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Formulation, consumer acceptability and commercial stability of pickled canned trout (*Oncorhynchus mykiss*)

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Canning and acidification are preservation methods for perishable foods such as hydrobiological foods. The goal of this study was to determine the optimal pickled formulation of canned rainbow trout (*Oncorhynchus mykiss*) for overall acceptability by people and for the stability of the canned product while in storage. First phase, seven canned recipes with different proportions of trout filet (20 to 50%), vegetables (carrot, cauliflower, onion, green beans and peas) and covering liquid (vinegar, vegetable oil, common salt, cumin and pepper) for a total of 225 g were studied. Preservation with acetic acid (pH = 3.5 ± 0.05) and sterilization at 125 °C for 7 min were both used to stabilize the preserves. Recipe three of canned trout (35% trout filet; 35% vegetables; and 22% covering liquid and 8% free space) had the highest value from the sensory analysis by twelve trained panelists with 26.3 ± 1.63 points out of a total of 30 points. Recipe seven was the least accepted with 21.0 ± 1.41 ($p < 0.001$). In the second phase, in addition to sensory analysis, the critical quality and stability parameters were pH, histamine content and absence of microorganisms at 180 and 700 days of storage. Formula 3, was named S-Trubeche and was accepted by both women (88) and men (115) consumers (24.8 ± 1.85 vs. 24.7 ± 1.68; $p < 0.495$, respectively). Regarding the commercial stability of the canned product, a pH of 3.9 ± 0.17 was obtained after processing, increasing to 4.8 ± 0.12 at 180 days and 4.9 ± 0.15 at 700 days ($p < 0.001$). In general, the histamine content was less than 60 ppm and no mesophilic or thermophilic microorganisms were detected (commercial sterility, 0/9). According to the sensory analysis, quality parameters and stability over prolonged storage, we conclude that the best canned trout is recipe three with an equal proportion of trout filet and vegetables (35%) and with 22% of covering liquid.

KEYWORDS

histamine, microorganisms, Peruvian food, pH, stability, trout pickles

Highlights

- First report of pickled Peruvian food, nutritious and healthy for human nutrition of all ages.
- The preserve has an adequate proportion of nutrients of animal and vegetable origin.
- Canned pickled trout preserves its nutritional characteristics for a long time.
- A novel product with potential for commercial development in the national and international markets.

Introduction

Fish, shellfish and similar food items have become an indispensable part of the human diet. Consumption has increased due to the nutritional and health benefits for consumers (Thilsted et al., 2016). Freshwater farmed rainbow trout (*Oncorhynchus mykiss*) is available in many regions, and due to its nutritional composition, sensory characteristics and easy quality control, it is a suitable product for conversion to large-scale processing (Surówka et al., 2021). Trout production in Lake Titicaca (Peru) exceeded 22,486 tn in 2023 and is considered to have the highest trout production in Peru (PRODUCE, 2024). Fish meat is highly perishable, but there are different types of preservation methods, such as refrigeration, freezing, smoking, drying, brining, fermentation and canning (Cedola et al., 2017). Canned fish currently has strong production growth and sales due to a long shelf life, an abundance of nutrients and portability (Zhao et al., 2021).

The canning process makes food available and edible long after processing (Ogbulie et al., 2014). Canned foods processed in metal containers remain stable for long periods at room temperature with excellent protection against microbiological and chemical contamination, ensuring the safety and quality of the packaged food (Lestido-Cardama et al., 2021). The shelf life of the product is extended by thermal sterilization and inactivation of microorganisms and enzymes (Rodrigo et al., 2016; Nketia et al., 2020). In prepared foods, the ingredients provide the flavor and nutritional properties of the food, so it is necessary to retain all the characteristics of fresh colors and flavors during processing (Featherstone, 2015). In addition, canned foods with natural additives are gaining importance over chemical and synthetic additives due to consumer awareness, concern and preference (Samanta and Choudhary, 2019).

