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Dried Salt-Cured Saithe (*Pollachius virens*): Exploring the Effects of a Two-Step Desalting Procedure - Immersion in Cold Water and Cooking

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ABSTRACT

Desalting of dried salt-cured whitefish is traditionally performed by immersion in water up to 48 h. This process reduces the salt content from approximately 20 to 2%. Alternatively, the fish is immersed in water for a few hours and then cooked. The cooking causes a crumbled product that fits traditional dishes found in Caribbean. In this study the weight changes, moisture, and salt content of dried salt-cured saithe, applying short time for immersion followed by cooking, was explored. Immersion for 2 min or 2 h, followed by three cooking sessions, with water exchanges in between, resulted in salt contents of 6-9%. Immersion in 16 h and cooking resulted in salt contents of 3-4%. Cooking for 20 min resulted in lower salt content than cooking just to boiling temperature. Compared to the traditional desalting, the two-step procedure with 16 h immersion and 20 min cooking, reduced the total preparation time significantly.

KEYWORDS

Desalting; immersion in cold water; cooking; salt content; moisture content; weight changes

Introduction

Dried salt-cured saithe (*Pollachius virens*), cod (*Gadus morhua* L.), or tusk (*Brosme brosme*), also known as "clipfish," are highly appreciated for various dishes due to their delicate taste and excellent storage stability. Dried salt-cured fish is primarily produced in Norway and Portugal and is exported and consumed in Southern Europe, Angola, Congo, Brazil, and the Caribbean (Norwegian Seafood Council 2021). In 2020 and 2021, Norway's export volume of dried salt-cured saithe to Jamaica was 5 630 and 5 797 metric tons, while the corresponding numbers for the Dominican Republic were 16,001 and 16,266 metric tons, respectively. The total export value of this product to these countries amounted to 712 and 758 mill. NOK (Norwegian Kroner) in 2020 and 2021, respectively (Norwegian Seafood Council 2021).

Before preparing dishes with the dried salt-cured fish, the product is traditionally desalted by immersion in cold water for 36 to 48 h. In addition to this method, the salt content can alternatively be reduced by combining a short immersion in cold water followed by cooking. In Jamaica and in the Dominican Republic, the dried salt-cured saithe is usually desalted by immersion in cold water for a couple of hours or overnight in the fridge or merely rinsing in tap water. Then, water is added and brought to boiling temperature. Next, the water is drained, cold water is added to the fish, and the fish is cooked to the water's boiling temperature once more. This procedure can be repeated a few times until the preferred salt content is achieved. After the cooking sessions, the fish muscle is crumbled. Typical dishes served in the Caribbean include crumbled fish mixed with ingredients like herbs, vegetables, or fruits (Alnæs 2020).

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After the salt curing, the fish is dried until the moisture and salt content is in the range of 43–48.1% and 16–26.1%, respectively (Oliveira et al. 2012). In the dried salt-cured fish product, the salt is present as brine attached to the proteins. During the drying process, an impermeable layer of salt and protein is formed on the fish's surface (Barat et al. 2004a). Before further preparation and consumption, the salt content must be reduced to about 2–3%. Initially in the desalting, a leakage of sodium and chloride ions from the fish muscle occurs (Hall 1997). Secondly, rehydration by water absorption of the cod matrix occurs. The rehydration is important as it affects the yield and thereby influences the industrial economy (Barat et al. 2004b).

During the immersion in water and cooking, the fish muscle loses salt while the moisture content increases. This is the strict opposite of the salt curing process. When the salt concentration reaches 9–10% in the salt curing process, the myofibrils shrink, and electrostatic bonds bind the salt to the muscle. Myofibril proteins, which are charged polymers, consist of positively and negatively charged amino acids. The electrostatic repulsive and attractive forces create a defined distance between the proteins in the muscle. At higher salt contents, repulsive forces are reduced, and more robust protein-protein bonds arise. The solubility of proteins is reduced, and this effect is commonly referred to as "salting-out" (Akse et al. 1993; Arakawa and Timasheff 1984; Borgstrom 1968).

Any salted foodstuffs to be cooked have two regions that the salt must pass: 1) the water-swollen substrate region (WSSR) and 2) the liquid water region (Hashiba et al. 2009). The WSSR is defined as the weight of the muscle containing water minus the weight of the liquid water imbibed in the meat. The arrangement of the two regions may lead to different degrees of resistance to the overall salt diffusion (Hashiba et al. 2009).

