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Effect of cooking in the production of Ensis macha pocket clam preserves, natural in relation to its acceptability for the European market

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Summary

The objective of this study was the production of natural pocket clam preserves (*Ensis macha*) in 1/4 club containers for the European market. The product was developed by experimental tests determining the cooking time and temperature, determination of the rate of heat penetration at the coldest point and the F0 value of the packaged product. This product was compared with similar products marketed in Spain in order to establish its sensory characteristics, and microbiological and chemical determinations of both the raw material and the final product were carried out. The recommended cooking time and temperature was 10 minutes at 95°C, with a yield of 47.23%. The F0 value found was 10.48 minutes with an effective heat treatment time of 40 minutes of process at 116.49°C. The chemical composition of the final product was 62.8% moisture, 23.2% crude protein, 2.7% fat, 3.2% minerals, and 8.1% carbohydrates. Microbiological tests yielded negative results for the presence of *Clostridium botulinun*, as well as negative mesophilic and aerobic and anaerobic thermophilic loading, demonstrating that the product is commercially sterile, safe and suitable for human consumption.

Key words: Ensis macha, razor clam, natural, preserves, heat treatment and physical-sensory evaluation.

Practical application:

The cooking and sterilization parameters could improve the acceptability of razor clam preserves (*Ensis macha*) for the European market.

Introduction

It is known that the production of canned fish in Peru is mainly destined for the domestic market due to its high demand, and a small fraction for export to Europe and the United States. However, it is very exceptional to find other types of canned products that are not fish, such as molluscs and crustaceans. Only a few small companies located in the geographical area of southern Peru, such as Pisco, carry out the production of these novel products. It was precisely when we were looking for new products and expanding the national offer that the idea of making razor clam preserves (*Ensis macha)* was born, with the vision of expanding our market with a range of products with increasing added value.

As the export statistics in the ADEX Data Trade (2022) show, Peruvian exports of razor clam (*Ensis macha*) have been declining for more than 10 years. This is due to the fact that in previous years most of the bivalve molluscs were exported fresh and with a high bacterial load. This led to the restriction of exports of these resources to the European market in 2008, with the exception of bivalves that came from aquaculture. So, at present, the only way to be able to export razor clam shell to the European Union is if it has some heat treatment that ensures its microbiological quality, as could be the case of the canned presentation, which corresponds to the most requested form in the market.

In view of the fact that the volumes of razor shell extraction have decreased significantly in recent years, due to the low domestic demand and the restrictions on exports due to sanitary issues, this has caused the natural banks to remain almost intact. Therefore, the challenge was to create a product that could satisfy the palate of customers according to the sensory standards of the international market.

To achieve this, plant tests and laboratory tests were carried out, where certain parameters were determined, such as cooking time and temperature, study and determination of the F0 necessary to ensure the death of the *Clostridium botulinum* spore, microbiological determination of commercial sterility, and sensory comparisons with commercial products, achieving a razor clam preserve (*Ensis macha*) in optimal conditions for the European market, packaged using the cooking exudate in 1/4 club tin containers as a governing liquid, in accordance with the parameters required for export to the European Union, as well as the performance parameters in the different unit operations of the process.

Materials and methods:

Place of execution

The experimental part of the process was carried out at the Center for Technological Innovation – CITE Pesquero of the Technological Institute of Production, located on the road to Ventanilla KM. 5.2 Ventanilla – Callao. The determination of heat treatment time, proximal analysis and commercial sterility were carried out at the Technological Institute of Production. Chemical and microbiological analyses were performed in the respective laboratories of the Faculty of Fisheries of the National Agrarian University La Molina.

Raw material

To carry out the experimental test of canned food production, the raw material was acquired at the DPA (Artisanal Fishing Landing) of Pisco, in the geographical area of Morro Quemado. These were packed in technopor boxes with ice to maintain the cold chain (≤3°C), and thus ensure their freshness. Finally, they were sent in an exclusive transport service to the respective laboratories and processing plant.

