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Research Article

Research on the production of bottled chili sauce added on nisin to reduce pasteurization temperature and improve quality, ensuring food hygiene and safety

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Abstract

Bottled chili sauce products are currently quite popular on the market and to preserve them for a long time, the product needs to be supplemented with some preservative additives. With the desire to produce pasteurized bottled chili sauce products with a long shelf life with natural preservative ingredients, having high sensory quality in terms of color, structure, and high nutritional value, the study chose to add nisin (food additive E234) with a content of 200 IU/g (5 mg/kg - calculated in pure nisin) to help reduce the pasteurization temperature to 80°C for 15 minutes. The final product has the same effectively pasteurized as the sample without the addition of nisin pasteurized at 95°C/15 minutes with parameters such as color (L, a, b are 8.15 ± 0.37, 11.17 ± 0.49 and 8.63 ± 0.37), the vitamin C content is retained at nearly 70%, the structure is consistent without separation, and the sensory evaluation is much higher than the pasteurized sample without adding nisin. This helps provide consumers with a chili sauce product that not only ensures food safety and hygiene but also has good nutritional and sensory quality.

Keywords: *chili sauce, tomato, chili, pasteurization, F-value, nisin*

1. INTRODUCTION

Nisin is known as a food additive E234, it is in nature a polypeptide biosynthesized by the lactic bacteria *Lactococcus sub lactic.* Nisin has been proven to be safe and effective in inhibiting many groups of microorganisms, especially disease-causing and toxin producing Gram (+) microorganisms [4] for examble *Clostridium botulinum, Staphylococcus aureus, Listeria monocytogenes,...* so it is currently used in many foods processing industries around the world such as milk, fruit juice, meat and fish, ... with an additional content of 30-400 IU/g (or 5-25 mg/kg [9]), it reduces the time and temperature of pasteurization, helping the

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product to be preserved for a long time while still retaining the original sensory values [5-7]. A. Sobrino-Lopez at all [2] showed that adding nisin 40 IU/mL to pasteurized milk at 72°C for 15 seconds can prolong the period by 7 days with samples without nisin addition. Catherine M.G.C [3] showed that the vitamin C content of some vegetables and fruits is greatly lost by the heating process, the vitamin C content of gazpacho vegetables is reduced by 72.91% after heating at 90°C for 1 minute, or with pumpkin, the vitamin C content is reduced by 19.2% when heated at 85°C for 5 minutes. Currently in the country, the application of nisin in food is quite rare and has only been added to pasteurized milk. Chili sauce is a spice used quite a lot in Viet Nam, the main ingredients of chili sauce are flesh of tomato and chili after separating the skin, seeds and fibers, are mixed with spices like sugar, salt,... the specific nature of chili sauce, it is easily discolored and sensitive to high temperatures when pasteurized. Currently, chili sauce can be produced by heated and then poured into bottles under clean hygienic conditions (technology a) or bottled and then heat pasteurized (technology b). However, with the technology (a), the entire bottle is not pasteurized, products have a short shelf life and must be supplemented with many preservative additives, leads to a high risk of losing food hygiene and safety. Meanwhile, whole-bottle pasteurization technology (b) overcomes the above disadvantages, but the nutritional and sensory value is reduced due to vitamin C significantly decreased, dark color and viscosity decreased. To overcome this weakness, the study chose to add nisin with a good antibacterial role that will help reduce pasteurization temperature while still ensuring the effectiveness of pasteurization, killing microorganisms and still retaining sensory properties, good nutrition of the product.

2. MATERIALS AND METHODS

2.1. Materials

Pink tomatoes and hot chili Chi Thien variety, raw materials to be at the right technical ripeness, the color should be red, not too overripe, not crushed, or rotten. Fruit size is uniform. The picture of tomatoes and chili for producing chili sauce is shown in Figure 1.