To our knowledge, a two-step desalting procedure in terms of immersion in cold water for a time period (similar to the traditional desalting) and then a cooking session has not been published. Thus, the objective of this study was to explore how such a procedure influences the salt content, moisture, and weight changes of dried salt-cured saithe.

Material and methods

Raw material, drying, sample preparation, and initial analyses

Split salted saithe were purchased in August 2020. Upon arrival at Nofima, Tromsø, excessive salt was removed by tossing two and two fish against each other. Next, the fish were labeled individually, weighed, and put into an in-house drying cabinet to produce dried salt-cured saithe. Before drying, the average fish weight was 969.41 ± 109.50 g. After drying for 188 h at ambient temperature, the average weight was 787.91 ± 98.90 g.

From the front and the rear of the split dried salt-cured saithe, four rectangular loins and tail samples, respectively, were cut. Additionally, a group of smaller samples was obtained by cutting the original 4 + 4 loins and tail samples into 16 + 16 rectangular samples. All samples were cut into approximately even sizes. Each sample was labeled (*T*-bar tags, Floy Tag, Inc., Seattle, WA, USA) for traceability purposes and then weighed and analyzed for the volume size, applying a Gocator 2370 3D laser profile scanner (LMI Technologies BV, Kerkrade, The Netherlands). The volume scanner was mounted 53 cm above a flat conveyor belt, with a laser line directing downwards perpendicular to the conveyor belt and a camera pointing down at an angle relative to the laser line. The image resolution was 0.3, 0.5, and 0.0022 mm across the belt (×), along the belt (y), and in the vertical (z) directions, respectively (Lorentzen et al. 2021).

The approximate dimensions (width x length x height) of the loin samples were 6 × 6 x 2 cm with an average volume and weight of 63.17 ± 12.84 cm^3 and 62.83 ± 12.65 g, respectively. The corresponding values for the tail samples were 6 × 6 x 1.5 cm, 58.97 ± 12.84 cm^3, and 57.59 ± 13.61 g, respectively. The approximate dimensions of the small loin samples were 3 × 3 x 2 cm with an average volume and weight

of 17.08 ± 5.28 cm^3 and 16.54 ± 5.03 g, respectively. The corresponding values for the small tail samples were 3 × 3 x 1.5 cm, with a volume of 12.79 ± 2.97 cm^3 and a weight of 11.95 ± 2.73 g. The total number of small and large samples was 27 and 73 from the tails and 51 and 78 from the loins, respectively.

Rinsing or immersion in cold water followed by cooking sessions

In the first step of the desalting process, three separate time intervals for the contact between water and fish products were applied. In detail, a) 2 min rinsing in cold water (RCW2), b) immersion in cold water for 2 h (ICW2), and c) immersion in cold water for 16 h (ICW16) was performed. The desalting by immersion in cold water was performed in a box with a grid mounted 2 cm above the bottom. The grid allowed released salt to sink below the fish samples. Fresh cold water was added at a product-to-water ratio of 1:9 for both the ICW2 and ICW16. The box was stored at 4°C After finalizing step 1, all samples were drained for at least 10 min before recording the weight.

In the second step, the fish samples were put into a boiler of 5 L, and water was added at the same product-to-water ratio as for the first step. A cooking session was performed by heating the boiler to the water's boiling temperature, draining the cooking water, and then recording the weight of all samples. Afterward, three fish samples were withdrawn before adding fresh water at the same 1:9 ratio for the remaining samples, followed by a repetition of the cooking session. In total, three cooking sessions were performed.

In addition, selected fish samples, both tails, and loins were boiled for 20 min. Tails from the RCW2 and ICW2 groups were brought to the boiling point 3 times and then cooked for 20 min. Loins from the RCW2, ICW2, and ICW16 groups were brought to the boiling point 1 and 3 times and then cooked for 20 min. After cooking, water draining and weight recording was performed as previously described. The sample size groups were kept separate through step 1 and step 2.

In selected cooking sessions, the water temperature and product core temperature was logged using K-type thermocouples connected to data loggers (model 175H1, Testo Ltd., Hampshire, UK).

Moisture, ash, and salt analyses

After drying, the moisture content was measured in horizontal strips from four selected split fish, i.e., the cross-section method (Codex Alimentarius Commission 2005). Also, the rectangular samples of both raw and cooked fish were analyzed for moisture and ash content. The moisture content was analyzed by oven drying at 105°C for 24 h (AOAC 1995a). Up to six parallel samples were run.