Materials and equipment used

Equipment: HERMASA horizontal steam autoclave (maximum working pressure of 3 bar, maximum working temperature 143 °C, capacity 7,200 cans of 1/2 lb prickly pear), OHAUS bench scale (capacity: 1.5 kg, accuracy: 0.01 g), SCALTEC bench scale (capacity 16 kg, accuracy 1 g), 3-burner industrial gas cooker, JK SOMME brand can seamer (capacity 120 cans/min), MaquiProcesos brand evacuator (Temperature 98 – 100°C, power 1.5 HP, speed 1-6 m/min, capacity 0.2m/sec), Traceable digital thermometer (range -50 to +300 °C).

Materials: high-density polyethylene bags, size 46x76 cm, stainless steel trays. 53x32.5x2.5 cm /32.5x26.5x2.5cm, stainless steel strainerø 26 cm, 1/4 club tin containers (104 x 60 x 27 mm), 7 L stainless steel pot, 10 ml graduated pipette, 30 cm stainless steel pan, stainless steel utensils (spoon, slotted spatula, tasting spoon), beaker400 ml.

Experimental scheme

Determination of the cooking time of the raw material

Three cooking times (3, 6, 10 and 15min) were evaluated at 95°C. Each evaluation was carried out in triplicate and the cooking time with the highest yield and less exudate was chosen. Razor clam samples were cooked with hot water at a temperature of 95°C. According to NTP 204.001:2019, the main purpose of pre-cooking is to extract liquid parts of the raw material in order to facilitate its subsequent processing. In the present case, in the production of razor clam preserves, pre-cooking facilitated the arrangement of the meat during packaging, in addition to this, the yields after cooking were taken into account, whose parameter was decisive for the choice of cooking time.

Determination of the Fo value and optimal treatment time.

We proceeded to fill 1⁄4 club containers with an easy-open lid (105x65x25 mm), with the knives cooked and cleaned, placing 95 g. per container. Two digital thermocouples were then placed in each preserve, introduced into the muscle of the canning. Finally, the liquid government was added, which consisted of the exudate itself from the firing of the razor clams. The preserves were placed in a metal basket and placed in the autoclave. The experimental sterilization process was programmed at 116.49°C for 60 minutes. At the end of sterilization, the preserves were cooled for 10 minutes. The thermocouples were then removed in order to obtain the information from the readings on a computer, and thus find the Fo and the optimal sterilization time. The data were recorded in an MPIII temperature data logger, with wireless sensors 18 mm wide by 23 mm long, weighing 15 g and made of stainless steel (Data Tracer, 2023)

Sensory analysis and acceptance of canned food in the European market.

Natural pocket clams of the most representative brands of that country were imported from Spain: Conservas Cuca and Portomar. These were analysed and compared with those obtained in the test test of this work, in order to observe if they resembled those currently found in the European market.

The content of the preserves was given to a tasting panel made up of people knowledgeable about the product in question. Observations about color, smell, texture, and taste were scored. These observations were then compared with those obtained in the preserves produced in the trial.

Conservas Cuca is one of the oldest products in Spain with more than 70 years, these are produced in Pontevedra (Galicia), Spain, in packaging commonly called dingley; very similar to the 1/4 club used in Peru, with an easy open lid. When opened, a liquid characteristic of natural preserves was found, finding 6 large cooked razor clams, 3 of which presented a green pigmentation due to the phytoplankton of the visceral area.

The Portomar brand preserves in their natural state, very similar to the national product tested, are made in Vigo (Galicia), Spain. The type of container it uses is commonly referred to as 1⁄4

oval, very similar to 1/4 club in terms of its capacity (ml). When he opened it, he found a liquid government characteristic of natural preserves. After removing the razor blades from the container, 8 knives were counted, which also observed a greenish coloration like the previous ones studied.

The comparative technical characteristics of the Spanish preserves Cuca and Portomar can be seen in Table 1, which served as references for the development of the national razor clam preserves, are shown below.

Item	CUCA	FOR TAKING
Country	Spain	Spain
Packing	colored cardboard	colored cardboard
Packaging type	dingley	¼ Oval
Labeled or lithographed container	Yeah	Yeah
Origin	Pontevedra, Spain	Vigo, Spain
liquid government	Water and salt	Water and salt
Net weight (g)	120	111
Drained weight (g)	65	63
Capacity (ml)	125	120
Number of knives	6	8

Own elaboration.

