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INFLUENCE OF GRAVADING PROCESS PARAMETERS ON PHYSICOCHEMICAL ATTRIBUTES OF RAINBOW TROUT (*Oncorhynchus mykiss*) GRAVADS

– Research paper –

Magdalena MICHALCZYK*, Ireneusz MACIEJASZEK

Department of Biotechnology and General Technology of Food, Faculty of Food Technology, University of Agriculture in Krakow, Balicka 122, 30-149 Kraków, Poland, magdalena.michalczyk@urk.edu.pl, ireneusz.maciejaszek@urk.edu.pl

Abstract: Gravads are a traditional type of Scandinavian delicatessen frequently made from salmon. Developing a gravading technology by using other fish like farmed rainbow trout may make gravads more popular in countries without a tradition in this field. The aim of the present study was to investigate the influence of gravading process parameters (composition and proportion of gravading mixture, time and temperature of ripening) on the physicochemical attributes of rainbow trout gravads. The influence of gravading process parameters (time, temperature, and the amount and relative proportions of the added salt-sugar mixture) on the yield and physicochemical attributes (water activity, protein, salt, sugar and dry matter content) of rainbow trout gravads were investigated using response surface methodology. The amount of the added sugar-salt mixture and gravading time were more important factors affecting the analyzed attributes than temperature or the proportions of salt and sugar. Mathematical models were developed to estimate the quality parameters of rainbow trout gravad obtained under different process conditions. Response surfaces representing changes in gravad attributes with varying processing conditions help to make the most desirable product. The results obtained in this work may facilitate the expansion of the range of nutritionally valuable fish products available on the market.

Keywords : gravad, response surface methodology, gravading conditions

INTRODUCTION

Fish are not only a source of protein, vitamins and minerals, but also have a high content of omega-3 fatty acids, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Numerous studies confirm the beneficial effects of fish consumption in reducing the risk of cardiovascular disease, including coronary heart disease and myocardial infraction, depression and mortality (Jayedi and Shab-Bidar, 2020; Innes and Calder, 2020).

Salting as a method of fish preservation has a long tradition dating back to Neolithic times. In ancient Egypt and medieval Europe salted fish were an important commodity (Knochel, 1993; Sikorski, 1980). Salting is also an integral stage in the production of smoked fish. Therefore, there is interest in the impact of the process modification not only on the quality of salted fish but also on smoked and dried fish products (Corrias et al., 2022; Gallart-Jornet et al., 2007a, Gallart-Jornetet al., 2007b, Rubai,y et al., 2020; Sánchez-Parra et al., 2023; Sigurgisladottir et al., 2000).

At present, some salted fish products, often obtained from high quality raw materials of attractive fish species, may be regarded as delicatessen foods. This includes anchovies and maatjes-herring, which are the best known products of this type in Europe, as well as the less popular gravad (gravlax), rakeorret, and surstromming. It should be pointed out, however, that the salting process sometimes involves the addition of sugar. Sugar helps, among other things, to balance the salty taste (Namiq and Milne, 2017). Sugar is added not only to gravads but also to sugar-salted herrings, as well as to sprats salted and sprinkled with sugar (Knochel, 1993; Sikorski, 1980).

Gravads are produced by sprinkling suitably fat fillets of fish such as salmon, trout, mackerel or Greenland halibut, with a salt-sugar mixture with

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* Corresponding author.
E-Mail address: magdalena.michalczyk@urk.edu.pl

added spices. The most popular raw material for the production of these products is salmon. The remaining species are used less frequently. The product ripens under chilled conditions for a few days before being removed from the released brine and either eaten or vacuum packed and stored for several weeks (Knochel, 1993; Paarup et al., 1996; Wiernasz et al., 2020).

Due to the nutritional advantages of fish on the one hand and the problems associated with their acquisition (Kamiyama et al., 2024) on the other, it seems important to expand the range of fish products by including species that have not previously been used or have been relatively rarely used in their production.