Figure 1. *Raw materials of tomatoes and chili for producing chili sauce*

Main ingredients of chili sauce*:* Tomato juice and chili juice at a ratio of 7/1; Spices calculated according to main ingredients: Salt (3%), sugar (6%), MSG (0.2%), pepper (0.1%, garlic (2%), modified starch (3.5%), acetic acid (0.2%).

The Nisin preparation has the trade name NISAPLIN (Danisco), containing about 2.5% wt Nisin, active force of 1050 IU/mg.

Chemical: 0.01 N iodine solution, starch indicator 0.5%, 2% HCl solution, PCA medium for isolating and counting total microbial

Equipment: pH meter METTER TOLEDO, viscometer Dial Brookfield Viscometer RVT, color-meter ColorLite sph860, Brix meter,...

2.2. Methods

Tomatoes and chili reach maturity ⟶ Blanch ⟶ Rubbed to separate the skin, seeds and fibers ⟶ Mix, heat ⟶ Pour into bottles ⟶ Pasteurize ⟶ Cool, insulate ⟶ Label

** Color measurement method*

Using color-meter ColorLite sph860, based on the CIE Lab (L*a*b*) system principle. In there: L* = Dark - light intensity, a* = Red – green chroma, b* = Blue - yellow chroma, ΔE : Standard deviation.

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

** Method for determining Vitamin C content: by iodine titration method [1].*

Vitamin C content is calculated according to the formula:

$$A_S = \frac{0{,}88.V_C V_1}{V.m} x100(mg\%)$$

In which:

0.88 is number of mg of ascorbic acid corresponding to 1 mL I_2 0,01 N

V_C is average value of I_2 0.01 N solution consumed during titration, mL

V_1 is volume of flask for dissolving sample, mL

V is volume of solution taken for titration, mL

m is volume (mass) of fruit juice taken for analysis, g.

Viscosity measurement method: using viscometer Dial Brookfield Viscometer RVT.

Determining total plate count: TCVN 4884-1:2015 (ISO 4833-1:2013)

Sensory evaluation method: Descriptive test (product profile construction method).

Select the product characteristics that need to be evaluated. Conduct training for members on the properties of the product and let members agree on how to use the given intensity scale. Evaluate the intensity of the selected characteristics on a scale: 0 points: lowest intensity rated, 9 points: highest intensity rated. The sensory properties of the product need to be evaluated:

Color: Bright red characteristic of chili sauce, brightness, color harmony

Structure: viscosity, uniformity

Taste: pungent smell of chili, characteristic smell of chili sauce, the smell of cooking Taste: salty, sweet & sour, spicy, harmony of taste

General favorability.

Method to evaluate the actual pasteurization efficiency L^Z_T compared to the necessary pasteurization efficiency F^Z_c ($L^Z_T \geq F^Z_c \rightarrow$ Achieve pasteurization efficiency), determined based on the results of measuring the temperature of the cold point of the product to calculate

effectiveness Actual pasteurization L^{Z}_{T} converted for both heating and cooling stages at temperatures T according to the formula:

$$L^{Z}_{T} = \sum l^{Z}_{T} . \Delta\tau$$

In which:

$l^{Z}_{T} = 10^{(t-te)/z}$ [2, 6], is the lethal value (heat treatment efficiency) at the temperatures when converted to the standard temperature

The standard temperature t_e for moderately sour products (pH = 4.6 - 4.7)

t_e= 90°C, corresponding to the typical organism *Clostridium botunilum* (type B, E) with Z=10 [1, 3].

Calculate the required sterilization efficiency

$$F^{z}_{c} = D_e . \lg\frac{Co . Vo . 100}{So}$$ [3]

In which:

$D_e = D_{90}$ = 1.1 (min) of *Clostridium botunilum* (type B, E) [3]

C_o is initial microbial density (CFU/g).

V_o is weight of product in bottle (g).