Analytical Methods of Evaluation

a. Sensory Evaluation:

The raw material was sensory evaluated according to the provisions of SANIPES (2016) in the manual of indicators or criteria of food safety and hygiene for food and feed of fishery and aquaculture origin. The evaluation of razor clam preserves was based on the indications of INACAL (2016) and SANIPES (2016) for hydrobiological food preserves.

b. **Chemical Evaluation:**

Proximal chemical composition analyses (moisture, ash, fat and protein) were carried out, both of raw material and final product, according to the methods of FAO (1986) and ITP (2009).

c. **Microbiological Evaluation:**

The analyses were carried out according to MINSA (2008) and the recommendations of SANIPES (2016), in its item for hydrobiological products such as canned foods, where it indicates: numbering of mesophilic aerobes, *Sthaphyloccus aureus, Escherichia coli* and *Salmonella spp*.

Results and Discussion:

Raw Material

Sensory analysis:

The captured specimens of razor clam were alive, with absence of dirt or mechanical damage, free of foreign matter, with the smell of seaweed, presence of intervalvar liquid and with a positive reaction to percussion. Therefore, as recommended by SANIPES (2016) the raw material was of very good quality.

Chemical analysis:

The results of the chemical analyses can be seen in Table 2, which show values very similar to those of other similar bivalve molluscs reported by INS (2009), for fresh products for human consumption.

2.6 ± 0.03

Item	Content (%)
Humidity	78,5 ± 0,02
Protein	16,5 ± 0,04
Fat	1,1±0,01
Minerals	1,3 ± 0,01
Carbohydrates	2,6 ± 0,03

Microbiological analyses:

The results of the microbiological analyses of the raw material can be seen in Table 3. These indicate that the limits established according to the microbiological indicators for fishery and aquaculture products of SANIPES (2016) were complied with.

Absence

Analysis	Result
Numbering of mesophilic aerobes	1.8 x 10^3 ufc/g
Staphyloccus aureus numbering	< 10^2 ufc/g
Escherichia coli numbering	0 NMP/g
Item	CUCA

Process

The flow of operations was performed according to Figure 1, in order to determine the value of the Fo and the optimal cooking time. Approximately 50% of the yield was lost in the dehulling and cooking stages, as well as an additional 7% in sterilization. However, an increase in yield was observed when the razor clam shells were washed, and the government liquid was added.

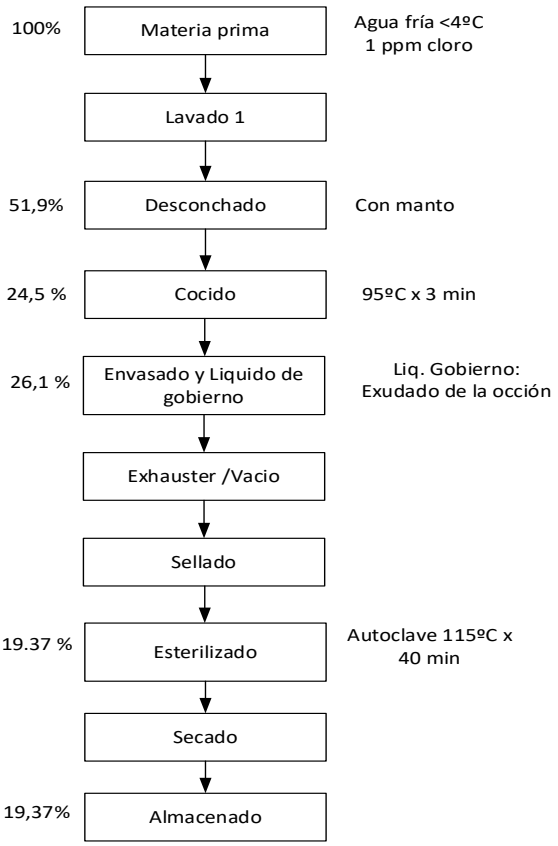

Figure 1: Processing Flow of Pocket Knife Preserves. In original Spanish language

From the final product:
Sensory analysis:

Cooked and canned specimens of razor clam (*Ensis macha*) had a good general appearance, with no foreign matter, odor and taste typical of the packaged product, and no green coloration in the muscle. According to SANIPES (2016), the final product was of good sensory quality and suitable for human consumption.