Gravad, a gastronomic high-valued product, is attracting interest due to the possibility of using new fish species in its production. In addition to publications on salmon gravad, the literature contains papers on the quality and storage changes of gravad obtained from Atlantic bonito (Altan et al., 2022; Vurat and Kocatepe, 2023, Rzepka et al., 2013). Altan et al. (2022) evaluated, among other things, consumers' taste preferences of gravlax obtained from Atlantic bonito (*Sarda sarda*) with the addition of various herbs. The durability of gravlax from this fish was also the subject of the evaluation {Vurat and Kocatepe, 2023}. An attempt to use the gravading process to process carp (*Cyprinus carpio*) fillets was also made by Durmuş et al. (2017), while Emir Çoban et al. (2020) used *Luciobarbus esocinus* living in the Euphrates-Tigris river system.

The gravad technique using low concentrations of salt and sugar is also being considered as a way of extending the shelf life of fish products, including those for subsequent heat treatment. A salt addition of 1.3% or salt-sugar mixture of 1.3% and 0.9% respectively, was used to extend the shelf life of stored rainbow trout fillets (Lyu et al, 2017). Based on sensory evaluation, the authors noted an increase in the possible storage time of dry-cured samples compared to the control and a lower cadaverine concentration. Shi et al. (2014) analysed the effect of the additions of 1.8% salt and 1.8% sugar to silver carp fillets on rigor mortis changes. Hong et al. (2012) used 1.1% salt or 1.1% salt and 0.9% sucrose for preservation in brine bighead carp fillets stored at 4ºC, in both cases finding an improvement in the quality and safety of product and extending its shelf life. Lyu et al. (2017) believe that for consumers, fish fillets seasoned with salt and sugar may be an attractive alternative to traditional products, while Pankyamma et al. (2020) report that gravading or sugar-salting is an innovative method for extending shelf life of fish products that will later be heat-treated.

Gravad type products could become attractive commodities in countries without a tradition in this field if technologies based on local raw materials were to be developed. One such raw material is farmed rainbow trout (*Oncorhynchus mykiss*), which has an appropriate fat content and desirable sensory attributes. In addition, rainbow trout, being a fish reared in closed ponds, it is easy to control, e.g. in terms of feed fed, which affects consumer safety. The aim of the present study was therefore to investigate the influence of gravading process parameters (composition and proportion of gravading mixture, time and temperature of ripening) on the physicochemical attributes of rainbow trout (*Oncorhynchus mykiss*) gravads.

MATERIALS AND METHODS

The raw material for the investigation was eviscerated 1-year-old rainbow trout (*Oncorhynchus mykiss*) of 300 ± 30g mean weight obtained from a local fish farm. Chilled in ice, the fish were transported to the laboratory and gravaded within four hours. The process involved filleting with the skin left on, manually rubbing both sides of each fillet with a salt-sugar mixture, matching them in pairs: meatside to meatside, and placing them in containers. Half way through the process, pairs of fillets were turned: those with skinside down were turned up and the fillets at the bottom were placed at the top. Finally, the gravads were removed from the brine which had formed and dried with paper tissue. The meat above the lateral line and below the dorsal fin was analyzed. Samples were taken from at least six different fillets and then minced in a meat mincer with a hole diameter of 2.5 mm.

The first stage of the investigation involved analyzing the effect of adding the salt/sugar mixture (at a rate of 200-450 g/kg) and the relative proportions of the substances in the mixture (ranging from 25 to 55% NaCl). In all variants, the process was performed at 3°C for 48 h. At the second stage, the influence of the time (from 8 to 72 h) and temperature (from -1 to 11°C) of gravading was investigated under the optimum parameters established in the first stage of the experiment. Response surface methodology was used to describe these interdependencies. A total of 13 different combinations of independent variables were used, nine according to the principles of second order central composite design (Cochran and Cox, 1957; Statistica 1991), and an additional four (combinations 1, 3, 11 and 13) (Table 1). The model was fitted with each data set as eq. 1 shows:

$Z_n=b_0 + b_1X_{ij} + b_2Y_{ij} + b_3X_{ij}^2 + b_4Y_{ij}^2 + b_5X_{ij}Y_{ij}$ [1]

where: Zn – particular dependent variable; X_{ij} – independent variable: salt contribution (%), time (h); Y_{ij} - independent variable: mixture addition (g/kg), temperature (°C); b_1, b_2 – parameters for linear terms; b_3, b_4 - parameters for quadratic terms; b_5 – parameter for interaction term, b_0 - constant.