The ash content of the fish muscle was calculated after 16 h at 550°C The ash content was used as a metric for the salt content of the fish muscle (AOAC 2005). Previously, the correlation between the salt content measured by titration with $AgNO_3$ (AOAC 1995b) and the salt content as measured by the ash content in cooked samples of dried salt-cured saithe has been explored (Lorentzen et al. 2020). On average, the salt content measured by the ash was 0.69 ± 0.28% points higher than the salt content measured by titration. Thus, the data for salt content presented in this paper is slightly elevated.

Statistical analyses

The data generated were analyzed using multivariate techniques, applying the software Unscrambler version 10.3 (CAMO Process AS, Oslo, Norway). Before the analyses, the variables were weighted with the inverse of the standard deviation of all objects to compensate for the different scales of the variables. Principal component analysis (PCA) (Martens and Næs 1989) was used to identify similarities and differences amongst samples based on volume, initial weight, moisture, salt, and weight changes after step 1 and after both steps 1 and 2. Multivariate calibration models based on Partial Least Square Regression (PLS) were developed to study the effects of initial product sizes (weight and volume), the method in step 1 (RCW2, ICW2, and ICW16), and the number and duration of cooking sessions on moisture content, salt content, and weight changes after both step 1

and 2 (g). The weight changes (g) after step 1 were analyzed using the same X-matrix except for cooking session procedures. Full cross-validation leave-one-out was employed as the validation technique.

Finally, linear regression was applied to evaluate if the independent variables in the study could be used to develop an empirical prediction model for the final salt content after steps one and two. The treatment variables (step 1 and step 2) were coded as categorical dummy variables, and a regression analysis was conducted in the software R (version 4.0.0) (The R Project for Statistical Computing 2020).

Results and discussion

Raw material properties

After the drying process, the average moisture content of four parallel split fish was 48.25 ± 2.15%, which is representative of dried salt-cured fish (Oliveira et al. 2012). The initial weight of the small and large rectangular samples after the cutting is presented in Figure 1. Both tail and loin samples were put together in each group. In the group of small samples, the values for the median, 25% quartile, and 75% quartile were 13.98, 11.34, and 17.47 g, while the corresponding values for the large sample group were 61.22, 52.34, and 69.76 g, respectively.

As control, the moisture content of the tails, RCW2 and ICW2, were 52.4 ± 1.85% and 60.01 ± 2.85%, respectively, while corresponding values for the salt content were 18.08 ± 1.23% and 13.43 ± 1.17%, respectively. Furthermore, the moisture of the loins, RCW2 and ICW2, was 53.00 ± 3.94% and 60.38 ± 3.21%, respectively, while corresponding values for the salt content were 16.86 ± 0.35% and 12.99 ± 0.25%, respectively.

Rinsing in water or immersion in water and cooking

After step 1 and step 2, analyses of the moisture and salt content of the fish were performed (Table 1). Loin samples, ICW16 cooked once for 20 min, obtained the lowest salt content, i.e., 2.92 ± 1.00%. Samples from the RCW2 and ICW2 groups obtained a substantially higher salt content.

When compared to a salt content ranging from 2 to 3% after traditional desalting with immersion in water of 24–48 h (Lorentzen et al. 2010), a procedure involving a long immersion in cold water followed by a prolonged cooking time obtained the lowest salt content. To lower the salt content beyond 2.92%, cooking for more than 20 min is assumed to be beneficial, especially in the case of immersion in water for less than 16 h. However, 2 to 3% salt refers to raw fish muscle. It is emphasized that the fish muscle loses additional salt during cooking, and the weight decreases due to protein leakage. Thus, the salt content of raw and cooked fish muscle is not directly comparable.

The time to reach the boiling temperature was about 27, 20, and 6 min for the cooking sessions one, two, and three, respectively. The progressively shorter time is explained by fewer samples to be cooked after each cooking session and consequently less water to add to achieve a product-to-water ratio of 1:9. Additionally, the temperature of the newly cooked fish samples was higher before the cooking sessions two and three compared to the first cooking session, thus contributing to the shorter time to reach the boiling temperature.

