

Food processing report

Preservative-free Chili sauce

Food technology

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I.Introduction

Chili sauce is one of the major used sauces to enhance aroma and taste in the world, especially in Asian countries. There is a tendency that more and more people put emphasis on health which means they do not want potentially harmful preservatives. Sodium benzoate is commonly industrial used preservatives for chili sauce and it has been found that it is genotoxic and directly linked with childhood hyperactivity (Zengin, N et al, 2011). This report introduces a new preservative-free chili sauce including the properties of its components, processing procedure, innovative technology and other related aspects.

II.Raw materials and properties

Red chili pepper

Composition and nutrition value

According to major components in red chili pepper (FoodData Central, 2019) and specific heat of certain components (Singh, R. P., & Heldman, D. R. ,2001), specific heat of red chilies at 20° C can be calculated.

table 1: major components in red chili pepper

| | ash | water | protein | fat | fiber | carbohydrate |
|---------------------|-------|--------|---------|-------|-------|--------------|
| Red chilies (/100g) | 0.87g | 88.02g | 1.87g | 0.44g | 1.5g | 5.3g |

Table 2: specific heat of certain components in red chili pepper

| | ash | water | protein | fat | fiber | carbohydrate |
|--------------------------|--------|--------|---------|--------|--------|--------------|
| Specific heat (kJ/ kg.k) | 1.1289 | 4.1766 | 2.0319 | 2.0117 | 1.8807 | 1.5857 |

First step is to calculate the fraction of components, then the table 3 below can be obtained.

Table 3: ratios of major components in red chili pepper

| | ash | water | protein | fat | fiber | carbohydrate |
|-------------------------|--------|--------|---------|--------|--------|--------------|
| Fractions of components | 0.0089 | 0.8982 | 0.0191 | 0.0045 | 0.0153 | 0.0541 |

Second step: according to the formula: $C_p = \sum_{i=1}^n C_{pi} X_i$, the specific heat of red chili pepper can be obtained.

$$C_p = 1.1289 \times 0.0089 + 4.1766 \times 0.8982 + 2.0319 \times 0.0191 + 2.0117 \times 0.0045 + 1.8807 \times 0.0153 + 1.5857 \times 0.0541 = 3.9239 \text{ kJ/ kg.k}$$

Apart from those macronutrients, red chilies contain various micronutrients. Red chilies are rich in high vitamin C which has the potential to counteract inflammation and oxidative damage and is fundamental in the biosynthesis of collagen (Grosso, G. et al, 2013). Red chilies also possess certain amount of potassium which may reduce the risk of heart disease when consumed in adequate amounts (Whelton, P. K., & He, J. ,2014). carotenoids and capsaicinoids are two major bioactive compounds in red chilies. Capsanthin is the main carotenoid in red chilies which is responsible for their red color

and its powerful antioxidant properties may fight cancer. Beta carotene is another carotenoid which can be converted into vitamin A in body (Kim, S. et al,2009). Capsaicinoids are a group of alkaloids contributing to the pungent flavor and capsaicin is the most abundant capsaicinoid content of red chilies. And some evidence suggests that capsaicin can promote weight loss by reducing appetite and increasing fat burning (Atli Arnarson,2019). The capsaicin content in red chilies is variable and ranges from 0.1% to 1% of the fruit weight approximately (Orellana-Escobedo, L. et al, 2013).

Safety concern

Red chilies are especially prone to be contaminated by aflatoxins which are poisonous carcinogens produced by certain molds, but levels reported are usually <25ug/kg. However, the widespread use of red chilies makes it important to control contamination by aflatoxigenic fungi (Roberts,2005).

Bacillus spp are frequently found in red chilies and Bacillus cereus is the most common occurrence which is responsible for food poisoning.

Red chilies can cause an intense burning sensation mainly due to the capsaicin. In high amounts, capsaicin causes severe pain, inflammation, swelling and redness. Over time, regular exposure to capsaicin may cause certain pain neurons to become insensitive to further pain. Moreover, red chilies may cause intestinal distress such as abdominal pain, a burning sensation in guts, cramps and painful diarrhea (Atli Arnarson,2019).

Salt

Composition and nutritional value

Salt is a mineral composed primarily of Sodium chloride (NaCl) which consists of 40% sodium and 60% chloride by weight. Some varieties of salt may contain trace of calcium, potassium, iron and zinc Iodine is often added to table salt.

sodium is an essential nutrient for human health via its role as an electrolyte and osmotic solute. It helps with fluid balance, nerve transmission and muscle function. The presence of sodium ions produces a taste of saltiness.