Multiple regression analysis was completed for each model, and the variance was partitioned into linear, quadratic and interaction components in order to assess the relative significance of these components. Moreover, coefficients of determination (R^2) were also calculated. To evaluate the relationships between all characteristics examined, the relevant correlation coefficients at $P< 0.05$ confidence level were computed. Statistical analyses and three-dimensional graphs with contour plots were generated from the regression equations over the range of variables tested using the CSS.Statistica package (StatSoft, Tulsa, OK, USA).

Dry matter content was determined according to the method 934.01 (AOAC, 2005) by drying the samples to a stable weight at 105°C using a laboratory dryer. Proteins (N×6.25) were analyzed by the Kjeldahl method (984.04, AOAC, 2005) and fat content by the Soxhlet method (930.09, AOAC, 2005). Sugar content was estimated using the phenol method described by Dubois et al. (1956); salt content by the Mohr method (969.23, AOAC, 2005); and water activity by the use of an AQUA-LAB, CX-2 apparatus (Decagon Devices, Inc. USA) at 26°C ± 0.5°C, with an accuracy level of up to ± 0.003.

Table 1. Coded and uncoded levels of independent variables of gravading process in response surface design

Combination	First step				Second step			
	Proportion of salt in mixture		Mixture addition		Time		Temperature	
	Coded	Uncoded (%)	Coded	Uncoded (g/kg)	Coded	Uncoded (h)	Coded	Uncoded (°C)
1	$-\sqrt{2}$	25.0	$-\sqrt{2}$	200	$-\sqrt{2}$	8.0	$-\sqrt{2}$	-1
2	$-\sqrt{2}$	25.0	0	325	$-\sqrt{2}$	8.0	0	5
3	$-\sqrt{2}$	25.0	$\sqrt{2}$	450	$-\sqrt{2}$	8.0	$\sqrt{2}$	11
4	-1	29.4	-1	237	-1	17.5	-1	1
5	-1	29.4	1	413	-1	17.5	1	9
6	0	40.0	$-\sqrt{2}$	200	0	40.0	$-\sqrt{2}$	-1
7	0	40.0	0	325	0	40.0	0	5
8	0	40.0	$\sqrt{2}$	450	0	40.0	$\sqrt{2}$	11
9	1	50.6	-1	237	1	62.5	-1	1
10	1	50.6	1	413	1	62.5	1	9
11	$\sqrt{2}$	55.0	$-\sqrt{2}$	200	$\sqrt{2}$	72.0	$-\sqrt{2}$	-1
12	$\sqrt{2}$	55.0	0	325	$\sqrt{2}$	72.0	0	5
13	$\sqrt{2}$	55.0	$\sqrt{2}$	450	$\sqrt{2}$	72.0	$\sqrt{2}$	11

RESULTS AND DISCUSSION

The effect of adding the salt/sugar mixture and the relative proportions of the substances in the mixture on gravad's features

The yield of a final product is one of the fundamental factors affecting the effectiveness of production. The yield of salted fish products is affected by the mass changes in water, salt and brine-soluble components of the protein fraction and non-protein nitrogenous compounds that occur during the process (Jiang et al. 2023). Figure 1A illustrates that the addition of the gravading mixture has a strong influence on this parameter: the higher the addition, the lower the yield. This tendency was more pronounced with higher proportions of salt, which is in line with the negative values of squared regression coefficients observed for both independent variables (Table 2). The difference in yield exceeded 15%. Undoubtedly, this parameter was also affected by the fat content in the salted material as well as the shape of the fillet (voluminous or slim). According to Mørkøre et al. (2001) fatty raw material of a voluminous shape gives a better processing yield in Atlantic salmon smoking.

