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USEFULNESS OF THE SOUS-VIDE METHOD OF HEAT TREATMENT OF COD FILLETS®

Przydatność metody sous-vide obróbki termicznej filetów z dorsza®

Key words: sous-vide (SV), process efficiency, sensory quality, nutritional value.

The aim of the work presented in the article is to determine the effect of the form of the raw material (fresh fillets, frozen fillets, frozen cubes) on the amount of "thermal leakage" and selected quality characteristics of cod meat subjected to heat treatment using the "sous-vide" (SV) method. It has been found that, of the many forms of fish on the market, unground fillets are the most suitable form that can be sous-vide cooked. Frozen fillets are less useful, although the thermal leakage is similar to that of non-frozen fillets. Frozen cube obtained before freezing by pressing fish pieces is characterized by poor suitability for sous-vide processing, because it favors the formation of a very large (over 40%) thermal leakage and less favorable sensory quality. The heat treatment of fish meat requires a relatively short time, because after 15-30 minutes a product with a soft consistency can be obtained. However, in order to obtain a consistency that is acceptable to the consumer, the most appropriate time for a temperature of 60°C is a heating time of 45 minutes. The SV technology can be used for the heat treatment of cod meat, which is considered a delicate meat.

Słowa kluczowe: sous-vide (SV), wydajność procesu, jakość sensoryczna, wartość odżywcza.

Celem pracy przedstawionej w artykule było określenie wpływu formy surowca (filety świeże, filety mrożone, kostka mrożona) na wielkość „wycieku termicznego" oraz wybrane cechy jakościowe mięsa z dorsza poddanego obróbce termicznej metodą „sous-vide" (SV). Stwierdzono, że spośród wielu form ryb znajdujących się na rynku, najbardziej przydatną formą do obróbki termicznej SV są filety nierozdrobnione. Mniej przydatne są filety mrożone, aczkolwiek wyciek termiczny jest podobny jak w przypadku filetów niemrożonych. Mrożona kostka (sprasowane kawałki ryb poddane mrożeniu) charakteryzuje się słabą przydatnością do obróbki SV, gdyż sprzyja powstawaniu bardzo dużego wycieku termicznego oraz daje mniej korzystną jakość sensoryczną. Technologia SV może być stosowana do obróbki termicznej mięsa dorsza uznanego jako mięso delikatne. Już po 15-30 minutach stosowania SV w temp. 60°C uzyskuje się produkt o dość miękkiej konsystencji, a po 45 min – produkt o konsystencji pożądanej sensorycznie.

INTRODUCTION

Today's consumers are often looking for prepared foods that are nutritionally valuable, safe to use, free of additives and preservatives, affordable, and taste similar to food prepared at home [19, 20].

A modern heat treatment ensuring the above features of food is the "sous-vide" (SV) method. It differs from the methods used in traditional cuisine, first of all, the need to use thermostable "vacuum bags" [1, 38].

In addition, the special equipment required to monitor temperature and processing times has increased the cost of producing food using the SV method for many years and, as a result, limited its use in the food industry for a long time. Recently, this technique has become more affordable for use both in households and restaurants, as well as in industry and is gaining popularity at a growing pace [20].

Vacuum packing is therefore a physical barrier against water loss. It provides very efficient and consistent heat transfer from the water to the food product, which typically reduces processing time and increases efficiency. The main advantage of the SV method is the gentle cooking conditions and, due to the lower processing temperature and lack of oxygen in the bags, losses of nutrients, water, and volatile compounds are reduced, oxidation processes are inhibited and the shelf life of cooked products is thus increased [4, 38].

Also from the point of view of sensory quality, the benefits of using this method against other conventional techniques are observed. Food obtained by the SV method is generally considered to be "better tasting" and more flavoursome, which encourages the use of less salt in food preparation. Due to the anaerobic environment of the food, the use of the 'sous-vide' technique inhibits oxidative degradation of the various components, which is widely considered to be the main

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cause of unattractive tastes and flavours when other cooking techniques are used. Reducing or hindering fat oxidation processes and limiting the formation of Maillard compounds means that such prepared dishes are often treated as "dietetic" [7, 16, 21].