Most of the canned foods currently sold contain fish filet without additional ingredients. We believe that Peruvian gastronomy, so varied and delicious (Matta, 2014) and it continues to expand, winning over consumers all over the world. For this reason, Peruvians must continue to work on the links in the production chain, in order to achieve continuous improvement (Aguirre-Sosa et al., 2023). In this case, could have an opportunity to develop a canned food that includes trout filet, vegetables and condiments. Trout filet is highly nutritious due to the amount of essential amino acids, omega-3 fatty acids and high digestibility in consumers (Rebolé et al., 2015).

The food called escabeche is a prepared food where the ingredients are cooked and then vinegar and spices are added to give stability and flavor to the food (Nadeau, 2020). Studies on the evaluation of the quality and stability characteristics of these prepared pickled foods are limited (Melih Secer et al., 2020). Therefore, the evaluation of quality changes and shelf-life prediction of these prepared foods is very important (Li et al., 2019).

Portable canned foods are very practical for occasions where fresh food is no available, such as field trips for work, picnics, and other activities far from an urban area. In addition, canning could contribute to sustainable production, job creation, and food security in the region (Bell et al., 2019). The aim of the research was to determine the optimal formulation of a pickled trout preserve through a sensory test by trained panelists, followed by sensory acceptance by local consumers, and the stability of the preserve over prolonged storage.

Materials and methods

Experimental site

Trout of the commercial line (Troutlodge®, USA) were produced in the aquaculture concession of the Chucuito Research and Production Center of the National University of the Altiplano de Puno. The canned fish were processed in the hydrobiological processing plant of the Special Binational Lake Titicaca Project (PEBLT), located in the Barco area of Chucuito Bay, between the coordinates 15°52′32.7”S 69°53′48.8” W.

Processing of the canned products

Before the dressing process, the whole trout were received and then the body weight (balance Kern® Alemania 5,000 ± 0.1 g) and total length in centimeters (Ichthyometer, Aquatic Eco-Systems®) were recorded. With the data on body weight (BW) and total length (TL), the body condition index (BCI) of the trout was determined using the following formula (BCI = (BW, g / TL^3, cm) * 100).

From the moment the trout were harvested until they were processed about 4 h elapsed, during which time they were kept at about 4 °C with the aid of crushed ice.

While for canning, the whole trout were washed, gutted, fileted and deboned (Table 1). The filets were treated by immersion in 5% brine for 5 min and cut into 5 to 7 cm pieces at a temperature of 4.0 ± 0.65 °C. Using an Alexander Mobba-Excell® SI-130 digital balance (0–2,500 ± 0.5 g), the filet was weighed and placed in the peripheral zone, forming a ring inside the 223 g capacity can (Figure 1).

The vegetables used for canning were onion (*Allium cepa*), cauliflower (*Brassica oleracea* L.), carrot (*Daucus carota*), bean (*Phaseolus vulgaris* L.), and pea (*Pisum sativum*). The vegetables were washed, disinfected and cut into rectangular shapes approximately 4 cm long and 1 cm wide and placed in the middle of the container. Finally, covering liquid containing cumin (*Cuminum cyminum* L.) and pepper (*Piper nigrum*), vegetable oil, sodium chloride, red wine vinegar (Venturo®) with pH 3.5 ± 0.05 was added, leaving a free space of 8% to complete the canning process (Figure 2). The seven recipes are shown in Table 2.

To determine the optimal sterilization process, previous tests were carried out with temperatures between 100 °C and 120 °C and when the time was longer than 20 min, it was observed that vegetable ingredients such as onion and cauliflower lost their natural physical structure. Therefore, the process included preheating-exhausting at 90 °C for 2 min to eliminate oxygen, followed by automatic sealing of the can and sterilization in an autoclave at 125 °C and 25 PSI pressure for 7 min. The cans were cooled in a 100 L capacity stainless steel tank. Then the cans were washed, dried, labeled and stored for sensory evaluation and analysis of autolytic changes in the canned trout product.