Safety concern

Too much salt intake can lead to high blood pressure, heart disease and stroke. It can also cause calcium losses, some of which may be pulled from bone.

High levels of sodium consumption are closely associated with increased risk of cardiovascular disease (CVD) and hypertension (Barr, S. I. 2010).

Sugar

Composition and nutritional value

Regular sugar refers to sucrose, a disaccharide composed of glucose and fructose. Sugar contains high amount of carbohydrate which can be the main energy source for human

body.

White vinegar

Composition and nutritional value

White vinegar is a clear solution generally containing 4-7% acetic acid and 93-96% water. Other constituents of vinegar include vitamins, mineral salts, amino acids, polyphenolic compounds such as garlic acid, catechin, caffeic acid, ferulic acid and nonvolatile organic acids like tartaric, citric, malic, lactic. Vinegar is low in calories and nutrients. vinegar has the tart flavor and pungent, biting odor.

Xanthan gum

Composition and nutritional value

Xanthan gum is a high molecular weight polysaccharide produced by a pure-culture fermentation of a carbohydrate with strains of *Xanthomonas campestris*. The xanthan gum polysaccharide consists of a backbone of β -(1 \rightarrow 4) linked d-glucose molecules. Xanthan gum is non-digestible in humans and serves to lower the calorific content of foods and improve their passage through the gastrointestinal (BeMiller et al, 2012).

Safety concern

xanthan gum is unlikely to be absorbed intact and cause no adverse effects even at high intake amount. Xanthan gum is no concern with respect to genotoxicity from long-term consumption. There is no safety concern for the general population to consumed Xanthan gum as a food additive (Mortensen, A et al, 2017).