Studies have shown that SV food is convenient and quick to prepare, has low health risks and has a long shelf life [23]. In addition, SV cooking is suitable for various raw materials, for use both at home, in restaurants, in hospitals and industrial production [3].

By strictly controlling the processing conditions, i.e. time and temperature, it is possible to ensure reproducible product quality and achieve microbiological safety [1, 28, 32].

During SV processing, pasteurisation conditions are maintained, avoiding the risk of bacterial contamination, while inhibiting the growth of anaerobic bacteria in food during storage. Thus, such food can be rapidly cooled to around 0-30°C after processing and stored in the refrigerator for an extended period (up to five weeks on average) before being reheated and served [3].

In addition, the SV method promotes the preservation of better texture and colour of food [38]. SV cultivation is suitable for the processing of various vegetable and animal raw materials [22, 37], ultimately offering both ready-to-eat foods (usually after heating) and various intermediates for further use [9, 13, 27].

In the last decade, the SV method has been used primarily for the processing of various vegetables, including legumes, cabbage, carrots and other root vegetables [16, 17, 35], including meat [3, 30, 31, 36] and, to a much lesser extent, fish [8, 10, 11, 14, 25].

The paper aims to determine the impact of the form of raw material (fresh fillets, frozen fillets, frozen cubes) on the size of the "thermal leak" and selected qualitative characteristics of the "sous-vide" (SV) heat-treated cod meat.

MATERIAL AND METHODS

Fresh cod fillets, frozen cod fillets and industrially obtained frozen cod cubes were tested. **Thermal treatment** - the temperature of the heat treatment of fish, set at 60°C, was selected on the basis of literature data [38, 39]. A different treatment time was used, fixed at: 15-, 30-, 46- and 60-min. After packing the fish pieces in vacuum bags (by HENDI), they were placed in a vacuum packing machine (MULTIVAC Sp. z o.o. Poland). The Sous vide GN 1/1 device by HENDI was used to prepare fish meat in the SV technology.

Thermal leakage and weight loss were calculated using the gravimetric method. The weight loss of the meat was calculated according to the formula [18]:

$$\text{Loss of weight (\%)} = 100*[(\text{weight of raw meat} - \text{weight of boiled meat SV})/\text{weight of raw meat}]$$

The hardness was determined on a TA HD Plus Stable Mikrosystems texture analyzer. The results were presented as the value of the maximum force that had to be used to cut the entire sample with dimensions of 20/20/20 mm. A ready-made software application was used, which was designed to test the force necessary to cut the sample. For each sample, at least 10 measurements were made.

The color was determined using the colorimetric method on the COLORFLEX EZ spectrophotometer operating in the LAB system. At least 5 determinations were performed for each sample. In the case of fillets, the color was measured on the superaxial meat flap from the inside. In the case of frozen cubes - after grinding the sample.

The sensory evaluation of selected texture characteristics of the cooked cod meat with the SV method was carried out using the hedonic scale method in the range of 1 to 9. The evaluation was carried out by a 10-person team of experts trained in the given method. The following features were assessed in the study: hardness, stickiness and palpability of fish meat particles.

RESULTS AND DISCUSSION

One of the main disadvantages of the SV method is the appearance of an unwanted „leak" inside the package. As a result of heat treatment, the raw materials change the content of individual nutrients, water loss, and thus the weight of the meat is reduced. The leakage resulting from heat treatment is very diverse and depends on many factors, but also on the type and form of the raw material used (water exuded from the product because of the loss of water retention during the heat treatment) [15].