Chemical Composition:

The results of the proximal chemical composition of the packaged product can be seen in Table 4. The results indicate a chemical composition similar to that of other similar canned mollusc products, where the moisture content was 62.8% lower than the raw material due to cooking; an increase in protein content to 23.2% due to decreased moisture, as well as fat, minerals and carbohydrates to 2.7%; 3.2%; and 8.1% respectively.

8.1 ± 0.05

TO TAKE	Country
Spain	Spain
Packaging	Colored cardboard
Colored cardboard	Packaging Type
Dingley	1/4 Oval
Labeled or lithographed packaging	Yes

Microbiological analysis:

The results of the microbiological analyses of the final product, regarding the content of Aerobes Mesophiles, Escherichia coli, Staphylococcus aureus, and Salmonella sp., yielded negative results. This means the influence of heat treatment and firing on the final product.

Determination of the cooking time of the raw material

The razor knife samples were cooked at a temperature of 95-100°C for 3, 6 and 10 minutes, following the recommendations of NTP 204.001:2019, which indicates that the main purpose of pre-firing is to extract liquid parts of the raw material in order to facilitate its subsequent processing. In the present case, in the production of razor clam preserves, pre-cooking facilitated the arrangement of the meat during packaging, in addition to this, the yields after cooking were taken into account, whose parameter was the decisive one for the choice of cooking time. Each evaluation was carried out in triplicate and the cooking time with the highest yield and less exudate was chosen. When it comes to When the muscle was cooked with the mantle in drinking water at 95°C for 3 minutes, a muscle with a higher yield of 47.23% was observed.

Table 5 shows that in the first 3 minutes of cooking, razor clam shells had a yield of 47.23%, however, after the next 3 minutes this yield decreased by only 4.33%; and as the cooking time increased, the yield indices continued to decrease to 2.27 and 2.78% as a result of the small loss of water and solids. This decreasing performance behavior may have been due to the fact that when the razor clam meat was in contact with hot water, the muscle quickly released a large amount of water and soluble components due to the coagulation of the protein (Maza, 2010), subsequently decreasing the rate of loss of these components as all the muscle protein was already denatured. . In addition, an increase in muscle consistency was observed as a result of muscle shrinkage due to heat (Watabe, 2020).

2,78(min)

Yes (min)	**Origin**	**Pontevedra, Spain**
Vigo, Spain	Liquid government	Water & Salt
Water & Salt	Net Weight (g)	120
111	Drained Weight (g)	65
63	Capacity (ml)	125
120	Number of knives	6

According to what was studied in the experiments in order to condition the razor muscle, it was recommended to cook for 10 minutes at 95°C with hot water, which allowed a 47.23% yield as a reasonable parameter for the process of making preserves.

Determination of the Fo value and optimal heat treatment time.

The Fo value determination test was performed in a vertical autoclave, which was programmed at a temperature of 116.49°C for a time of 60 minutes. Table 6 and Figure 2 show the temperature variation data of the two thermocouples (MT1 and MT2) placed in 2 samples of razor clam preserves, and of the retort (RT) used during heat treatment.

Figure 2 shows the temperature distribution of the two thermocouples placed in the respective containers. From these results, it was observed that the working temperature of 116.49°C was reached in the first 20 minutes of the process, this value being considered the heating time of the autoclave, or CUT (Come Up Time), according to Ball, 2023. The rate of heat penetration in the tested containers was very similar, although we could say that the MT1 thermocouple was slightly slower than the MT2, but without being conclusive in this aspect. However, when analysing the development of the Fo value, it was found that MT1 was actually the slowest warm-up. Therefore,

it could be taken as the point of slowest heat penetration for the purposes of heat treatment calculation.