Regardless of tails or loins or time in contact with the water, the moisture content increased, and the salt content decreased with an increasing number of cooking sessions. Also, a cooking time of 20 min caused a lower salt content compared to one, two, or three cooking sessions, which ended just after reaching the boiling temperature. The effect of two or three cooking sessions instead of only one was more apparent for samples being pre-desalted in cold water for 2 h (RCW2 and ICW2) than for the samples being pre-desalted for 16 h (ICW16). This undoubtedly shows the positive effect of a prolonged pre-desalting time, which thereby makes the number of cooking sessions less critical.

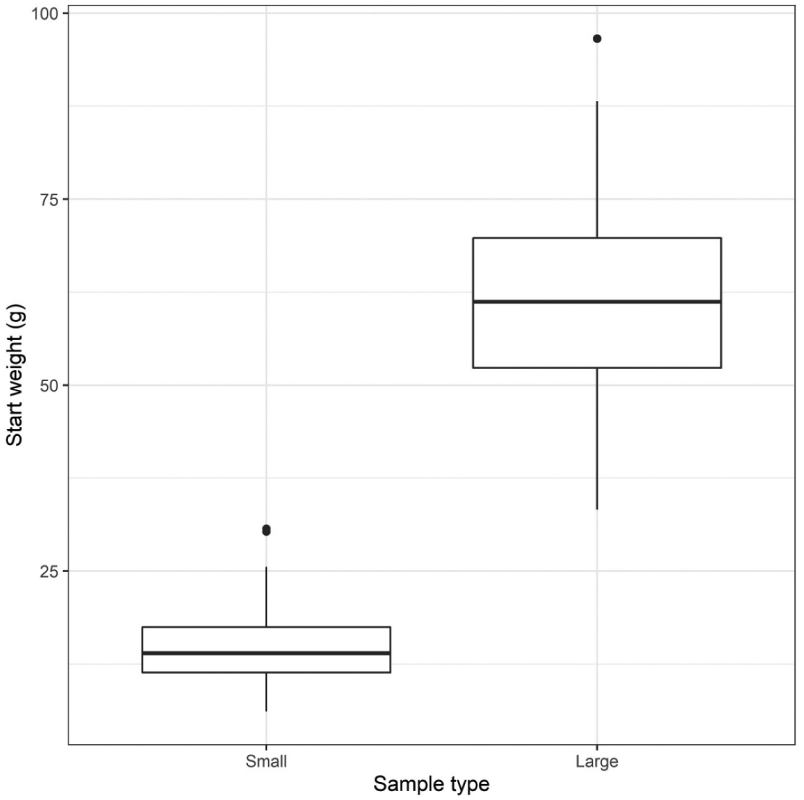

Figure 1. Box plot of the initial weight of the samples according to sample size, small and large. Minimum and maximum values are 1.5 x Interquartile range.

Irrespective of sample size, tails, or loins, the denaturation of the proteins due to salting and cooking is similar. During the denaturation, it is assumed that a substantial share of the salt inside the muscle is enclosed by a three-dimensional protein network (TDPN), leading to high salt content. Denatured proteins allow more Na+ and Cl- ions to make strong bindings to the amino- and carboxyl groups of the proteins. S bindings require time before they can loosen from the protein structure (Akse et al. 1993; Arakawa and Timasheff 1984; Puolanne and Halonen 2010). It is hypothesized that 16 h immersion in water and 20 min cooking was required to loosen these bindings, which resulted in salt content of 2.92 ± 1.00% (Table 1).

Main effects

PCA was carried out to reveal a potential grouping of the data (Figure 2). In total, the data from 229 samples were included in the analysis. No grouping due to the product type, tails or loins, number of cooking sessions, or cooking time was observed (data not shown).

Although the outer ellipses indicate 100% of explained variance, the weight change after step 1 and step 2 (WC after Steps 1 and 2) was located outside this threshold. This is due to the implementation of PCA in Unscrambler, which is based on the NIPALS (Nonlinear Iterative Partial Least Squares) algorithm. The presence of highly correlated variables can affect the analytical results in such a way that the length of the arrows in the loading correlation plot exceeds 1 (10 February 2021 email from Camo Analytics). The same calculations were done using the Singular Value Decomposition in R, and the results were identical except for the length of the loading vector (data not shown).

Table 1. Moisture and salt content of tails and loins of dried salt-cured saithe after a two-step desalting procedure. The first step; rinsing in cold water for 2 min (RCW2), immersion in cold water for 2 h (ICW2), or 16 h (ICW16). The second step; cooking. Values are expressed as mean ± SD.