The development of the canned product consisted of two phases. First, seven canned product recipes were developed with different proportions of solids and control covering liquid (Table 2). The different experimental formulations (EF) were developed to offer tasters different possibilities to determine consumer acceptability. Thus, the proportion of trout filet and vegetables was similar from EF-1 to EF-5 and different

TABLE 1 Production parameters of trout for the formulation of pickled preserves.

Variable	Formulation of experimental preserves[1]	SD[2]	Preserve S-Trubeche prototype[1]	SD
Body weight, g	505.2	±164.51	842.0	±184.57
Total length, cm	34.2	±2.62	39.8	±2.95
Body Condition Index	1.2	±0.14	1.3	±0.12
Carcass weight, g	436.3	±136.74	751.3	±166.86
Carcass yield, %	86.7	±1.98	89.2	±2.61
Head plus backbone weight, g	101.7	±24.23	152.5	±34.44
Filet yield, %	64.8	±1.59	65.0	±5.01
Filet trimmings, %	9.5	±0.88	10.7	±1.44

[1]n = 30.
[2]Standard deviation.

FIGURE 1
Location of the ring-shaped trout filet inside the can.

FIGURE 2
Presentation of the vegetables and the governing liquid inside the can.

in EF-6 and EF-7. On the other hand, in the governing liquid of the first formulas, the vinegar and oil contents were increasing, while the proportions of common salt and spices were decreasing. Second, after sensory testing of the seven formulas, the canned product with the highest acceptance by the trained panelists was then canned at a larger scale (S-Trubeche) for further study.

Sensory evaluation

The first sensory evaluation was of the 7 formulas canned and stored at 12 °C for 30 days. This time is necessary to allow the vinegar, vegetables and spices to mature in the canned product. The sensory test included the evaluation of 6 variables (aroma, color, general appearance, taste and texture of trout filet and vegetables), based on a traditional five-point hedonic scale (1 = very bad, 2 = bad, 3 = neither bad nor good, 4 = good and 5 = very good) for each parameter (Borg et al., 2017). The panel was made up of 12 panelists that included university professors and researchers with an age range of 45 to 70 years old, people of both sexes were considered and their level of education was a master's degree and a doctorate.

First the panelists received the record of the evaluation test and then the samples were randomly distributed to the panelists in white polystyrene plates with seven codes (EF-1, EF-2, EF-3, EF-4, EF-5, EF-6 and EF-7). Between samples, panelists were provided water to reduce interference from one sample to another. This sensory test was carried out in a single event and a total of score of 24 points was considered the threshold for acceptance of the canned trout pickled product.

The most widely accepted formula (S-Trubeche) was then mass-produced (Figure 3) for the second sensory evaluation with 203 local consumers and untrained university students. This evaluation was conducted with a panel of participants invited to evaluate in groups of approximately 20 people, conducting a total of 12 sensory sessions at the university facilities. The panelists were of both sexes (88 women and 115 men), ranging in age from 18 to 70 years. The mean age of the women was 38.0 ± 15.07 years, while that of the men was 35.7 ± 11.99 years. The general appearance of the canned pickled trout is shown in Figure 4.

TABLE 2 Experimental formulations and sensory analysis of pickled trout canned products.

		Experimental formulations						
Ingredients		EF-1	EF-2	EF-3	EF-4	EF-5	EF-6	EF-7
Canning solids (70%)	Trout filet, %	35.0	35.0	35.0	35.0	35.0	50.0	20.0
	Vegetables %	35.0	35.0	35.0	35.0	35.0	20.0	50.0
Governing fluid (22%)	Vinegar %	9.0	9.5	10.8	12.0	14.0	12.0	12.0
	Vegetable oil %	1.0	2.0	2.0	3.0	4.5	3.0	3.0
	Common salt %	10.0	9.0	7.5	6.0	3.0	6.0	6.0
	Spices (pepper and cumin) %.	2.0	1.5	1.7	1.0	0.5	1.0	1.0
Vacuum space %		8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total %		100.0	100.0	100.0	100.0	100.0	100.0	100.0
First sensory analysis[1]								
Average evaluation ($p < 0.001$)		$23.0^{c} \pm 1.41$	$22.8^{c} \pm 1.47$	$26.3^{a} \pm 1.63$	$24.7^{b} \pm 1.51$	$21.8^{cc} \pm 0.75$	$23.3^{bcd} \pm 1.21$	$21.0^{e} \pm 1.41$

[1]Each average includes 12 replicates. Means with different letters in the same row are statistically different according to LSMeans ($p < 0.05$).