72.21

8	**TEMPERATURE (°C)**		
Min	**MT_1**	**MT_2**	**RT**
0	23.50	23.43	24.18
5	24.52	24.37	38.88
10	29.45	28.58	69.52
15	Item	Content (%)	Humidity
78.5 ± 0.02	Protein	16.5 ± 0.04	Grease
1.1±0.01	Minerals	1.3 ± 0.01	Carbohydrates
2.6 ± 0.03	114.01	114.63	116.47
35	115.26	115.51	Analysis
Result	Numbering of mesophilic aerobes	1.8 x 103 cfu/g	Numbering of Staphyloccus aureus
< 102 cfu/g	Numbering of Escherichia coli	0 MPN/g	Numbering of Salmonella sp.
Absence	116.08	116.15	116.66
49	116.43	116.45	116.66
50	116.46	116.48	116.41
55	116.56	116.57	Component
Result (%)	Humidity	62.8 ± 0.04	Protein
23.2 ± 0.03	Grease	2.7 ± 0.05	Minerals
3.2 ± 0.02	Carbohydrates	8.1 ± 0.05	116.59
59	116.45	116.39	116.74
60	116.27	116.17	116.18
65	Time	Yield of treated squid chunks (%)	Speed of weight loss (%)
0	100	0	3
47.23±0.57	-	6	42.90±1.05
4,33	10	40.63±0.96	2,27
15	37.85±1.58	2,78	99.25
86	95.92	93.28	99.13
87	92.61	TIME	TEMPERATURE (°C)

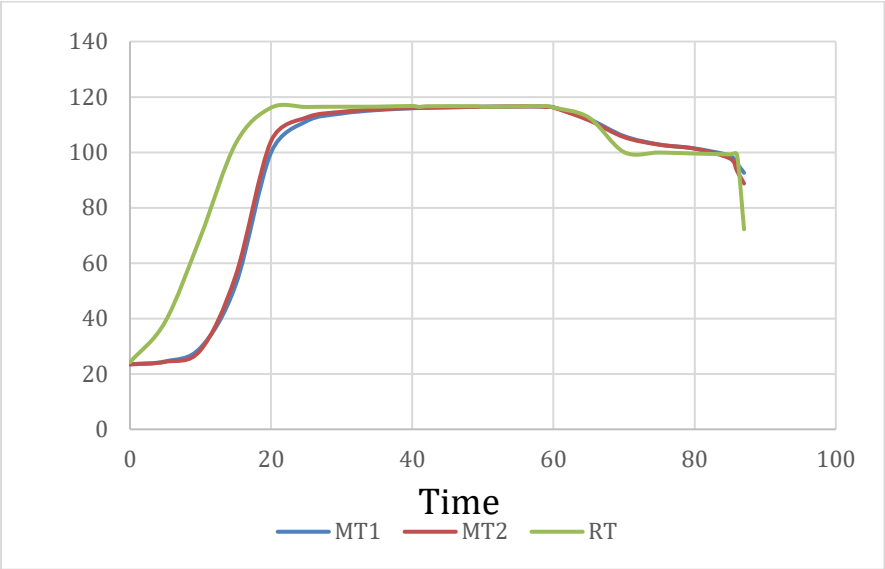

Figure 2: Evolution of Temperature in Natural Razor Clam Preserves during Heat Penetration Tests.

On the other hand, Table 7 presents the values of the lethality calculated from the values of the temperatures recorded according to Table 6; and in Figure 3, we can see the lethality curve of the process that began at 20 minutes with the autoclave heating period. I continue with the lethal process period for 40 minutes until the 60th minute, then proceed with the cooling period for 10 minutes, until the 70th minute.