		2. step		
Sample	1. step	Cooking sessions/minutes in boiling water	Moisture (%)	Salt (%)
Tails	RCW2	1/0	52.93 ± 3.40	10.48 ± 1.33
		2/0	56.22 ± 4.08	7.70 ± 1.35
		3/0	57.26 ± 3.16	7.53 ± 1.32
		3/20	56.83 ± 1.22	4.87 ± 0.81
	ICW2	1/0	57.68 ± 2.70	9.35 ± 1.76
		2/0	58.80 ± 2.26	6.31 ± 0.85
		3/0	59.99 ± 1.84	6.31 ± 0.85
		3/20	59.06 ± 1.33	4.54 ± 1.31
	ICW16	1/0	64.09 ± 1.88	4.95 ± 0.94
		2/0	65.68 ± 2.90	4.66 ± 1.16
		3/0	65.56 ± 2.28	3.70 ± 1.20
Loins	RCW2	1/0	50.57 ± 1.63	12.77 ± 0.83
		1/20	57.09 ± 1.03	6.54 ± 1.04
		2/0	51.74 ± 2.78	10.02 ± 0.44
		3/0	54.41 ± 1.95	9.43 ± 1.01
		3/20	54.26 ± 0.98	7.78 ± 0.20
	ICW2	1/0	54.56 ± 2.42	10.05 ± 0.74
		1/20	61.18 ± 3.17	5.45 ± 1.17
		2/0	56.68 ± 1.75	8.04 ± 0.41
		3/0	57.45 ± 2.23	7.32 ± 1.12
		3/20	58.72 ± 2.23	5.86 ± 1.09
	ICW16	1/0	64.75 ± 3.89	4.87 ± 1.46
		1/20	66.98 ± 1.23	2.92 ± 1.00
		2/0	64.47 ± 2.83	3.84 ± 1.80
		3/0	63.69 ± 1.81	4.03 ± 0.93

In the correlation loading plot, a grouping of initial weight, volume, weight change after the first step, i.e., RCW2, ICW2, and ICW16 (WC after Step 1), and weight change after both the first and second step; RCW2, ICW2, and ICW16, and cooking (WC after Steps 1 and 2) was observed to the right (Figure 2a). This grouping follows PC-1 with an explained variance of 67%. As expected, the salt content correlated negatively with the moisture content, as shown by the location bottom right and top left, respectively. This shows a mass transfer of water into and salt out of the fish sample during the first and second steps. Unlike the grouping with PC-1, water and salt follow PC-2 with an explained variance of 26%.

The distribution according to sample size is illustrated in score plot B (Figure 2b). A grouping is observed in the small samples located to the left, while the large sample group is located to the right. The grouping is mainly explained along PC-1, which is related to variables like weight changes, volume, and initial weight (Figure 2a). In addition, the occupied area for the small samples is less compared to the area for the large samples. It is assumed that this is related to a broader weight variation of the large samples than for the small samples (Figure 1), and this results in a broader range of moisture content, salt content, and weight change after the first step and after both the first and second step.

Samples that were immersed in cold water for 16 h are seen as a horizontal grouping on the top in the score plot, while a tendency of a grouping of samples being rinsed for 2 min is observed at the bottom (Figure 2c). The sample grouping according to immersion time intervals is in accordance with the location of salt and moisture content in the loading plot. This is reasonable, as the salt content decreases and the moisture content increases with the duration of the immersion time.

To obtain an overview of how the initial weight, volume, time interval for step 1, and cooking influenced the moisture content, salt content, and weight changes (after step 1 and after both step 1 and step 2), a set of PLS analyses were run (Table 2).