FIGURE 3
Presentation of the S-Trubeche canned food.

FIGURE 4
General appearance of the S-Trubeche can when it is opened.

Determination of pH

Samples of S-Trubeche were crushed in a mortar until a homogeneous mass was obtained and then the pH was measured with a Mi150 pH meter (Milwaukee, USA), calibrated with standard solutions (pH = 4 and pH = 7). The pH of covering liquid used in the canning process was recorded (3.6 ± 0.13) and the pH of the S-Trubeche canned product was monitored at 0, 180 and 700 days of storage. For each pH analysis time, three replicates were performed and for each replicate, a homogeneous mixture of three cans of canned food was considered.

Canning stability

The stability of the trout preserves was determined by monitoring the specific parameters of the pH of the covering control liquid and the homogeneous mass of the preserves according to the AOAC (Association of Official of Analytical Chemists) (2011) method. Histamine content was determined at https://bhioslabs.com/ using the BHIOS-BQ-028 method (Determination of Histamine in Fish and Products, version 02–2014). Commercial sterility and control of microbiological parameters were determined using the Bacteriological Analytical Manual method (FDA, 2001), in triplicate (4–5 g). For the determination of aerobic mesophilic and thermophilic microorganisms, acid broth and malt extract broth were used for 14 days of pre-incubation at a temperature of 35 ± 0.5 °C, while for anaerobic mesophilic and thermophilic microorganisms, acid broth was used for 14 days of pre-incubation at a temperature of 55 ± 0.5 °C. Both histamine and commercial sterility tests were performed at 180 and 700 days.

Proximate composition

The canned product (Strubeche) was analyzed according to the method of AOAC (Association of Official of Analytical Chemists) (2011). The dry matter was determined after drying at 105 °C for 24 h. Gross energy was determined using a bomb calorimeter (Parr Instrument 6772® USA).

Statistical analysis

Sensory analysis data were examined by the normality test, followed by a one-way analysis of variance using the general linear

TABLE 3 Sensory analysis of canned food (S-Trubeche).

Sensory test variables	Women[1]	SD[2]	Men	SD	*p*
Color	4.1	±0.44	4.0	±0.41	0.519
Aroma	4.1	±0.45	4.0	±0.45	0.433
Taste	4.2	±0.51	4.2	±0.49	0.710
Trout texture	4.3	±0.48	4.2	±0.37	0.377
Vegetable texture	4.1	±0.43	4.1	±0.40	0.583
General appearance	4.2	±0.38	4.1	±0.42	0.113
Total evaluation	24.8	±1.85	24.7	±1.68	0.495

[1]Each mean includes 88 women and 115 men tasters. [2]Standard deviation.

model (GLM) procedure of the Statistical Analysis System (SAS Institute Inc, 2004). p values <0.05 were considered statistically significant. When significance was obtained in the ANOVA, the means of the variables were subjected to least squares means analysis (LS Means with pdiff stderr, Table 2). For the analysis of pH and Histamine of S-Trubeche, the means were compared with Student's t-test (Table 3). While data on trout production parameters ($n = 30$) and laboratory analysis of proximate composition ($n = 3$) were expressed as mean and standard deviation.

Results and discussion

Trout

The trout used in the 7 difference recipes had a mean body weight of 505.2 ± 164.51 g, body condition index of 1.2 ± 0.14, carcass yield of 86.7 ± 1.98% and filet yield of 64.8 ± 1.59%. The trout for canned S-trubeche had a body weight of 842.0 ± 184.57 g, body condition index of 1.3 ± 0.12, carcass yield of 89.2 ± 2.61% and filet yield of 56.0 ± 5.01% (Table 1).