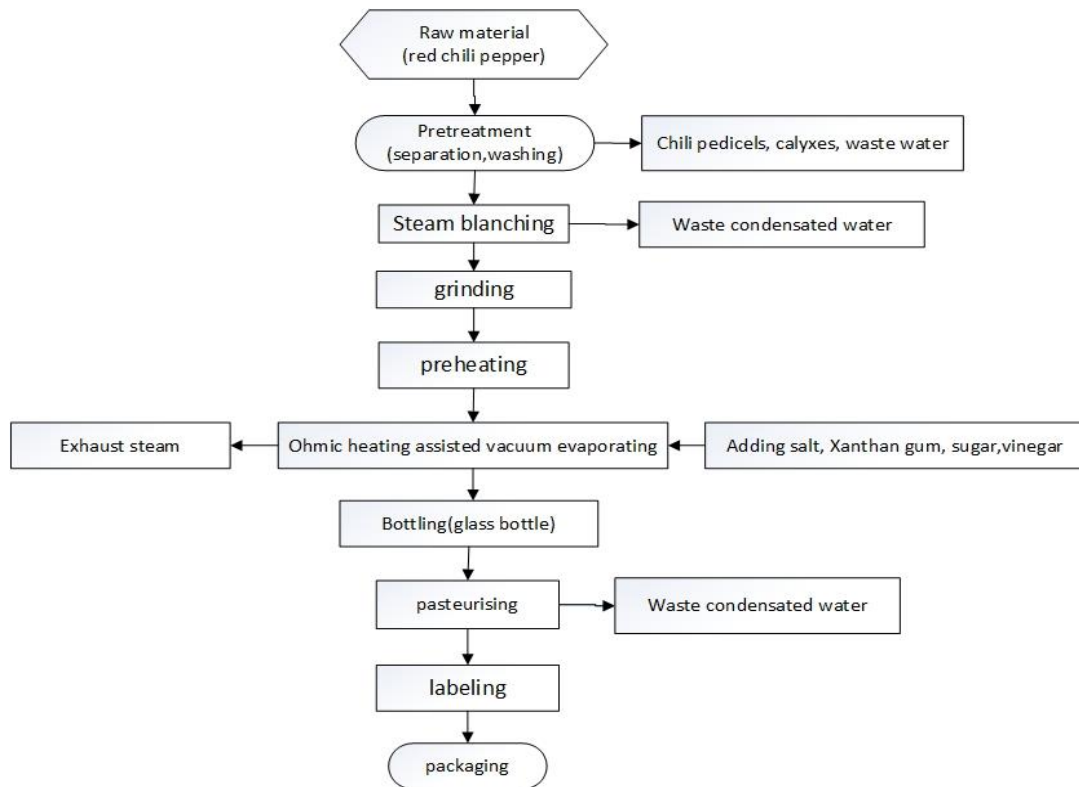
physicochemical and sensory properties

Xanthan gum is soluble in cold or hot water and stable over a broad range of pH values. It needs intensive agitation when introduced into aqueous medium in order to avoid the formation of lumps. The viscosity of Xanthan gum changes significantly when different shear stresses are applied- the higher the shear, the lower the viscosity. (Katzbauer, 1998) With the addition of xanthan gum, particles and cloudiness increase and all texture characteristics like viscosity, slipperiness, starchy mouthcoating and oil mouthcoating increase significantly (Kim, H et al, 2017).

III. Specific processing and technique

The flowchart below gives the general idea of preservative-free chili sauce procedure.

Figure 1: flow chart of preservative-free chili sauce



pretreatment

using the chili washing machine, stems, pedicels and calyxes of red chilies are separated and washed thoroughly with water to remove soil and foreign materials.

Figure 2: chili washing machine



Steam blanching

Using the steam blanching machine, enzymes in chilies are inactivated. One relevant study has showed that blanching at 100⁰ C for 6 min was adequate in completely inactivating unfavorable enzymes in chili processing namely peroxidase and lipoxxygenase (Ismail, N., & Revathi, R. 2006).

Grinding and preheating

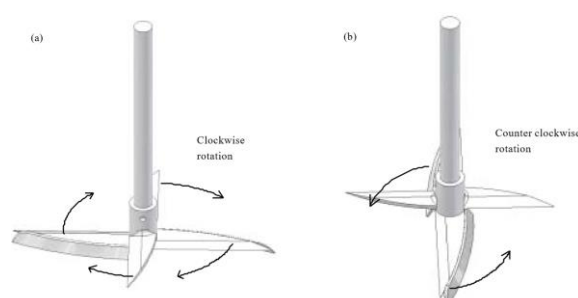
By grinding, red chilies are cut into relatively smaller particle sizes and liquefied. By

preheating, the temperature of red chilies is increased to make following evaporating more efficient. A new blending-heating machine is used to combine those two steps. The machine has four process parameters shown in table 4. This machine is controlled by programmable-logic-controller unit. The machine starts with both heating and blending operations, during the blending operation, blades are rotated in a clockwise direction at high speed(R1) using the sharp cutting surface along the edges of blades for liquefying red chilies. When the T1 (the particle size greatly depends on this temperature) is achieved, the rotation of the blades stops. Then the rotation of the blades in a counter clockwise direction at low speed (R2) where the wing flaps on the blade edges works in order to agitate to achieve better heat transfer. When T2 (temperature is near to boiling point) is achieve, blades stop (Mazlina et al, 2014).

Table 4: four process parameters of blending-heating machine

| Process parameter |
|--|
| Controlled temperature, T1 (°C) |
| Controlled temperature, T2 (°C) |
| Blade assembly speed during blending operation, R1 (rpm) |
| Blade assembly speed during cooking operation, R2 (rpm) |

Figure 3: rotation of blade assembly, (a) during blending operation and (b)during agitating operation



Add salts, sugar, Xanthan gum, vinegar

Adding Xanthan gum is to increase the viscosity of chili sauce and prevent layer separation and for longer shelf-life. Adding salt, sugar and vinegar contributes to the preservative effect and enhances the flavor. The salt and sugar can draw available water from within the food to the outside and insert salt or sugar molecules into the food interior and consequently reduce the water activity which measure of free water molecules in the food that is necessary for microbial survival and growth. Vinegar inhibits the growth of spoilage and poisoning bacteria due to acetic acid (Levine, A. S. et al, 1940). A preservation index which is used to calculate the amount of sugar and acid to be added is a measurement of the preserving power of combinations of acid and sugar (sugar is measured as 'total solids'). The formula is shown below:

$$\frac{\text{total acidity} * 100}{(100 - \text{total solids})} = \text{not less than } 3.6\%$$