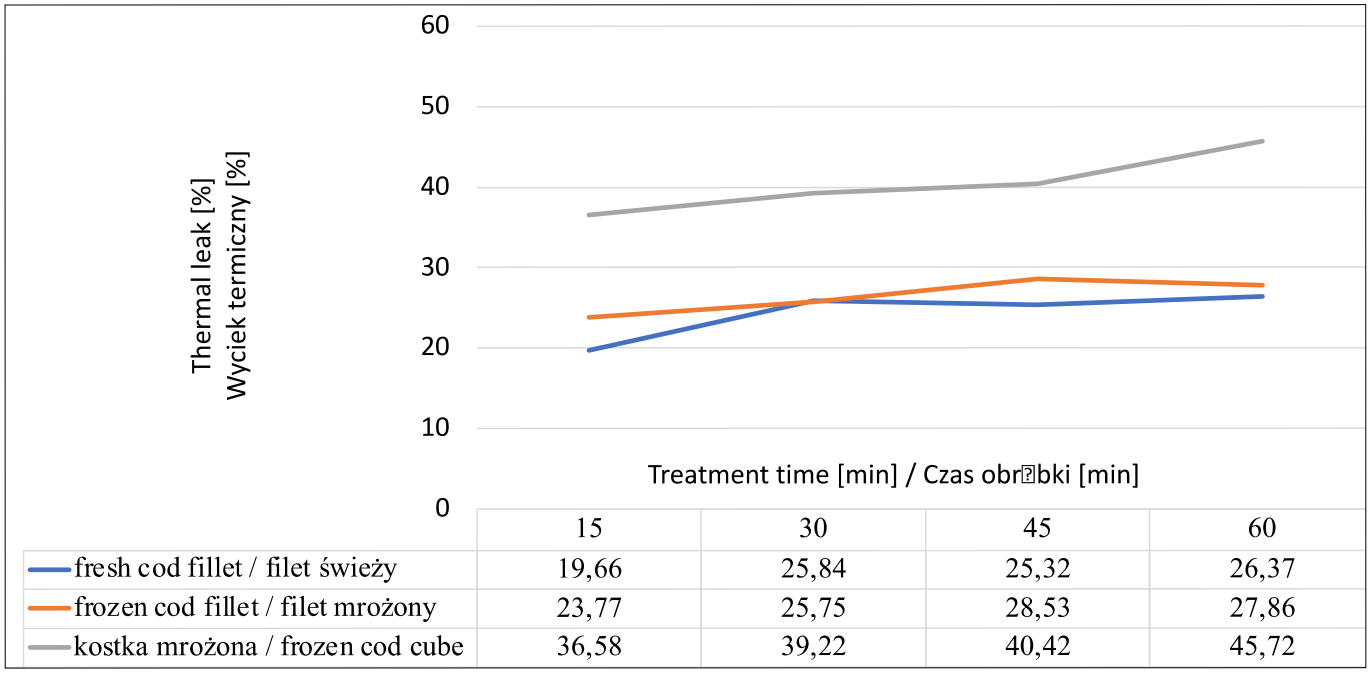
In Figure 1. the amount of thermal leakage resulting from cooking at different times of different forms of cod meat was compared. This leakage ranged from 19.66 to over 45% and depended on both the cooking time and the form of the raw material. For each SV cooking time tested, the leakage from the frozen cube was higher by approx. 20% of the leakage resulting from cooking whole fillets (both fresh and frozen). However, for each form of raw material, the highest leakage was observed after 15 minutes of processing. Extending the processing time resulted in a further increase in thermal leakage, which stabilized after approx. 30–45 min.

Thermal leakage during processing is a reflection of meat mass yield. Therefore, this paper also determined the loss of meat mass and calculated the efficiency of the process (Fig. 2).

Literature data indicate that thermal losses of the raw material mass during traditional cooking can reach up to 35% [34]. It is also indicated that, in the case of SV technology, the use of variable processing temperatures has a greater impact on the amount of meat weight loss than the duration of the process [18, 24].

Thermal leakage during proces sing is a reflection of meat mass yield. Statistical analysis showed that freezing the fish in the form of whole fillets did not significantly affect the weight of meat after cooking, and thus the efficiency of SV treatment. The efficiency of the SV process for whole fish fillets ranged from 72.5 to 75.7% and was approx. 13% higher than in the case of cooking a formed frozen cube, consisting of small pieces of cod (Fig. 2).