The parameters of canned trout are higher than the acceptable ranges considered in trout production. Crouse et al. (2023) reported a yield of skin-on filets of 43.2 ± 1.3% to 51.4 ± 1.6%. In general, for the production of canned trout, it is recommended that the trout should have a body weight greater than 500 g.

Sensory evaluation

The results of the analysis of the first sensory test (Table 2) show that experimental formulation 3 (EF-3) with 35% trout filet and 35% vegetables was the most appreciated by the trained evaluators and experimental formulation 7 (EF-7) with 20% trout and 50% vegetables was the least accepted (26.3 ± 1.63 *vs* 21.0 ± 1.41 points; $p < 0.001$, respectively). The other 5 formulations had intermediate results. Both texture and taste criteria of EF-3 contributed to its selection as the better product.

EF-3 was renamed S-Trubeche and was mass-produced. The sensory analysis included women and men consumers, obtaining similar total scores for both sexes (24.6 ± 1.46 *vs* 25.0 ± 1.61points; $p < 0.117$, respectively). Neither for color, aroma, taste, trout texture, vegetable texture and overall score (Table 3). However, the general appearance variable was better evaluated by men than by women ($p < 0.045$). According to the consumers comments, the canned food would be a practical alternative for camping or work trips in remote places where it is difficult to find food of acceptable healthiness.

Texture is a commonly used criterion to define the sensory quality of food, and this variable is also considered important in promoting safe and efficient swallowing (Steele et al., 2015). Therefore, one of the attributes that contributed to the acceptability of canned trout was its texture. Sensory attributes, such as aroma and flavor, also contributed significantly to sensory quality. These results confirm what has been reported by different authors when evaluating the sensory characteristics of canned products stored at 3.0 ± 0.5 °C (Michalczyk and Surówka, 2007; Atitallah et al., 2019; Surówka et al., 2021). Airtight canning allows the positive sensory attributes of products such as trout pickles to be preserved over the long term. In fact, the color of the vegetables and the aroma of the spices and vinegar remained similar to their natural presentation (Figure 4). In contrast, high temperatures modify the color and flavor of the ingredients. Jiang et al. (2022) investigated the effect of temperature during drying and sterilization of tilapia tortillas (105, 115, and 121 °C) on product quality. They reported that 105 °C is the optimum temperature, while temperatures of 121 °C modified the original color and caused the loss of positive flavoring substances.

pH control

The pH values of S-Trubeche (Table 4) were different during the storage period of 0, 180, and 700 days (3.9 ± 0.17, 4.8 ± 0.12, and 4.9 ± 0.15; $p < 0.001$, respectively). These results are within the range established to guarantee the stability of canned fish, although the values are lower than those observed by Kaewprachu et al. (2017) during the storage of bluefin tuna slices, who reported that the pH varied between 5.4 and 5.7. Such differences could be attributed to the composition of the products and processing conditions. Melih Secer et al. (2020) suggested that pH changes in canned products may be related to the degradation of organic acids into different compounds during high-temperature storage or the oxidation of organic acids by residual oxygen during canning.

Also, the pH values indicate the degree of sterilization of the canned product and reduces the likelihood of microbial survival during storage. In fact, pH did not vary significantly during the incubation period in the commercial canning stability study (4.9 ± 0.15 vs. 5.0 ± 0.12; $p > 0.05$, respectively). Nketia et al. (2020) point out that both pH, drained weight and color are considered indices of canning quality, i.e., changes in pH could indicate spoilage of canned foods. For example, a decrease in pH is associated with the production of lactic acid through the metabolism of lactic acid bacteria and the release of inorganic phosphate through the breakdown of adenosine triphosphate (ATP). While an increase in pH during canning reflects the degree of deterioration of the fish due to the accumulation of basic compounds such as ammonia and trimethylamine resulting from autolytic and microbial reactions (Chang et al., 2008).