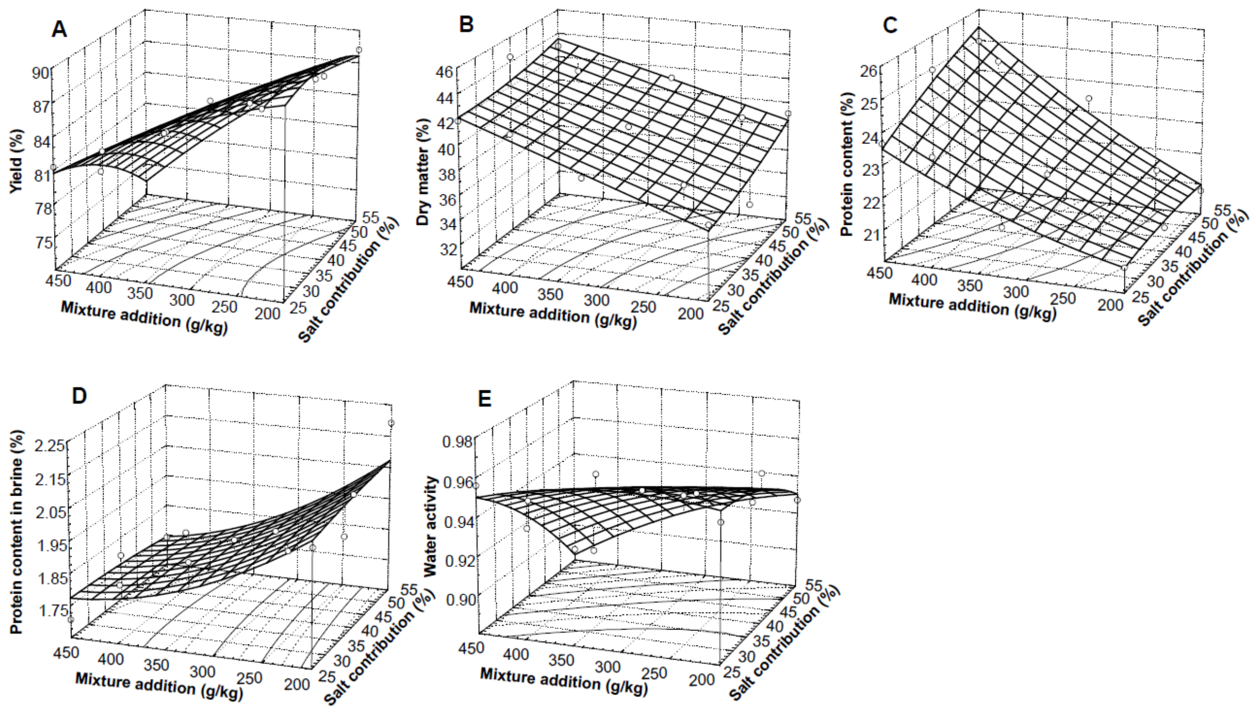

Figure 1. Response surface and contour plot showing the effect of salt-sugar mixture composition and addition to rainbow trout fillets on: A - yield of gravad, B - dry matter content, C - protein content in gravads, D - protein content in brine, E - water activity of gravads. Conditions: time 48 h, temperature 3°C.

Table 2. Parameters for second order polynomial equations for the effect of gravading mixture composition (b_1, b_3) and its addition to fish (b_2, b_4) as well as interactions between them (b_5)

Analyzed attribute	Regression equation parameters						R^2 (%)
	Constant b_0	Parameters for linear terms		Parameters for quadratic terms		Parameter for interaction term b_5	
		b_1	b_2	b_3	b_4		
Yield (%)	80.14904	0.527845	0.026932	-0.00516	-0.000061	0.00081	94
Dry matter (%)	28.90063	0.012181	0.031616	0.001648	0	-0.000216	86
Protein content in ravid (%)	20.35252	0.002322	-0.00568	-0.000517	0.000017	0.000230	95
Protein content in brine (%)	2.460201	0.005399	-0.00322	-0.000029	0.000004	-0.000009	78
Water activity	0.88116	0.002309	0.000394	-0.000026	0	-0.00001	88

The fat content of the rainbow trout fillets being the raw material for this study, was approximately 4.5 ± 0.79%. Such fillets may be categorized as medium fat, slightly voluminous raw material.