The meat of cod cooked by the SV method was subjected to sensory assessment at various times, determining its hardness (consistency) on a 9-point scale (Tab. 1). Irrespective of the form of the raw material, samples cooked for 45 minutes were



	15	30	45	60
fresh cod fillet / filet świeży	19,66	25,84	25,32	26,37
frozen cod fillet / filet mrożony	23,77	25,75	28,53	27,86
kostka mrożona / frozen cod cube	36,58	39,22	40,42	45,72

Fig. 1. Comparison of the amount of thermal leakage from different forms of cod meat during sous-vide cooking at different times.

Rys. 1. Porównanie wielkości wycieku termicznego z różnych form mięsa dorsza podczas obróbki termicznej metodą sous-vide w różnym czasie.

Źródło: Badania własne

Source: The own study

found to be "quite soft" and were comparable in this respect to samples cooked for 60 minutes. On this basis, 45 minutes was considered sufficient processing time for cod meat using the SV method.

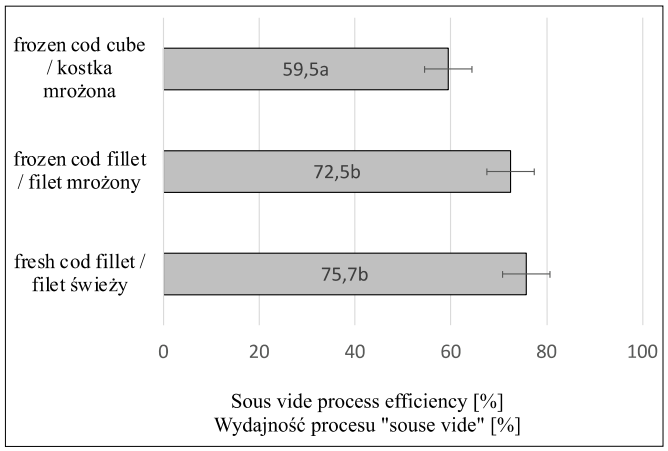


Fig. 2. The efficiency of the SV process of various forms of cod meat.

Rys. 2. Wydajność procesu SV różnych form mięsa dorsza.

Źródło: Badania własne

Source: The own study

In the consumer assessment of food products, an important aspect is the texture of the meat, which changes significantly after heat treatment, as demonstrated by the example of beef [29]. Such "cooking" at low temperatures makes the meat soft and easy to cut [6].

Table 1. The consistency of cod meat assessed by the method of a 9-point hedonic scale depending on the time of SV processing at the temperature of 60°C and the form of the raw material

Tabela 1. Konsystencja mięsa z dorsza oceniana metodą 9-punktowej skali hedonicznej w zależności od czasu obróbki SV w temp. 60°C oraz formy surowca

Treatment time [min] / Czas obróbki [min]	Fresh cod fillet / Filet z dorsza świeży	Frozen cod fillet / Filet z dorsza mrożony	Cube frozen from pieces of cod / Kostka mrożona z kawałków dorsza
15	6,1 ± 1,2	3,8 ± 2,0	4 ± 0,9
30	5,6 ± 0,9	5,4 ± 1,1	5,4 ± 1,2
45	**7,6 ± 1,2**	**6,9 ± 0,9**	**6,0 ± 0,9**
60	7,8 ± 0,8	7,0 ± 1,2	6,2 ± 0,8

Źródło: Badania własne

Source: The own study

Literature data show that the effect of SV cooking parameters on meat textureis inconclusive, as demonstrated with meat from slaughter animals. It is indicated that this is primarily related to the type of meat, differences in muscle cell diameter, thermostability of collagen and its content in the muscle. These differences are the result of, i.a.: the type of meat and muscle, the age of the animal, the maturation time of the meat, storage conditions and a combination of temperature and cooking time [2, 26].