Histamine

The results of the evaluation of histamine content in S-Trubeche at 180 and 700 days were 59.2 ± 15.00 ppm and 3.0 ± 0.43 ppm ($p < 0.003$), respectively (Table 4). These observed levels do not exceed the acceptable limits for histamine recommended by the European Community (100 ppm) and the FAO/WHO (200 ppm), with levels above 500 ppm being highly hazardous to human health (FDA, 2001).

Histamine is a thermostable biogenic amine (2-(1H-imidazol-4-yl) ethanamine) derived from free histidine in muscle and produced endogenously by bacteria that produce histidine decarboxylating enzymes under inadequate refrigerated storage conditions (Harmoko et al., 2022). Fresh and properly refrigerated fish contain less than 10 ppm of histamine (Shams-Ghahfarokhi et al., 2017).

Red fish muscle produces more histamine than white muscle (Rzepka et al., 2013) and can range from 1 to 229 mg/kg (Yesudhason et al., 2013). In tuna *Thunnus thynnus*, it is reported from 0.45 to 83.73 mg/kg (Silva et al., 2011) and lower levels in mackerel *Scomber scombrus* and sardines *Sardina pilchardus* (26.67 ± 0.90 and 52.99 ± 1.38 mg/kg, respectively).

Cooking and smoking do not destroy histamine and high levels are not associated with changes in taste and odor and can cause severe food poisoning (Annunziata et al., 2022; Yadav et al., 2019).

Histamine levels in S-Trubeche are below the acceptable levels for canned fish and are consistent with those reported by Evangelista et al. (2016). Our results suggest that canned products made with vegetables and spices contain less histamine than canned products made with fish alone (Harmoko et al., 2022). In addition, the low histamine content observed in this study for canned trout could be due to the fact that the trout used had a short storage period and the good temperature conditions in which they were kept.

Commercial sterility

The results of the microbiological evaluation confirmed the absence of thermophilic and mesophilic microorganisms at 180 and 700 days of storage (Table 5). The study demonstrated commercial sterility up to 700 days, confirming the absence of both aerobic and anaerobic mesophilic and thermophilic microorganisms in most of the samples, only one out of nine samples analyzed was positive for mesophilic aerobes. Secondary analyses were performed to determine spore-forming bacteria, with negative results. The presence of these microorganisms could be explained by variations in intrinsic and extrinsic factors such as nutrient components, pH, water activity, gas composition and temperature (Rodrigo et al., 2016).

Aerobic mesophilic bacteria or plate aerobes are microorganisms widely used as food hygiene indicators for fishery products (Anihouvi et al., 2019; Correia Peres Costa et al., 2020). Under anaerobic conditions, spores germinate to grow and excrete toxins (Samanta and Choudhary, 2019). Food safety requires quality control through verification and confirmation of proper pasteurization and routine microbiological testing for pathogenic and other organisms (Ogbulie et al., 2014). Although Khaskheli et al. (2015) indicated the presence of *Escherichia coli* and *Lactobacillus* in pickled products stored at room temperature (26 ± 4 °C) for 90 days.

S-Trubeche preserves are fairly stable under the storage conditions studied, at around 12 °C ambient temperature, with a range of −4 °C and 17 °C during the year. The lowest temperatures occurred in May and June and the highest in February and March. Relative humidity was below 50% under natural conditions in the Puno region. In fact, Featherstone (2015) indicates that in processed foods, the shelf life and sterility of the product should be prolonged, colors and flavors should be as similar as possible to the fresh ones, i.e., they should retain the taste and textural attributes of the original products. However, achieving product sterilization is an important step in food processing and the heat treatment of prepared foods can improve aroma diffusion. Zhao et al. (2023) demonstrated that heat treatment significantly improves aroma quality, this was proven by an increase in the volatile compound content of a fish sauce with bean paste, vinegar, garlic and spices. However, when temperatures higher than 120 °C are applied during the canning process, the nutritional quality of the product is reduced (Aubourg, 2001).