0.00

Min	**MT1**	
MT2	**RT**	**0**
23.50	23.43	24.18
5	24.52	24.37
38.88	10	29.45
28.58	69.52	15
52.31	55.62	103.28
20	100.00	104.11
116.13	25	111.22
112.58	116.39	30
114.01	114.63	116.47
35	115.26	115.51
116.50	40	115.92
116.02	116.75	41
116.01	116.08	116.37
42	116.08	116.15
116.66	49	116.43
116.45	116.66	50
116.46	116.48	116.41
55	116.56	116.57
116.62	56	116.58
116.59	116.63	57
116.58	116.59	116.76

58	116.55	116.53
116.59	59	116.45
116.39	116.74	60
116.27	116.17	116.18
65	112.08	111.58

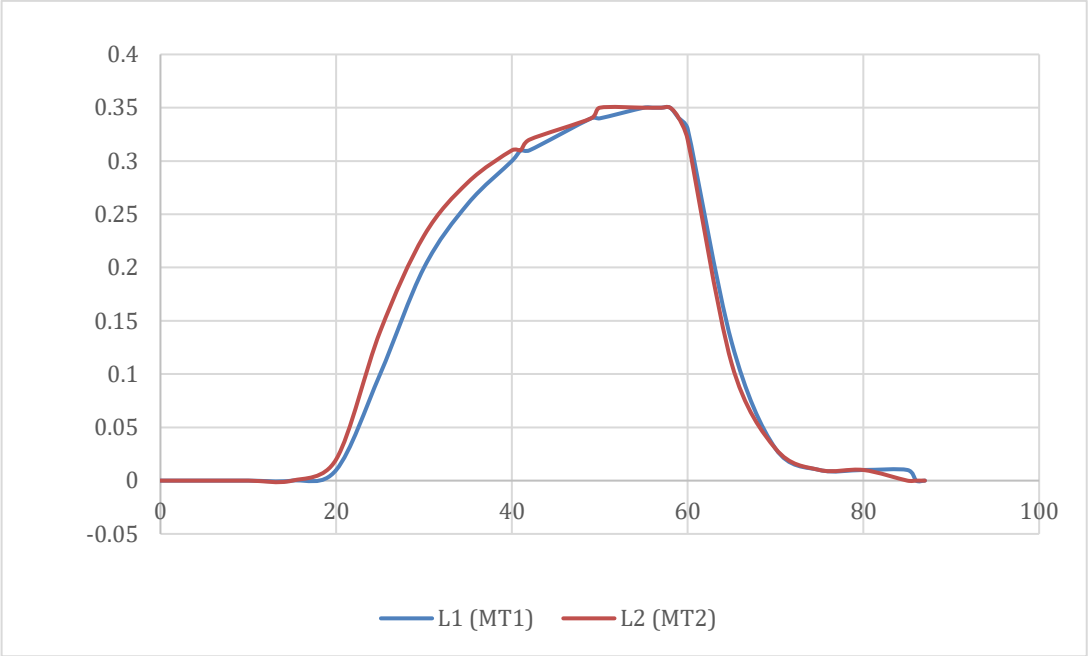

Figure 3: Calculated Lethality Curve for Natural Razor Clam Preserves.

Table 8 and Figure 4 show the variation of the Fo value in both thermocouples tested. As can be seen, the MT2 thermocouple presented the highest Fo value of 12.51 minutes; while the MT1 of 12.08 minutes. This meant that the MT1 thermocouple was the one with the slowest heating compared to the coldest point of the containers after 87 minutes of process. Therefore, the values obtained for both thermocouples could ensure lethal treatment for the product under investigation. However, in the canning industry and food technology, the main goal of the thermal process is the removal of the *Clostridium botulinum spore*, which is highly resistant to heat and capable of producing the botulinum toxin that is deadly to humans. Therefore, the value of F0 was chosen for the heat treatment tested to be that of the MT1 thermocouple (F01), for the preservation of razor clams.