S_o = 0.001% - allowable damage rate

3. RESULTS AND DISCUSSION

3.1. Research determined the pasteurization formula for 500 g bottled chili sauce without adding nisin

The mixture flesh of tomato and chili after mixing with spices and additives such as salt, sugar, and acetic acid was determined for pH, vitamin C content, color and initial total microbial content, the results are shown in the following Table 1.

Table 1. *Evaluate the criteria of chili sauce before pasteurization*

pH	***Bx***	***Vitamin C content (mg/100g)***	***Colour (L*, a*, b*)***	***Total plate count (CFU/g)***
4.7	16.8	42.47	9.6/ 13.4/ 9.5	4.5 x 10^6

(The ratio of tomato flesh/chili pepper selected is 7/1)

With a pH value of 4.7, it is classified as a food with moderate acidity and total microbial content, the appropriate pasteurization temperature for this product can be set at 90-95°C, the pasteurization time depending on size and volume of product in jar to destroy completely microorganisms to help preserve the product for a long time at room temperature [3].

The mixture of tomato and chili flesh is mixed with spices and additives, heated to 80°C and then poured into bottles with a net weight of 500 g for the purpose of removing gas from the product. Determine the pasteurization formula by using a double clamp thermometer to measure the temperature of the cold point of the product during the pasteurization process, the interval between two measurements is t = 3 minutes. Based on the results of measuring the temperature at the cold point of the product, calculate the actual pasteurization efficiency L^{Z}_{T} compared to the required pasteurization efficiency F^{Z}_{c}, if $L^{Z}_{T} \geq F^{Z}_{c}$ → Achieve pasteurization efficiency. The results are shown in Figure 2.

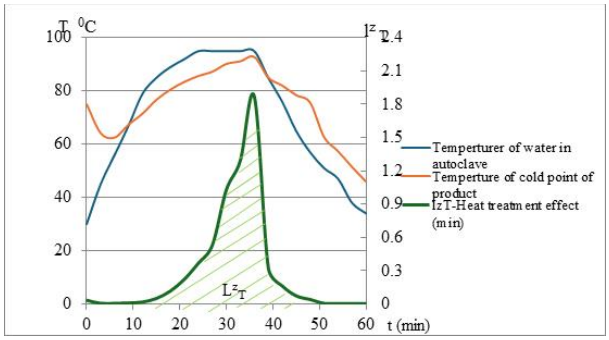

Figure 2. *The process of pasteurizing chili sauce samples without adding nisin at 95°C*

Based on the results of measuring the temperature of cold point of the product to calculate the actual pasteurization efficiency l^{Z}_{T} converted for both heating and cooling stages at temperatures T calculated according to the formula:

$$l^{Z}_{T} = 10^{(t-te)/z} \quad [3]$$

In which:

t_e is the standard temperature;

t_e= 90°C for a moderately sour product (pH = 4.6 - 4.7), corresponding to particular microorganism *Clostridium botulinum* (type B,E) with Z=10 [1, 3], we have the actual total pasteurization efficiency for the whole process as:

$$L^{Z}_{T} = \sum l^{Z}_{T} \,.\, \Delta\tau = 6.0748 \times 3 = 18.22$$

$\Delta\tau$ = 3 minutes, temperature reading interval.

Calculate the required pasteurization efficiency: F^{z}_{c}

In which: $D_e = D_{90}$ = 1.1 for *Clostridium botulinum* (type B, E) for medium sour canned foods (pH = 4.6-4.7) [1, 3]

$C_o = 4.5\times10^6$ (CFU/g); V_o - 500 (g); S_o = 0.001%

The product has achieved pasteurization effect: $L^{Z}_{T} \geq F^{z}_{c}$

Thus, the chili sauce sample pasteurized at 95°C with the formula (24-15-21)/95°C for a bottle with a net weight of 500 g has achieved a pasteurization effect without adding nisin product. However, due to the high temperature, the color is a bit dark and the sensory properties of the sample are not favorable, so this is the basis for us to reduce the pasteurization temperature to 80-85°C to improve the sensory properties as well as nutritional value of the product while still achieving pasteurization efficiency with samples supplemented with nisin preparation, a very safe antibacterial additive currently applied in food processing technology in many countries. [4, 5], which is still rarely mentioned in Vietnam.