The higher the proportion of NaCl in the gravading mixture, the greater the osmotic pressure outside the muscle tissue of the fish, leading to more intensive migration of water from cells and finally to a decrease in yield, which is negatively correlated with dry matter and protein content in the product (Table 3). This was confirmed by the response surfaces (Figures 1B and C), an analysis of which revealed that more dehydrated and higher-protein gravads can be obtained by increasing both the amount of sugar/salt mixture applied and the proportion of salt in the mixture. However, in this case, the yield is generally low. It should also be pointed out that the quantity of gravading mixture had a greater effect on the above parameters than the mixture composition.

Table 3. Correlation coefficient values between analyzed attributes during optimization of gravading mixture addition and its composition

Analyzed attribute	Yield	Water activity	Dry matter content, %	Protein content in gravid, %
Protein content in brine	0.78	0.37	0.74	-0.83
Protein content in gravad	-0.92	-0.66	0.90	
Dry matter content	-0.82	0.60		
Water activity	0.73			

Changes in dry matter due to the gravading mixture addition are characterized by a strong positive linear effect, whereas in the case of protein level, the positive effect of the second degree overlaps the negative linear effect (Table 2). Pankyamma et al. (2020) used a gravading process for enhancing the shelf life of Nile tilapia (*Oreochromis niloticus*) steaks. When evaluating the gravadas obtained at salt/sugar ratios of 1:0.5; 1:1; 1:1.5 and 1:2 and mixture addition to the fish of 0.1:1 and 0.2:1, they found that increasing sugar ratio in mixture did not have a significant effect on reducing the moisture content, while increasing the addition of mixture to steaks exhibited such an effect. Fuentes et al. (2008), who used salt concentrations in sea bass fillets ranging from 0.11 to 0.27 g salt/g dry material, observed that use of increasing amounts of NaCl resulted in higher weight loss and water loss as well as higher salt uptake. In turn, Jiang et al. (2023) point out that salt also changes the water-holding capacity of fish tissues, due to the binding of salt ions, and in high concentrations it can cause significant shrinkage of muscle fibers, which are also factors affecting th yields of salted products.

The gravading process is accompanied by water migration from the rainbow trout tissue. The resulting salt/sugar brine contains also protein as well as non-protein nitrogenous substances. Changes in their concentration in the brine, expressed as total protein, are given in Figure 1D. As can be seen, this feature is mainly affected by the addition of the gravading mixture itself rather than by the proportion of salt in the mixture. The lower concentration of total protein in the brine with increased amounts of added mixture, results from greater dilution of the brine by water in the tissue fluids being released due to osmosis. Total protein content in the brine correlates positively with dry matter content and product yield, and negatively with protein content in the product (Table 3). The quantity of protein dissolved in the brine can be regulated by adjusting the pH of the fish meat, which may be explained by the phenomenon of approaching or distancing from the isoelectric point of the protein. Additionally, the presence of salt-derived cations can induce conformational changes in proteins and affect their solubility (Martínez –Alvarez and Gómez-Guillén, 2005). According to the above authors, brine with a pH of 6.5 from the cod processing contained myosin heavy chains (MHC), actin and other short chain proteins like tropomyosin.

Michalczyk and Surówka (2007) showed that the brine obtained in the gravading process of rainbow trout fillets contained myosin heavy chain (MHC), α-actinin, actin, β-tropomyosin, and α-tropomyosin. No presence of M-protein, C-protein and troponin was detected, but two proteins appeared, with a molecular weight of 61.0 and 29.2 kDa, which were found neither in the raw fillets nor the gravads obtained from them.

