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Glazing of frozen fish: Analytical and economic challenges

Lynn Vanhaecke[a,*], Wim Verbeke[b,c], Hubert F. De Brabander[a,c]

[a] Ghent University, Faculty of Veterinary Medicine, Department of Veterinary Public Health and Food Safety, Laboratory of Chemical Analysis, Salisburylaan 133, B-9820 Merelbeke, Belgium
[b] Ghent University, Faculty of Bioscience Engineering, Department of Agricultural Economics, Coupure Links 653, B-9000 Ghent, Belgium
[c] Institute Quality Control, Laarbeeklaan 79 (bus 7/11), B-1731 Zellik/Asse, Belgium

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ABSTRACT

Adequate glazing (6–10%) of fish fillets prior to frozen storage protects the final product from dehydration, oxidation and quality loss. Excessive glazing (>12%) on the other hand may significantly affect the economic value and end user satisfaction of frozen fish fillets. This paper describes the optimization, validation and application of a gravimetric procedure for the quantification of the ice-glaze content of frozen fish fillets (accredited under ISO 17025). This procedure has been utilized to determine the glazing percentage of multiple batches ($n = 50$) of 11 different fish species sampled from 2005 until 2009. Average glazing percentages were 8.7 ± 2.0% for the pooled samples ($n = 712$), and ranged between 6.6 ± 2.2% (salmon/cod) and 10.6 ± 1.6% (plaice). The lower threshold value of 6% glazing for sufficient protection was violated in only one batch, whereas none of the batches exceeded the 12% excessive glazing threshold. The annual market place value of one %-point glazing is estimated at 1 million Euro in a low to moderate fish consumption market like Belgium. The large variability of glazing, combined with this technology's possible implications with respect to end-product-quality and economic value urges for technology improvement, monitoring and more controlled application of the glazing process in the frozen fish industry.

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1. Introduction

Consumer demand for seafood has steadily grown during the last decades [1]. This evolution was accompanied by a growing importance of frozen as opposed to fresh fish [1]. In 2006, 54% of the 110 million tons of worldwide fish produced for human consumption underwent some form of processing. The share of frozen fish in the total quantity of fish being processed before consumption amounted up to 42% in 2006 [1]. The success of this processing method may be explained by its efficacy with respect to the preservation of an otherwise highly perishable product. A progressive loss of intrinsic and sensory seafood quality has indeed been reported throughout chilled and frozen storage of fish [2,3]. One particular established technology generally applied during freezing and frozen storage of seafood is the application of a layer of ice to the surface of a frozen product by spraying or brushing on water or by immersing the product in a water bath [4], referred to as glazing. During frozen or cold storage, seafood products may develop surface drying and dehydration, which may lead to freezer burn, and may suffer from quality loss owing to oxidation or rancidity. Glazing of seafood products typically prevents the incidence of these processes during frozen storage [5]. The ice layer excludes air from the surface of the product and as such reduces the rate of oxidation [4]. Glaze is typically applied from 4% to 10% depending on the product, though ranges from 2% to 20% have been reported as well [6]. In extreme cases up to 25–40% glaze has been observed for some seafood products [4,7], although it should be noticed that seafood products such as shrimps and squid rings as a result of their high surface to volume ratios can have unavoidable water-ice glaze up to 25%.

Determination of the ice-glaze content of fish fillets is relevant for multiple purposes. Firstly, the degree of glazing affects the quality of the product offered; in particular a too low degree of glazing (<6%) may lead to a hampered protective function. Secondly, glazing is relevant from a market and economics perspective. Excessive glazing (>12%) might imply additional direct profits for sellers at the expense of buyers, which may lead to trade conflicts, and misleading of consumers. In any case, the risk of yielding customer dissatisfaction, either from inferior quality frozen fish caused by a too low degree of glazing, or from the perception of being ripped off since buying water for fish, is substantial. Moreover, a too high degree of glazing may contribute to the ecological foot-

* Corresponding author at: Ghent University, Faculty of Veterinary Medicine, Research group Veterinary Public Health and Zoonoses, Department of Veterinary Public Health and Food Safety, Laboratory of Chemical Analysis, Salisburylaan 133, B-9820 Merelbeke, Belgium Tel.: +32 9 264 74 62; fax: +32 9 264 74 92.
E-mail addresses: Lynn.Vanhaecke@UGent.be (L. Vanhaecke), Wim.Verbeke@UGent.be (W. Verbeke), Hubert.DeBrabander@UGent.be (H.F. De Brabander).

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Table 1
Fish species or products for which the glazing percentages were determined; period 2005–2009.