3.2. Research to find a pasteurization mode for chili sauce bottled with nisin added

To find the appropriate temperature and concentration of nisin supplementation, we conducted research on 03 samples with nisin addition and pasteurization mode as follows: (1) Nisin adding 150 IU/g pasteurizing temperature 80°C/20 minutes; (2) Nisin adding 200 IU/g pasteurizing at 80°C/15 minutes; (3) nisin adding 150 IU/g pasteurizing at 85°C/15 min [4]. Prepare the same chili sauce mixture according to result 1 and proceed to fill jars, pasteurize according to the 3 modes above and evaluate microbial quality after 2 weeks of incubation, the result are shown in Table 2.

Table 2. *Results of total plate count of chili sauce samples*

Sample	*Condition*	*Total plate count*
1	Nisin 150 IU/g – 80°C/20 min	80 - 10^2 cfu/g
2	Nisin 200 IU/g – 80°C/15 min	None
3	Nisin 150 IU/g – 85°C/15 min	None
Control	95°C/15 min	None

Exclude sample 3 - nisin 150 IU/g – 80°C/20 min due to ineffective pasteurization

Conduct further analysis of physicochemical indicators, comparing the above samples to select the sample with the best results.

Color measuring (L*, a*, b*) for chili sauce products using a ColorLite sph860 colorimeter (with the standard color being the chili sauce sample before pasteurizing). Visual images (Figure 3) combined with color measurement (Figure 4) show us the change in color of chili sauce products pasteurized at different temperatures. When pasteurizing at high temperatures from 80°C, 85°C, up to 95°C, the L* brightness value shows a tendency of decreasing, the red intensity a* also decreases significantly, the yellow intensity b* also decreases slightly, and the difference in ΔE value becomes larger as the pasteurization temperature increases, and the color of the chili sauce darkens as L*, a* decrease, the characteristic red color is lost. This is explained that when pasteurizing at high temperatures, the reactions of caramelization, Maillard,... will create dark compounds, along with lycopene pigment of tomatoes or anthocyanin of chili which are antioxidants will discolor & darken significantly.

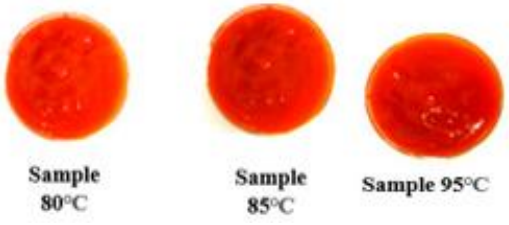

Figure 3. *Color of chili sauce samples pasteurized at 3 different temperatures*

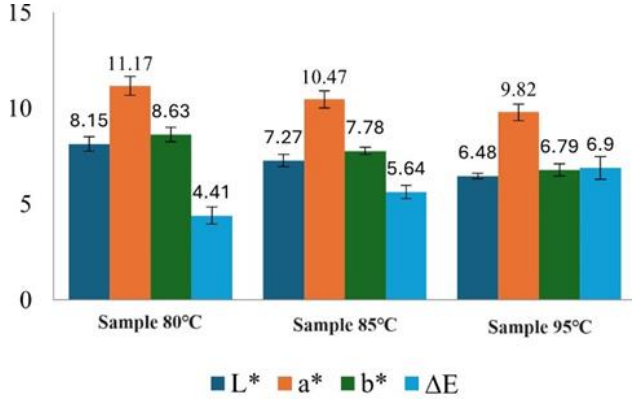

Figure 4. *Color measurement results (L*, a*, b*, ΔE) of chili sauce samples pasteurized at 3 different temperatures*

The content of vitamins, including vitamin C, is destroyed mostly when heated above 80°C. The results of evaluating the vitamin C content of chili sauce samples under different pasteurization modes are compared with the mixture before pasteurizing are shown in Figure 5.