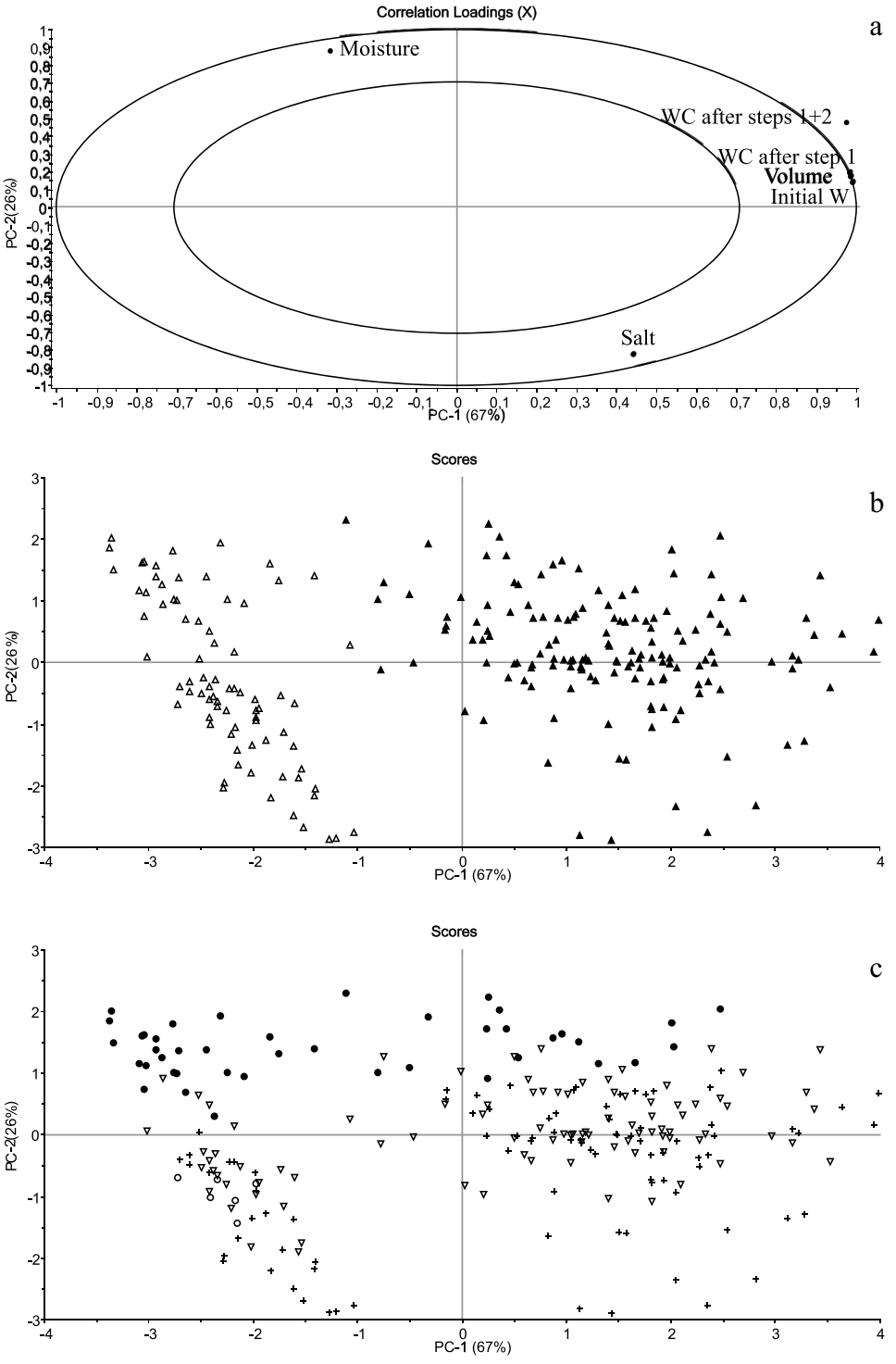

Figure 2. A correlation loading plot (a) with moisture, salt, volume, initial weight (initial W), weight change after desalting (WC after step 1), and weight change after desalting and cooking (WC after steps 1 + 2). Score plots of samples with observations grouped by sample size; small samples (Δ), large samples (▲) (b), and desalting time; 0 min (○), 2 min (+), 2 h ( ), and 16 h (●) (c) obtained by PCA. PC-1 and PC-2 explained 67% and 26% of the total variation in the data, respectively.

Table 2. Variables with significant impact on attributes of desalted saithe after step one, i.E., rinsed in fresh water for 2 min (RCW2), immersed in fresh water for 2 h (ICW2), or 16 h (ICW16) and after step 2; cooking. The effect is based on a weighted regression coefficient (R_w). Significance is identified by Martens uncertainty test ($p < .05$). PLS analysis, Y-matrix, weight changes after step one (g), weight changes after step one and step two (g), moisture content (%), salt content (%). X-matrix, initial weight (g), volume (cm^3), time interval in step one (min), cooking sessions (numbers) and cooking 20 min of the products. The same X-matrix, except cooking sessions (numbers) and cooking 20 min was used for the variable weight changes after step one (g).