12.51

112.60	**70**	
105.86	**105.49**	**100.09**
75	102.84	102.74
99.94	80	101.41
101.34	99.58	85
98.79	97.77	99.25
86	95.92	93.28
99.13	87	92.61
88.75	72.21	1.46
35	2.29	2.75
40	3.73	TIME

LETHALITY	Min	L1 (MT1)
L2 (MT2)	0	0.00
0.00	5	0.00
0.00	10	0.00
0.00	15	0.00
0.00	20	0.01
0.02	25	0.10
0.14	30	0.20
0.23	35	0.26
0.28	40	0.30
0.31	41	0.31
0.31	42	0.31
0.32	49	0.34
0.34	50	0.34
0.35	55	0.35
0.35	56	0.35
0.35	57	0.35

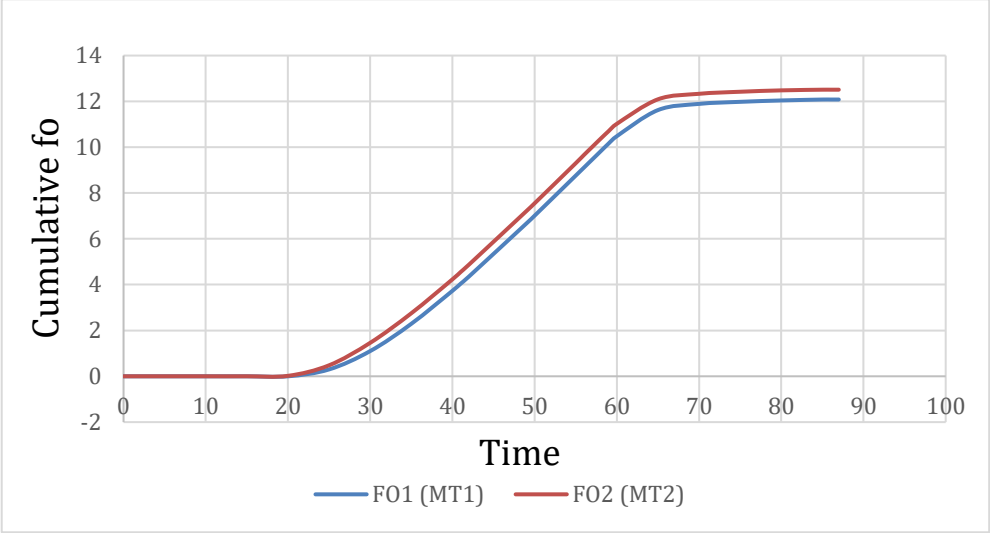

Figure 4: Cumulative Fo curve (min) for natural razor clam preserves.

Figure 5 shows the summary of the temperature and Fo values obtained in the autoclave for the thermocouples tested. Taking into account the slowest warm-up point (MT1), the value of Fo1 according to the programming he gave to the autoclave was 10.48 minutes in 60 minutes, and 7.01 minutes in 50 minutes; which correspond to 40 and 30 minutes of the process, discounting the heating period of the autoclave (CUT) which was 20 minutes.

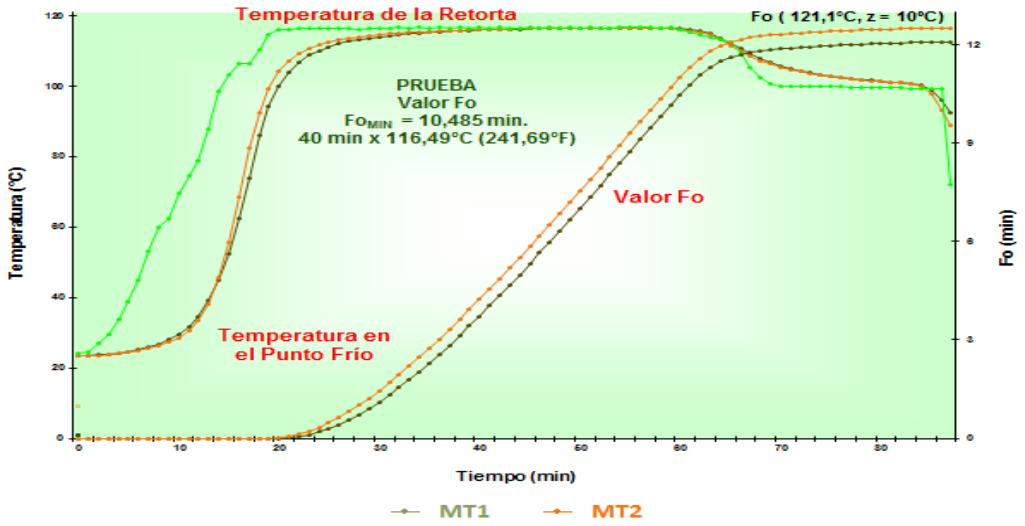

Figure 5: Heat penetration curve in natural razor clam preserves in 1/4 club containers. In original Spanish language

