w). Commercial samples were purchased in local supermarkets, transported to the laboratory and analysed 15 days before expiration date. The commercial samples were, at distribution point, sliced, vacuum packed, and stored at 4 °C. Pack weights was 100 g and the ingredients given in the labels were the same in all the cases: trout, salt and natural smoked. Raw material of these products was aquacultured rainbow trout from different EU countries (Norway, Denmark, and France). Fish was processed using traditional cold-smoking techniques. The raw material of these products was aquacultured rainbow trout, processed according to traditional cold-smoking techniques: dry salting, followed by a smoking step in a smoking chamber.

All the reagents and culture media were provided by Scharlau Chemie, S.A. (Barcelona, Spain).

2.2. Experimental design

2.2.1. Phase I: Developing a reduced sodium smoke-flavoured trout product

The optimal conditions for obtaining smoke-flavoured trout were established by studying the effect of the amount of salt doses and processing time on the final product physico-chemical properties. These conditions were set to obtain smoke-flavoured trout with similar characteristics to currently marketed products. The values considered as reference were obtained from the analysed commercial products.

Trout fillets were subjected to a simultaneous smoking-salting procedure based on the use of water vapour permeable (WP) bags (Fig. 1a) following the method developed by Rizo et al. (2015a). Diluted liquid smoke was applied to fish by spraying fish surface for 30 s. In this phase, three salt dose concentrations were considered, 2, 4, and 6 g/100 g salt fresh trout, as were two processing times, 12 h and 24 h. Then trout samples were vacuum-packaged (Tecnotrip mod. EV-25-CD, Barcelona, Spain) in highly water vapour permeable (WP) bags. It should be noted that vacuum packaging was used merely to ensure good initial contact between fish and the WP bag. The smoke-flavouring process was carried out at 60% relative humidity (RH) and 5 °C in a drying chamber (Binder mod. KBF. Tuttlingen, Germany). After the processing time, trout samples were removed from the bags and were placed in saturated brine under constant stirring for 30 s to remove any traces of salt attached to surfaces. Finally, fillets were dried with absorbent paper and weighed. The obtained smoke-flavoured trout was characterised by analyses of moisture, chloride content, a_w and weight loss (ΔM_t). The sensory acceptance of the obtained products was also evaluated.

After establishing the appropriate processing conditions (4 g/100 g of salt dose, 24 h), the sodium reduction approach was applied (Fig. 1b). Trout fillets were processed by using a salt mixture of 50% KCl-50% NaCl (w/w) and 100% NaCl (control samples). The percentage of substitution was selected according to the results obtained in a previous work (Fuentes et al., 2011), which concluded that NaCl can be replaced with up to 50% KCl without affecting the smoke-flavoured fish sensory and physico-chemical traits. The obtained samples were characterised by physico-chemical and microbiological analyses, and a sensory test was conducted.

2.2.2. Phase II: Physico-chemical and microbial quality during storage

The objective of the second phase was to evaluate the quality and shelf life of the novel reduced sodium smoke-flavoured trout fillets obtained in Phase I. For this purpose, samples were vacuum-packaged and stored for 42 days at 4 °C. The physico-chemical and microbiological analyses were performed on the smoke-flavoured products (reduced-sodium and control) on cold storage days 0, 7, 14, 21, 28, 35 and 42. On each sampling day, three bags were analysed by salt formulation (n = 3). Duplicate analyses were performed on each sample, except for pH, which was measured in quintuplicate.

2.3. Analytical determinations

2.3.1. Physico-chemical analyses

Moisture and lipid content were determined in accordance with AOAC methods 950.46 and 991.36, respectively (AOAC, 1997). Chloride content was determined after sample homogenisation in distilled water using an automatic Sherwood Chloride Analyser Model 926 (Sherwood Scientific Ltd., Cambridge, UK). The same extract was used to determine sodium and potassium contents by absorption spectrophotometry using a Perkin-Elmer spectrophotometer, model 3100 (Norwalk, CT, USA). pH measurements were taken by a micropH 2001 digital pH-meter (Crison Instruments, S.A., Barcelona, Spain) with a puncture electrode (Crison 5231) at five different locations on the fish fillets. Water activity (a_w) was measured with an Aqualab dew point hygrometer model 4 TE (Decagon Devices, Inc., Washington, USA). Total volatile basic nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N) contents were determined by steam distillation according to the method described by Malle and Tao (1987). The thiobarbituric acid (TBA) index was measured by a spectrophotometric method with some minor modifications (Tarladgis et al., 1960), results are expressed as mg malonaldehyde (MDA)/kg fish sample.

2.3.2. Texture measurements

A texture profile analysis (TPA) and a shear force test were performed on the smoke-flavoured trout fillets with a Texture Analyser TA.XT2® (Stable Micro Systems, Surrey, UK) equipped with a load cell of 250 N. Previously skinned fillets were cut to obtain parallelepiped pieces (3 × 2 cm) from the dorsal part of fillets. Measurements were taken of the samples at room temperature.

For the TPA analysis, a flat-ended cylindrical plunger SMS P75 (75 mm diameter was employed. This plunger was pressed into the

Please cite this article in press as: Rizo, A., et al., Development of a novel smoke-flavoured trout product: An approach to sodium reduction and shelf life assessment, Journal of Food Engineering (2017), http://dx.doi.org/10.1016/j.jfoodeng.2017.04.031