English name	Dutch name	Scientific name	Number of pieces per bag	Average price (Euro/kg)
Anglerfish	Staartvis	*Lophius piscatorius*	8–10	28.70
Witch flounder	Hondstong	*Glyptocephalus cynoglossus*	16–23	7.80
Haddock	Schelvis	*Melanogrammus aeglefinus*	10–13	13.50
Cod	Kabeljauw	*Gadus morhua*	9–13	14.60
Rose fish	Roodbaars	*Sebastes marinus*	14–16	10.20
Ray	Rog	*Raja clavata*	8–9	7.80
Pollack	Koolvis	*Pollachius pollachius*	9–12	6.30
Wolf fish	Zeewolf	*Anarhichas lupus*	9	10.50
Plaice	Pladijs	*Pleuronectes platessa*	10–11	14.60
Salmon/witch flounder[a]	Zalm/hondstong	*S.salar/Glyptocephalus cynoglossus*	8–9	17.50
Salmon/cod[a]	Zalm/kabeljauw	*S.salar/Gadus morhua*	23–26	10.50

[a] Combinations of 2 fish species.

print of seafood since unnecessary amounts of ice (water) are being cooled, stored, shipped and transported. The latter argument for a better control of the glazing process is increasingly important, owing both to the increase in frozen fish trade and to the public debate concerning sustainability that is gaining momentum [8].

Although glazing is a widely applied technology for fish products whose market shares are increasing, surprisingly little research has been published in this domain, apart from a few notable studies focusing either on microbiological safety [9] or quality preservation, in particular lipid oxidation [10] effects from glazing. A number of methods exist for the determination of the net contents and glaze contents, notably for the case of frozen shrimps. The CODEX ALIMENTARIUS procedures developed by the FAO/WHO and applications thereof are among these [11,12]. Some more recent publications deal with the development and application of an enthalpy technique for measuring the glazing percentage of frozen shrimps [13–15]. But to the best of our knowledge, the application and/or accreditation of an analytical procedure for the determination of glazed fish fillets have not been reported yet. Therefore, the goal of this study was to develop, optimize and validate a procedure for the quantification of the glazing percentage of different types of frozen fish species. The accreditation under ISO 17025 of this validated procedure is reported and the results obtained with this technique over a period of five years as a quality control measure for the glazed fish products marketed by a major retailer on the Belgian market is presented. Finally, the economic importance of glazing is evaluated and discussed.

2. Materials and methods

2.1. Origin and preparation of commercial material

The different fish species used for commercial purposes in Belgium (Table 1) were captured in the North East Atlantic Region (FAO Statistical Area 27), except for the salmon, which was farmed in Chile. Upon catching, the fish was stored in ice up to three days before landing. Whole fishes were washed, cleaned and fish fillets were prepared whenever required. Upon cleaning the whole fish or fish fillets were deep frozen and merged in a 0 °C water bath for 30 s to apply an even layer of glaze. Glaze was subsequently allowed to set by storage at −18 °C, the whole fish or fish fillets packed in bags and transferred to the cold store.

2.2. Gravimetric procedure for determining the glazing percentage

The percentage of glazing was determined according to the following procedure. First, the frozen fish sample (at −18 °C or below) was removed from the freezer and its gross-weight (= $W1$) determined on a PB 3003-5 scale (Mettler Toledo S.A., Greifensee, Switzerland). Subsequently, the frozen sample was immersed into a water bath (GFL mbH, Burgweidel, Germany) and gently agitated for about 30 s until all visible ice-glaze was removed. This was checked by carefully feeling the fish surface with the finger tips. When the smooth surface of the glaze disappeared and the rough surface of the fish itself could be felt, the deglazing procedure was stopped. Ideally, the water bath contains an amount of fresh water equal to about 10 times the declared weight of the product; the temperature should be adjusted to about 20 ± 2 °C. Finally, the sample was carefully dipped dry (without pressure) with a cotton rag and the non-glazed or net-weight (= $W2$) determined. The percentage of glazing or glaze-weight relative to gross-weight was then calculated as follows:

$$\%\,\text{Glazing} = \frac{(W1 - W2) \times 100}{W1}$$

The procedure for the determination of the percentage of glazing is described in the CODEX ALIMENTARIUS Committee for Fish and Fishery Products: CODEX STAN 190-1995 [11].

2.3. Validation study

Validation studies were performed by using a batch of eight fish samples, consecutively re-glazed for every test phase by immersing the fish samples in a water bath at 0 °C and allowing the glaze to settle overnight. Precision of the gravimetric procedure, determined as relative standard deviation, was obtained from the repeated determination ($n = 5$) of the glaze content of the aforementioned batch by one analyst on three consecutive days (repeatability, $n = 24$) and by three different analysts on randomly selected days (reproducibility, $n = 40$). Recovery of the method was evaluated by comparing the repeated gravimetric results ($n = 24$) under reproducibility conditions with the initial glaze percentages, as obtained from the fish processing company.

2.4. Data analysis procedures

The dataset used for analysis contained data from 712 individual pieces from 50 different batches (see Table 1 for information about the species). Data analysis procedures include descriptive statistical analyses with determination of mean weights, glazing percentages for individual pieces and batches, either pooled per species or time period. Standard deviations of glazing percentages are provided in tables or graphs as a measure of dispersion around the mean. The relationship between glazing percentage as dependent and net-weight, species and season as independent variables was analyzed through regression analysis using SPSS 15.0. Market data from FAO (2009) [1] and GfK (2009) [16] are used for the evaluation and discussion of economic implications.

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