Taking this into account, it was recommended that the Fo value be 10.48 minutes, which meant 40 minutes at 116.49°C, enough to ensure the safety of the product. To which should be added, the 20 minutes of autoclave heating and 10 minutes of cooling found. The times and temperatures of the process did not alter the texture, color and flavor conditions of the final product.

Commercial sterility

The results reported show no growth of aerobic (mesophilic) and anaerobic (thermophilic) microorganisms, complying with the microbiological requirements mentioned in the Manual of Sanitary and Safety Indicators for Fishery and Aquaculture Products for the National and Export Market in its item VII Sanitary and safety indicators for food of fishery and aquaculture origin for direct human consumption. Therefore, the product was termed commercially sterile.

Sensory comparison of natural razor clam preserves.

Finally, the preserves of Spanish origin were compared with the preserves produced in this experiment indicated as PRB. HAYDUK. Differences were found mainly in terms of color and texture, as shown in Table 9.

Table 9: Results of sensory surveys of Spanish preserves and canned food tested. In original Spanish language

ENCUESTADOS	1			2			3			4		
CONSERVA	CUCA	PORTOMAR	PRB. HAYDUK	CUCA	PORTOMAR	PRB. HAYDUK	CUCA	PORTOMAR	PRB. HAYDUK	CUCA	PORTOMAR	PRB. HAYDUK
TEXTURA												
Gusta Mucho	X									X		X
Gusta Poco		X		X	X	X	X		X		X	
Indiferente			X									
Desagrada Poco								X				
Desagrada Mucho												
OLOR												
Gusta Mucho	X											
Gusta Poco		X	X	X			X	X	X	X		
Indiferente					X	X					X	X
Desagrada Poco												
Desagrada Mucho												
COLOR												
Gusta Mucho												
Gusta Poco						X			X	X		X
Indiferente			X				X					
Desagrada Poco	X			X	X			X			X	
Desagrada Mucho		X										
SABOR												
Gusta Mucho	X									X		
Gusta Poco		X	X	X	X	X	X	X			X	
Indiferente									X			X
Desagrada Poco												
Desagrada Mucho												

finished products did not show greenish coloration. Regarding taste, all of them were pleasant for the respondents. In terms of texture, respondents found the Spanish razor clams softer than the tested ones, which was not a determining factor of preference since there were some panelists who preferred firmer textures. Finally, the size of the razor clams of the Spanish preserves was more appealing, although it obviously contained less product.

4. CONCLUSIONS

1. The heat treatment time obtained for razor clam preserves (*Ensis macha*), with an established programming of 116.49°C, was 40 minutes, with a Fo = 10.485 minutes; which allowed to obtain a commercially sterile and safe final product for human consumption.
2. In order to condition the razor muscle in the containers, it was recommended to cook for 10 minutes at 95°C in hot water; This allowed us to obtain a cooking yield of 47.23%, which was an acceptable parameter for the process of making natural razor clam preserves.
3. The chemical composition of the final product was 62.8% moisture, 23.2% crude protein, 2.7% fat, 3.2% minerals, and 8.1% carbohydrates. Microbiological tests yielded negative results for the presence of *Clostridium botulinun*, as well as negative mesophilic and aerobic thermophilic and anaerobic load, demonstrating that the product is commercially sterile, safe and suitable for human consumption.
4. The recommended processing flow for the production of natural razor clam preserves was as follows: reception, washing with cold water (4°C and 1 ppm chlorine), manual chipping, cooking for 10 minutes in 95°C in hot water, packed in 1/4 club cans using the cooking exudate as a governing liquid, evacuated at 95°C with steam, sealing, heat treatment at 116.49°C for 40 minutes, drying of containers, and storage to the environment. Raw material yield was 26.1%

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