Dependent variable (Y)	Independent variable (×)	R_w	R^2_c	R^2_p	Components (no.)
Weight changes after step one	Initial weight	0.5249	0.9915	0.9910	2
	Volume	0.4990			
	Immersion in cold water	0.0704			
Weight changes after step one and step two	Initial weight	0.5100	0.9825	0.9815	3
	Volume	0.5082			
	Time interval (step one)	0.0935			
Moisture content	Time interval (step one)	0.7866	0.6355	0.6230	2
	Cooking sessions	0.1080			
Salt content	Time interval (step one)	−0.5736	0.7469	0.7342	2
	Cooking sessions	−0.4931			
	Cooking 20 min	−0.2972			
	Initial weight	0.1401			
	Volume	0.1060			

R_w: weighted regression coefficient.
R^2_c: Coefficient of determination of calibration.
R^2_p: Coefficient of determination of prediction.

The initial sample weight, volume, and time interval were significant for the weight changes both after step 1 and after both step 1 and step 2. The time interval in step 1 and the number of cooking sessions significantly affected the moisture content, while the time interval in step 1, the number of cooking sessions, and the initial sample weight significantly affected the salt content of the samples. Neither sample size (large or small) nor product type (tails or loins) influenced the independent variables. The weight changes observed were observed both during step 1 and step 2. This is assumed to be due to the loss of water and salt–soluble proteins since the conformational stability and denaturation of the myofibrillar proteins are greatly affected by the salt concentration in the muscle (Thorarinsdóttir et al. 2002).

Table 2 shows the model parameters for the different PLS models. A high fit is achieved with two components when modeling the weight changes, while the moisture and salt content models have a lower fit due to the way the cooking session variable was encoded. The regression coefficients (R_w) are reasonable, as the weight changes during the first and second steps are positively influenced by the initial sample weight, volume (which are highly correlated), and the duration of the time interval in water before cooking. A prolonged time interval in water and cooking increases the final moisture content, while the salt content decreases. The initial weight does not have a strong influence on the moisture content but affects the salt content.

Prediction of salt content

A linear regression model to predict the salt content after both step 1 and step 2 was obtained (Table 3). Initially, hierarchical linear regression was used to identify the variables that contributed to explaining the variation in the data. The parameters of initial weight, time interval, cooking sessions, and minutes in boiling water significantly explained the final salt content in the fish muscle. By including data on sample volume, no improvements to the model were obtained (data not shown). This can be explained by the grouping of volume and initial weight in the PCA, making the volume a redundant parameter in the regression model since it is highly correlated with weight (Figure 2a). The coefficients for the cooking data increased negatively with the number of cooking sessions and with 20 min cooking instead of no cooking. This is supported by the values for salt content (Table 1), where the salt content decreased with an increasing number of cooking sessions and a prolonged cooking time.

Table 3. Parameters for linear regression analysis of initial weight, time interval for rinsing or immersion in cold water (step 1), and cooking (step 2) to predict the final salt content in salt-cured saithe. Each variable has been divided by their standard deviation.

Intercept	Initial weight	Time interval (step 1)	Cooking sessions/minutes in boiling water (step 2)	R^{2a}	RMSEP[b]	$Q^{2\ c}$	RMSECV[d]
4.34***	0.11**	−0.51***	−1.40*** (1/0) −2.37*** (1/20) −1.95*** (2/0) −2.11*** (3/0) −2.84*** (3/20)	0.84	0.40	0.83	0.41

**$P \leq .01$, ***$P \leq .001$.
[a]Coefficient of determination (goodness of fit).
[b]Root mean squared error of prediction.
[c]Coefficient of determination (goodness of prediction). This has been calculated by means of leave-one-out cross-validation.
[d]Root mean squared error of cross-validation.

In addition, the predicted vs. the actual standardized salt content was plotted (Figure 3). The grouping in the upper right corner are the raw control samples, which had an overall higher salt content and are therefore not captured well by the model.

Compared to the PLS model (Table 2), the fit of the regression model (Table 3) is better since each cooking treatment was encoded as a binary dummy variable. Nevertheless, both models agree that the combination of step 1 and step 2 of desalting reduced the final salt content while the initial sample weight influences the salt content. However, this is of minor importance compared to the time interval in step 1 and cooking (Table 3).