Proximal composition of the canned food

The nutritional values of S-Trubeche are presented in Table 6. The crude protein content of 6.7 ± 0.27% from the trout filet and vegetables makes it ideal for feeding children and the elderly. The low levels of carbohydrates (5.0 ± 1.81%) and fiber (2.0 ± 0.47%) indicate that this is a dietary canned food, since the inclusion of vegetables in the formulation of the canned food is important not only for their nutritional value, but also for their fiber contribution. Likewise, the low fat and energy content (3.4 ± 0.74 and 0.85 ± 0.06 kcal/g) would be indicators of a low-calorie canned product with omega-3 fatty acids, making it very healthy for people who want to avoid consuming saturated fats (Rebolé et al., 2015).

The inclusion of vegetables and spices in pickled preserves has improved the organoleptic acceptability of the product without

TABLE 4 pH level and histamine content during storage of the S-Trubeche.

Biochemical markers				
Storage, days	pH	SD[1]	Histamine, ppm	SD
0	3.9[b]	±0.17	–	–
180	4.8[a]	±0.12	59.2[a]	±15.00
700	4.9[a]	±0.15	3.0[b]	±0.43
p	0.001		0.003	

[1]Standard deviation. Means with different letters in the same column are statistically different according to LSMeans ($p < 0.05$).

TABLE 5 Commercial sterility of S-Trubeche.

Microorganisms	Thermotolerant	Storage, days	
		180	700
Aerobes	Mesophilic	0/9	1/9
	Thermophiles	0/9	0/9
Anaerobes	Mesophilic	0/9	0/9
	Thermophiles	0/9	0/9

0/9 = no growth of microorganisms out of nine samples tested.

TABLE 6 Proximal composition and crude energy of canned S-Trubeche (as food).

Variable	Average	SD[1]
Humidity, %	82.0	±0.51
Crude Protein, %	6.7	±0.27
Carbohydrate, %	5.0	±1.81
Crude Fiber, %	2.0	±0.47
Fat, %	3.4	±0.74
Ash, %	2.0	±0.09
Gross Energy, kcal/g	0.85	±0.06

Each average includes 3 replicates. [1]Standard deviation.

altering its microbiological quality. Moreover, to providing nutritional components, the addition of vegetables adds a natural source of nutrients, such as fiber, carotenoids and vitamins. Trout filet provides proteins of high biological value and omega-3 fatty acids which are beneficial to human health.

This research on trout pickle production seeks to contribute to the knowledge of new food alternatives for human nutrition. In addition, the production and economic viability of the canned S-trubeche was carried out by Yépez-A et al. (2023), concluding that it is feasible to produce it at a unit price that consumers are willing to pay of US$1.6. It should be noted that trout production in the Puno region represents the best option for meeting future food demand. We must recognize that aquaculture is a highly profitable, efficient, and sustainable production system that produces excellent quality animal protein at a very low cost.

Conclusion

During the sensory evaluation, the S-Trubeche formula was the best accepted by the tasting panel and also by the local consumers. The equal proportions of trout filet and vegetables (35%), accompanied by vinegar, vegetable oil, common salt and spices as the dominant covering liquid (22%), and the thermal processing, allow stability for a fairly long time, maintaining an appropriate pH range, low histamine levels and remarkable commercial sterility.

The canned trout in pickled sauce developed by S-Trubeche is a novel product with great potential for commercial development in the national and international markets due to its consumer acceptability, low cost of its ingredients, nutritional value and health benefits for human nutrition of all ages.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://github.com/maranibar-oss/Animal-Production-.

Ethics statement

The manuscript presents research on animals that do not require ethical approval for their study.

Author contributions

RO-B: Investigation, Writing – original draft, Methodology. EV-H: Investigation, Writing – original draft, Conceptualization, Formal analysis. MB-E: Writing – original draft, Project administration, Validation. HA-B: Writing – original draft, Data curation, Formal analysis. MA-A: Writing – original draft, Funding acquisition, Investigation, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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