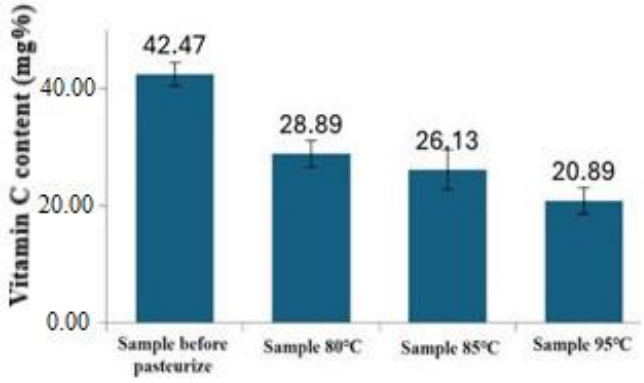

Figure 5. *Vitamin C content of 3 chili sauce samples with different pasteurizing temperatures*

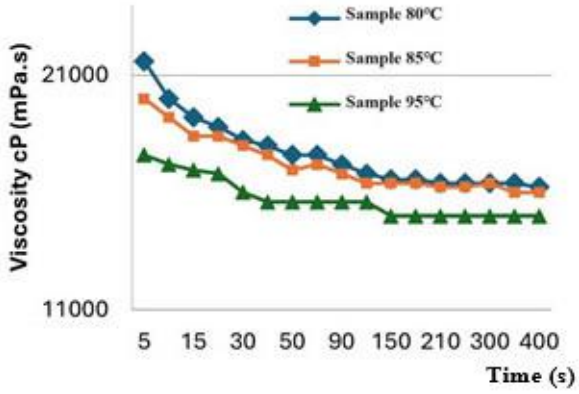

Figure 6. *Chili sauce viscosity of 3 chili sauce samples with different pasteurizing temperatures*

Figure 5 showed that chili sauce changed not only in color, but the Vitamin C value also decreases strongly under the heat effect. After pasteurization, the chili sauce sample at 80°C had the highest Vitamin C value, of 28.89 mg/100g, only reduced by nearly 30% compared to the original, the lowest content was the 95°C sample, only 20.89 mg/100g, reduced by more than 50%. This is quite consistent with some studies showing that the vitamin C content of gazpacho vegetables is reduced by 72.91% after heating at 90°C for 1 minute, or with pumpkin, the vitamin C content is reduced by 19.2% when heated at 85°C for 5 minutes [3].

In addition, for chili sauce, viscosity is an important indicator to evaluate the structural quality of the product. Chili sauce with high viscosity, good consistency, and good uniformity will result in a product that meets quality requirements. The results in Figure 5 of measuring viscosity using a Viscometer show that the 80°C pasteurized sample has a higher viscosity than the 85°C and 95°C samples, the higher the pasteurization temperature,

the more chili sauce viscosity reduced, when pasteurized at low temperature, at 80°C, the pectin structure is not broken, so the consistency of chili sauce/tomato sauce is maintained.

For more accurately evaluating when choosing pasteurization mode for chili sauce, we conducted a sensory test with a panel of 10 members using the method of describing the profile of the product's typical properties according to the intensity scale from 1 to 9 points, sensory evaluation results are shown in Figure 7.