Water activity is a parameter which characterizes the potential stability of stored food. According to Fuentes et al. (2008), the value of this parameter correlates strongly with the NaCl weight fraction in the aqueous phase of salted products. The changes in a_w are shown in Fig.1E, indicating that this parameter depends more on the salt concentration in the gravading mixture than on the dose of the mixture. Both the addition of salt and sugar reduce water activity. The greater effectiveness of the same amounts (by weight) of salt and sugar, is due to the difference in molar mass of the two substances and the breakdown of salt into ions (Damodaran, 2017). In the present study, water activity was in the range of 0.89 – 0.97. The water activity of products is crucial for their stability and determines the possible growth of particular microorganisms. For example, the growth of *Clostridium botulinum* type E is inhibited at $a_w<0.965$, which corresponds to 5-6% concentration of NaCl in the water phase (Troller and Christian, 1978). As Tsironi and Taoukis (2014) report, minimum water activity for *Pseudomonas spp*. is 0.937. However, Paarup et al. (1996) observed, finished "gravad" type products could be characterized by fairly high heterogeneity. In addition, Namiq and Milne (2017) also observed the effect of salmon fillet thickness on the water activity value achieved after the gravadding process and storage of the resulting products. Moreover, according to Paleari et al. (2003), water activity established for other lowprocessed meat products is close to that determined for gravads in the present study, being in the range of 0.88 – 0.95. For salami it was reported in the range of 0.84 – 0.96 (Leung 1986).

The sensory features of rainbow trout gravad obtained at the same ranges of values for mixture ratio and mixture addition, were studied by Michalczyk and Surówka (2003). The results reported revealed that the highest sensory quality was obtained using 350 g of mixture per kg of fillets, with a salt concentration of 33%. Analysis of response surface (Fig.1A) showed that such a product had a yield of approx. 84.5%. Based on the above-cited work, this version of gravad was chosen for further investigation as having the best sensory attributes and satisfactory remaining parameters. Therefore, at the next stage of this experiment, fillets were rubbed with a mixture containing 33 % salt at a rate of 350 g of mixture /kg and stored at different temperatures for different lengths of time. Pankyamma et al. (2020), when assessing sensory acceptability of the aforementioned gravading versions of Nile tilapia steaks, also found that the proportion of 1:2 was an optimum salt/sugar ratio.

The influence of the time and temperature of gravading on gravad's features

In almost all measurements of the influence of temperature and time on gravad characteristics, time was found to be the more significant factor. Its effects were most clearly seen in: changes in yield (Figure 2A); the content of dry matter (Figure2B) and salt and sugar (Figure 2D and 2E); and proteins lost in brine (Figure 2F), (Table 4).