In Table 2, the results of the instrumental measurement determining the hardness of cod meat subjected to 45-minute SV cooking at 60°C. The results are given as the minimum and maximum force necessary to completely cut the samples. There were no significant differences in the hardness of cooked cod meat for all tested forms of raw material.

Analysis of the texture of cod fillets after cooking using the SV method showed that the hardness of cooked meat did not depend on the form of the raw material (fillet /frozen cube) but significantly changed after heat treatment (Tab. 2).

This is also indicated by the literature data. Increasing the heating temperature (also in the SV method) significantly affects the shear strength, elasticity, cohesiveness and chewability of aquatic food products [12]. Also, Cropotova et al. [5] showed, using the example of mackerel, that the hardness of the fillets increased with increasing temperature in the SV method (60–90°C), with the additional use of vacuum favouring the desired hardness in a much shorter time, even at temp. 90°C.

Baldwin [1] explains this fact by the fact that the lysis of the connective tissue of fish meat in the temperature range of 50–70°C leads to the obtaining of soft meat, while the denaturation of myogenic fibrous proteins occurring at higher temperatures leads to the obtaining of hard meat. Colour components were determined in the L*, a*, and b* systems using the colourimetric method. The results are presented in Tab. 3.

One of the important characteristics taken into account by consumers is the colour of fish meat. The brightness (L*) of whole, raw fillets (fresh and frozen) did not differ significantly, but it showed significant variability in relation to the same fillets after cooking (L* parameters higher by approx. 10 units).

Table 2. Results of the instrumental measurement determining the hardness of cod meat after heat treatment with the SV method (60°C and 45 min)

Tabela 2. Wyniki pomiaru instrumentalnego określającego twardość mięsa z dorsza po obróbce termicznej metodą SV (60°C i 45 min)

Forma ryby	Value of the average and maximum force [N] necessary to cut the sample / Wartość średniej i maksymalnej siły [N] niezbędnej do przecięcia próbki	
	X average /średnie	X max.
Raw (fresh fillet) / Surowy (filet świeży)	8,1 ± 0,29a	9,02 ± 1,03A
Fresh fillet after heat treatment / Filet świeży po obróbce termicznej	3,17 ± 0,42b	6,33 ± 0,33B
Fillet frozen after heat treatment / Filet mrożony po obróbce termicznej	3,05 ± 0,99b	6,01 ± 0,45B
Cube frozen after heat treatment / Kostka mrożona po obróbce termicznej	2,95 ± 1,23b	5,93 ± 1,25B

*/ jednakowe oznaczenia literowe przy wartościach w kolumnach świadczą o braku istotnych różnic

the same letter signs next to the values in the columns prove that there are no significant differences

Źródło: Badania własne

Source: The own study

Table 3. Basic components of cod meat color, measured before and after heat treatment

Tabela 3. Podstawowe składowe barwy mięsa dorsza mierzone przed i po obróbce termicznej

Produkt / forma		Color parameters / Parametry barwy		
		L*	a*	b*
Raw cod \ Dorsz surowy	Fresh fillet / Filet świeży	79,6 ± 2,5 (76,10 – 82,62)	5,78 ± 1,10 (3,72 – 7,34)	4,91 ± 0,85 (3,7 – 6,15)
	Frozen fillet / Filet mrożony	79,2 ± 4,0 (73,92 – 85,43)	5,95 ± 0,86 (4,54 – 7,08)	3,65 ± 0,84 (2,74 – 4,96)
	Frozen cube / Kostka mrożona	53,31 ± 3,69 (50,70 - 55,92)	3,7 ± 0,86 (3,09 – 4,31)	10,06 ± 0,83 (6,45 – 14,67)
After heat treatment / Po obróbce termicznej (60°C, 45 min)	Fresh fillet / Filet świeży	89,00 ± 1,3 (87,99 – 91,97)	1,02 ± 0,41 (0,59 – 1,95)	19,06 ± 1,27 (17,27 – 21,45)
	Frozen fillet / Filet mrożony	86,3 ± 3,4 (84,2 - 91,52)	0,32 ± 0,11 (0,13 – 0,48)	20,49 ± 2,08 18,11 – 23,76)
	Frozen cube / Kostka mrożona	59,54 ± 1,64 (58,38 - 60,70)	2,25 ± 0,21 (2,11 – 2,40)	17,08 ± 0,76 (16,54 – 17,62)