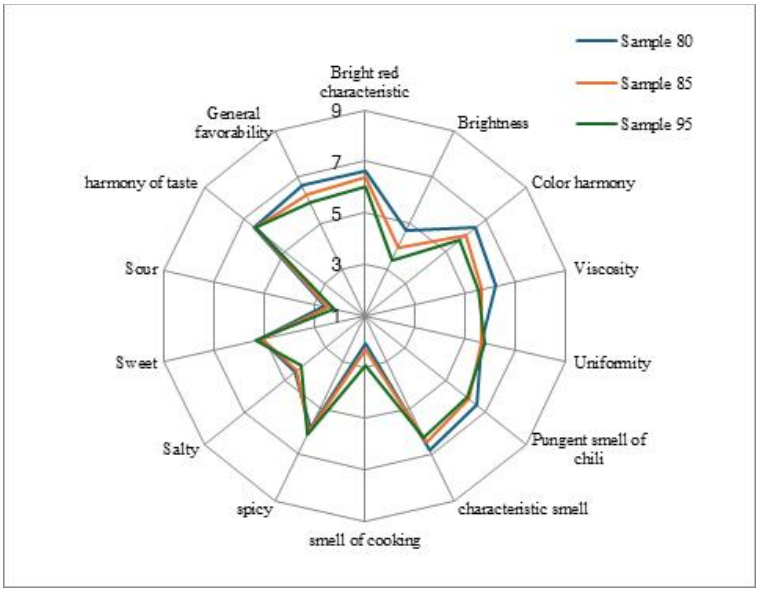

Figure 7. *Results of sensory evaluation of chili sauce products at 3 pasteurization temperatures*

Figure 8. *Chili sauce samples after 2 weeks and after 06 months of storage*

Figure 8 shows that the chili sauce sample pasteurized at 80°C has a higher brightness than the 85°C sample, and the 95°C sample. The red color intensity of the 80°C sample is better than the other two samples. For general liking, color harmony, and characteristic flavor, the 80°C sample is also preferred.

The criteria for spicy, salty, sweet, or sour taste, there is not much difference between samples. However, the 95°C sample was commented having stronger smell and stronger cooking smell than the other two samples. Therefore, the appropriate pasteurizing temperature for chili sauce will be selected at 80°C for 15 minutes with the addition of Nisin preparation 200 IU/g of product. This is a low-temperature pasteurization mode so it minimizes the effects of high pasteurization temperature affects product quality. Chili sauce

is a canned food with a low-medium pH (pH 4.7), and is added the appropriate Nisin preparation to ensure pasteurization effect, killing all vegetative microorganisms. In this mode, the product retains its characteristic red color, high brightness, does not change color much, and has good viscosity.

Chili sauce after pasteurizing is incubated and stored for 2 weeks and storage is monitored for 06 months. Then, check the stability of the product based on physicochemical criteria and total aerobic microorganisms content. The results are shown in Table 3.

Table 3. *Quality criteria of chili sauce products added Nisin preparation*

Criteria / ***Sample***	***Soluble solids (°Bx)***	***pH***	***Vitamin C content (mg/100g)***	***Color (L*,a*,b*,ΔE)***	***Total plate count (CFU/g)***
After 2 weeks of incubation	16.8	4.7	28.89 ± 2.25	L*=8.15±0.37, a*=11.17±0.49 b*= 8.63±0.37, ΔE= 4.41±0.46	0
After 06 months of storage	16.8	4.7	28.02 ± 2.68	L*=7.98±0.89, a*= 10.96±0.76 b*= 8.12±0.54, ΔE= 4.58±0,52	0

The above table shows that the quality of chili sauce products added Nisin preparation after 6 months of storage has no significant changes, the quality indicators of chili sauce are still stable and safe.

4. CONCLUSION

The research found a heat pasteurization mode for 500 g bottled chili sauce without adding nisin using experimental methods and calculated the pasteurization efficiency at the slowest heating point of 95°C/15 minutes, achieving pasteurization efficiency, however, the sensory quality is not as expected. The appropriate pasteurization mode with the addition of nisin 200 IU/g was determined at 80°C/15 minutes and the quality of the product was evaluated through microbiological criteria, color, viscosity, and vitamin C content and are better in all indicators compared to samples without nisin adding.

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