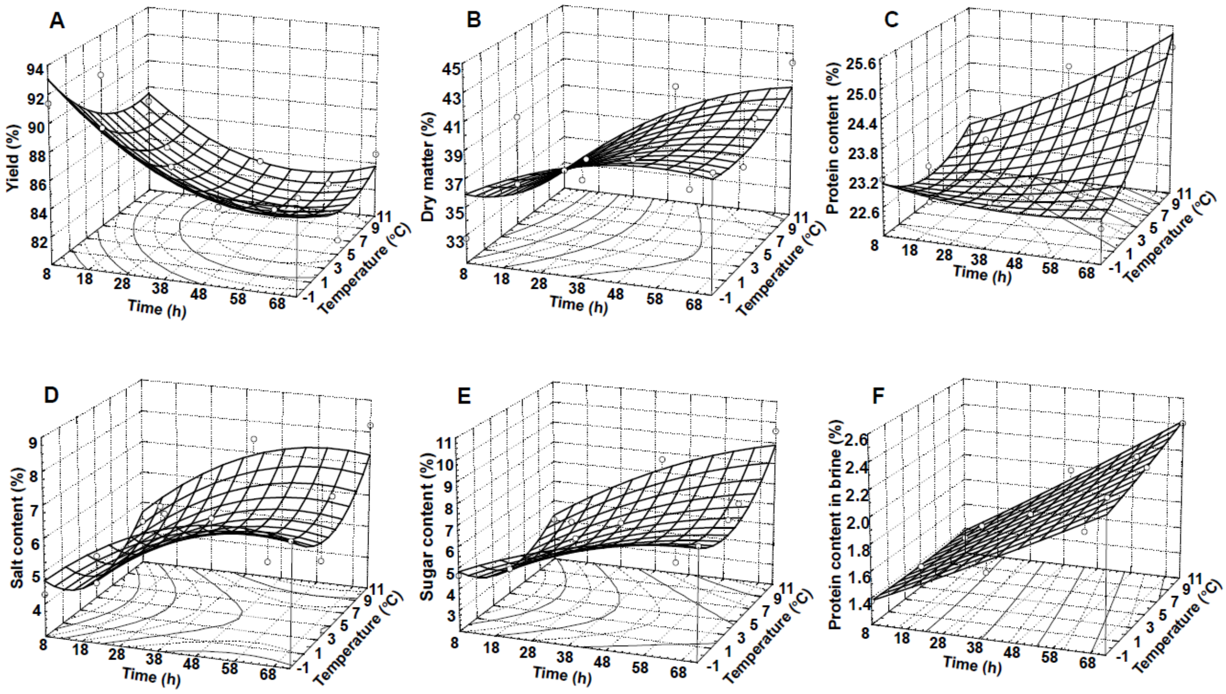

Figure 2. Response surface and contour plot showing the effect of time and temperature on: A - yield of gravads, B - dry matter content, C - protein content in gravads, D - salt content, E - sugar content, F - protein content in brine. Gravading mixture: composition: 33% NaCl, 67% sucrose; rate of addition to fillets: 350 g·kg^{-1}.

Table 4. Parameters for second order polynomial equations for the optimization of time (b_1, b_3) and temperature of gravading (b_2, b_4) as well as interactions between them (b_5)

Analyzed attribute	Regression equation parameters						R^2 (%)
	Constant b_0	Parameters for linear terms		Parameters for quadratic terms		Parameter for interaction term b_5	
		b_1	b_2	b_3	b_4		
Yield (%)	94.17188	-0.29364	-1.03361	0.002398	0.053807	0.004006	85.31
Dry matter (%)	34.0823	0.167667	-0.582013	0.001416	0.02403	0.006566	53.91
Sugar content (%)	3.711969	0.0863	-0.44323	-0.00058	0.03727	0.002955	82.47
Salt content (%)	3.55292	0.106971	-0.33443	-0.00092	0.032596	0.000689	60.59
Protein content in gravad (%)	23.01843	-0.01329	-0.17524	0.000175	0.014395	0.003343	88.78
Protein content in brine (%)	1.27836	0.012012	-0.005425	0.000015	0.000353	0.000279	96.96

In the products examined, dry matter content increased with longer gravading time (Figure2B); however, the effect of temperature was considerably less. The important role of salting time was also reported in other studies. Corrias et al. (2022), assessing the effect of dry salting of swordfish, emphasise that the diffusion process is affected by the contact time of meat with salt. In the studies of the above-mentioned authors, the uniform distribution of salt was also adversely affected by the irregular shape of fillets.

Nketsia-Tabiri and Sefa-Dedeh (1995) noticed that salting time was an important factor affecting water content in salted dried tilapia. In turn, Tsironi and Taoukis (2014), using a first degree polynomial model, described the effects of both maltodextrin concentration in the osmotic solution and processing time on the water activity of osmotically dehydrated gilthead seabream fillets. Moreover, according to Deumier et al. (1996), time had a clear linear effect on water loss in venison tenderloins undergoing dewatering and impregnation soaking. The time of osmotic pre-treatment with solutes containing high dextrose equivalent maltodextrin or trehalose or glucosamine and NaCl–also affected changes in water loss, solid gain, salt content and water activity of gilthead seabream fillets (Tsironi and Taoukis, 2017). Fuentes at al. (2008) analysing the effects of salting time, contact area salt/fillets, thickness and initial weight of sea bass fillets, found that, of the mentioned variables, salting time had the strongest effect on changes in total weight, water weight and liquid phase NaCl weight fraction of the product. Furthermore, the cited authors note that during the salting time, water loss is higher than salt gain in fillets, which is evident as weight loss of product.