Źródło: Badania własne

Source: The own study

The raw frozen cube was much darker than the raw fillets (L* parameter values by approx. 30 units lower in relation to whole fish lobes), was less saturated with red and yellow (lower parameters of the component a*) and more saturated with blue (approx. 2–3 times higher values of the b* parameter). Cod cubes were rated as more „blue" than uncrushed cod fillets.

After cooking SV, the meat of each tested form of fish was brighter (higher values of L* parameters) and was characterized by lower parameters of component a* (lower share of red and yellow) and much higher values of component b* (higher saturation with blue).

The colour of fish muscles is a species trait, conditioned, among others, by the activity of fish, the less active the lifestyle of the fish, the brighter the meat. White fish meat has been proven to be low in fat, a good source of easily digestible protein, minerals (selenium, calcium, phosphorus), vitamins (vitamin A, D, from group B) and n-3 and n-6 acids. Cod belongs to the family of cod, less active, with white, tender meat belonging to lean meat, recommended for use, especially in low-calorie diets [33].

As various authors point out [39], colour is one of the most direct and sensory indicators of food quality. Fish meat is susceptible to discolouration due to various biochemical processes occurring during heat treatment at high temperatures. You can get fish meat with an attractive, lighter colour by using SV cooking at a lower temperature, Cooking SV is an anaerobic treatment, which is also conducive to obtaining a lighter meat colour.

The meat of fish is similar in fibre to that of slaughter animals and poultry but is less hard. The texture of fresh fish depends primarily on the age and species of the animal, the nutritional status and the study of biochemical modifications occurring in the muscles after bleeding or dreaming. Fresh fish meat with low collagen content is less hard compared to collagen-rich fish. However, after heat treatment, fish meat containing more collagen is more juicy and brittle, and fish poor in collagen are more fibrous and dry. A distinction is therefore made between fish with very tender and brittle flesh, e.g. the sturgeon family and the perch family and some flatfish and fish with little brittle flesh, e.g. horse mackerel. The juiciness of cooked, roasted or raw meat depends on its water absorption, which also depends on the protein content [33].

CONCLUSIONS

Based on the results obtained, the following conclusions were drawn:

1. Of the many forms of fish found on the market, the most useful form suitable for heat treatment by the SV method are whole fresh fillets. Frozen fillets are less useful, although the resulting thermal leak is similar to fresh fillets.
2. Frozen fish cubes (obtained before freezing by pressing pieces of fish flesh) are characterised by poor suitability for SV processing, as they promote very high thermal leakage and the sensory quality of the meat is less desirable.
3. Processing fish meat using the SV method at 60°C requires a relatively short time. After 15–30 minutes, a product with a soft consistency can be obtained, and after 45 minutes – a product with a sensory desired consistency.

PODSUMOWANIE

W oparciu o uzyskane wyniki sformułowano następujące wnioski:

1. Spośród wielu form ryb znajdujących się na rynku, najbardziej przydatną formą nadającą się do obróbki termicznej metodą SV są całe filety świeże. Mniej przydatne są filety mrożone, aczkolwiek powstający wyciek termiczny jest podobny jak w przypadku filetów świeżych.
2. Mrożona kostka ryb (otrzymana przed mrożeniem poprzez prasowanie kawałków mięsa ryb) charakteryzuje się słabą przydatnością do obróbki SV, gdyż sprzyja powstawaniu bardzo dużego wycieku termicznego, a sensoryczna jakość mięsa jest mniej pożądana.
3. Obróbka mięsa ryb metodą SV w temp. 60°C wymaga stosunkowo krótkiego czasu. Po 15–30 minutach można uzyskać produkt o miękkiej konsystencji, a po 45 min – produkt o konsystencji pożądanej sensorycznie.

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