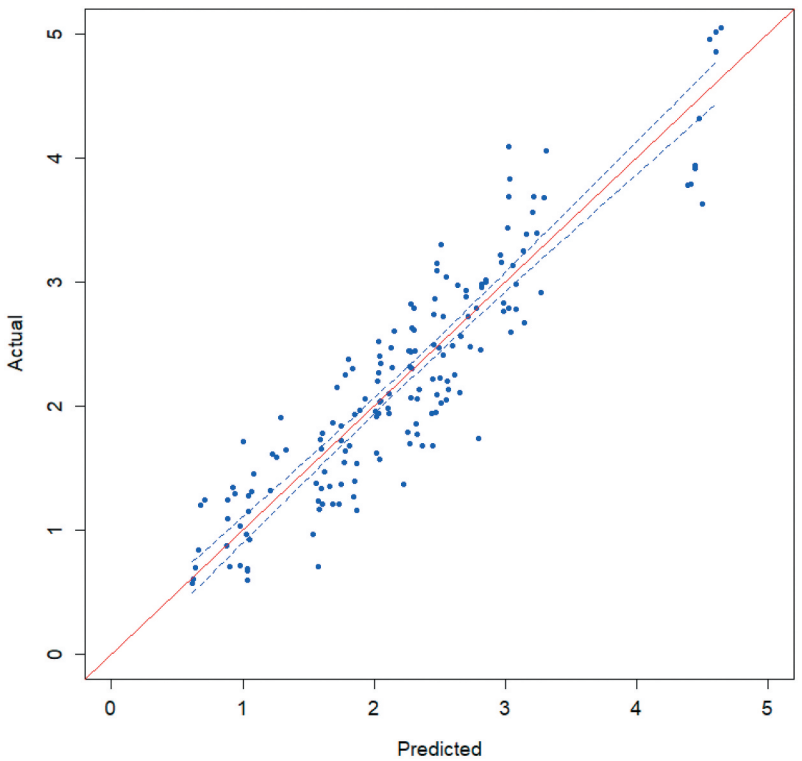

Figure 3. Prediction error plot for the linear regression model on salt content. The values on the axes are the salt content after desalting and cooking divided by the standard deviation.

General considerations

The results for the decrease in salt content, increase in moisture content, and weight changes are assumed to be dependent on the pickle salting method applied. In the case of other salting methods, like brine injection, a local denaturation of the proteins occurs. Furthermore, brine injection leads to more loosely bound water in the muscle compared to the more denatured proteins after the pickle salting (Gudjónsdóttir et al. 2015). As prolonged cooking resulted in a lower salt content (Table 1), it is assumed that this is related to the attachment of the salt to the muscle proteins. In the case of more loosely bound water and salt, it is expected that this also involves other results for salt and moisture content than presented.

Conclusions

To lower the salt content in dried salt-cured fish, desalting by immersion in water for 36 to 48 h is usually performed, resulting in a reduction of the salt content from approximately 20 to 2%. This study showed that a shorter time interval in water combined with cooking lowered the salt content of the loin and tail samples of the dried salt-cured saithe. The lowest salt content, 2.92 ± 1.00%, was obtained after 16 h in cold water, followed by cooking for 20 min. When bringing the samples to the boiling temperature only once, the average salt content of the fish was 4.87 ± 1.46%. When applying a shorter time interval in water and only one cooking session, the final salt content was about 10–12% and 9–10% for loin and tail samples, respectively. The time interval in cold water, the number of cooking sessions, and the fish sample initial weight significantly influenced the product's salt content. Moreover, as expected, the salt and moisture contents were negatively correlated, while the weight changes after step 1, the immersion in water, and after step 1 and step 2, immersion in water and cooking, correlated positively with the sample volume. Compared to traditional desalting with immersion in water for up to 48 h, immersion in water for 16 h combined with cooking for 20 min reduced the total preparation time significantly.

Highlights

- Desalting of dried salt-cured saith by immersion in cold water followed by cooking
- Immersion in cold water for 2 h or 2 min followed by three cooking sessions, i.e., the time required for boiling, resulted in 6-9 % salt in the fish.
- Immersion in cold water for 16 h and three cooking sessions resulted in 3-4 % salt in the fish
- The total preparation time of desalted dried salt-cured saith is reduced by combining immersion in cold water with repeating cooking sessions.

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Disclosure statement

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