Changes in the protein content of gravads resulting from different temperatures and times applied during processing did not correlate significantly with dry matter content (Table 5). In consequence, the response surfaces for these two parameters differed significantly (Figures 2C and 2D). The protein content is determined by the positive quadratic effects of temperature and time as well as their interactions suppressed by the negative linear influence of both these independent variables (Table 4). Consequently, the gravads which ripened for the longest time at the highest temperatures had the greatest protein content. The response surface runs, illustrating changes in sugar and salt content (Figures 2C and 2D) in the different variants of the product, were very similar, which was confirmed by the high correlation coefficients (Table 5). As both these charts demonstrate, time was the dominant factor, and the effects of temperature on the process only became apparent with longer gravading times. Collignan et al. (2001) noticed that sugar, having a higher molecular mass than salt, diffuses into the product more slowly than salt and remains mainly on the surface, forming a dense layer which substantially inhibits salt penetration. The rate and dynamics of diffusion are also considerably affected by fat content and the size of the fillets: the higher the fat content, the lower the salt diffusion and moisture loss (Collignan et al. 2001).

The brine remaining after the gravading contains a certain amount of nitrogenous substances due to the equalization of osmotic pressure. With the lapse of time, their concentration, given here as total protein content, showed an almost linear increase (Figure 2F). The effect observed for temperature was much lower and became noticeable only after a longer period of time.

According to earlier findings (Michalczyk and Surówka, 2003), the most sensorially attractive rainbow trout gravad was obtained when the gravading procedure was carried out at 3°C for 48 hours. This temperature is also beneficial with regard to the inhibition of the *Clostridum botulinum* growth under anaerobic conditions, since thisbacteria cannot grow below 3°C (Lund and Peck 2000). However, such temperatures do not protect against the development of *Listeria monocytogenes*, which can grow even at -1.5 ºC (Gao et al., 2023). Zakrzewski et al. (2024) report that the incidence of this microorganism is significantly higher in ready-to-eat fish products than in raw fish and amounted to an average of 14.5% in products, according to the authors' meta-analysis. However, the authors noted that the occurrence of *L. monocytogenes* over the years shows a downward trend.

Among the proposals aimed at preventing the growth of this bacterium during salmon gravlax storage, is the use of lactic acid bacteria. Of the several strains examined by Wiernasz et al. (2020), antilisterial activity and no additional spoilage compared to controls, was shown by *Carnobacterium maltaromaticum* SF1944. Similar proposals for the use of probiotic bacteria to limit growth and toxin formation by *C. botulinum* are reported by Alizadeh et al. (2020).

Table 5. Correlation coefficient values between analyzed attributes during optimization of time and temperature of gravading

Analyzed attribute	Yield	Dry matter content	Protein content in gravad	Protein content in brine	Salt content
Sugar content	-0.54	0.80	0.67	0.84	0.93
Salt content	-0.49	0.82	0.48	0.67	
Protein content in brine	-0.67	0.69	0.61		
Protein content in gravad	-0.46	0.41			
Dry matter content	-0.32				

CONCLUSIONS

The amount of sugar-salt mixture added and the gravading time were found to affect chemical composition far more strongly than either temperature or salt/sugar proportions in the mixture. The only exception was water activity, where the determining factor was the salt content in the gravading mixture rather than the quantity of mixture. The response surfaces obtained in this work, which represent changes in quality indicators accompanying variations in gravading parameters may facilitate selection of the appropriate conditions for manufacturing rainbow trout gravads with the assumed characteristics. It may also facilitate selection of the appropriate conditions for the use of a salt-sugar mixture as a method of extending the shelf life of fish fillets.

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CONFLICTS OF INTEREST
The authors declare no conflict of interest.

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