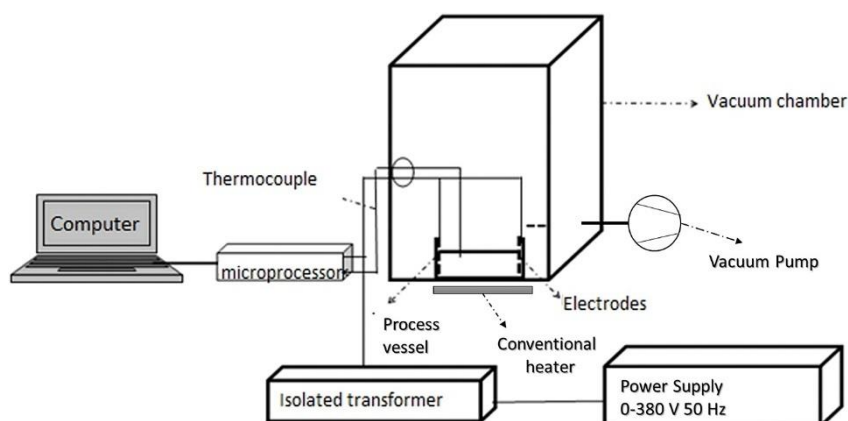
The correct preservation index ensures that chili sauce does not spoil after opening and can be used a little at a time. The preservation index of preservative-free chili sauce is

over 3.6%.

Ohmic heating assisted vacuum evaporating

The main aim of evaporation is to make chili sauce more concentrated. Moreover, the evaporating process not only can make chili sauce have higher resistance to microbial growth due to the reduction of water activity, but also can diminish the volume of chili sauce and therefore decrease the transport, storage, and packaging costs. However, the formation of undesired components and loss of quality characteristics are distinguished in the case of thermal evaporation method. A novel method ohmic heating assisted vacuum evaporation system (OVE) is used to substitute traditional thermal evaporation to reduce total process time and use energy more efficiently. The principle of ohmic heating (OH) is passing alternative current through the foodstuff with two electrodes which is used as a resistance and is heated as a result of intrinsic electrical resistance (Varghese et al, 2014). The vacuum evaporation is the most common evaporation method that utilized in industry. Vacuum evaporation is the process of decreasing the pressure in food container to below the vapor pressure, causing the water to evaporate at a lower temperature. Vacuum evaporation can minimize the damage to the food. The schematic diagram of ohmic heating integrated vacuum chamber system is shown in figure 4. The system consists of a vacuum chamber, a vacuum pump, a power supply with the isolating-variable transformer and a microprocessor board. It has a conventional heater to supply heat for vacuum evaporation process. The thermocouple measured the temperatures and microprocessor recorded voltage, current and temperature data which is conveyed to computer. The chili sauce is held between the two electrodes and the flow of electricity is through the chili sauce where it acts as a conductor (Sabanci et al, 2017).

Figure 4: schematic diagram of ohmic heating integrated vacuum chamber system



Bottling and pasteurizing

Using hot fill technology which contains the pasteurization is a good way to extend the shelf life and merge bottling and pasteurizing into one step. The chili sauce and hot fill bottles are first pasteurized to remove any microorganisms and then the hot fill bottles

are hot filled, capped and turned on their sides. Once this has taken place, the hot filled bottles are rapidly cooled through the use of water in the form of steam or shower. The glass bottle has excellent gas and water barrier properties and temperature resistance.

Labeling

Using the labeling machine, chili sauce is labeled. The label can provide complete information regarding the product including ingredients, usage, date of manufacturing, expiry date, batch number and other related information.

Packaging

Using automatic high-speed cartoning machine, 24 bottles of chili sauce are packaged into one carton. In this way, the transportation and storage are much more convenient.

IV. final product

Shelf life and Storage conditions

Due to the blanching which inactivates the enzymes in chili, evaporating which lowers the water activity, natural preservatives of salt, sugar and vinegar, hot filling technology combined with pasteurizing, the shelf life ranges between six months and 12 months. An unopened bottle of chili sauce should be kept in a cool and dark place, away from sunlight and sources of heat. Once the bottle is opened, it should be stored in the refrigerator to retain the freshness and quality for longer.

Nutritional value and sensory properties

Commercial chili sauces normally contain quite portion of oil and preservatives. But this chili sauce is low calories, preservative-free and much healthier. The chili sauce has bright red color containing of large amounts of particles which provided high flavor intensities and moderate heat intensity and sweet taste with high sourness and saltiness.

V. conclusion and discussion

This report investigates the processing of preservative-free chili sauce from raw materials to the final product using several new process units such as uniform blending-heating machine, ohmic heating assisted vacuum evaporation (OVE), hot filling technology. Moreover, choosing correct preservative index can avoid adding chemical preservative like sodium benzoate. Although the processing involves new process units to improve energy efficiency and the quality characteristics of chili sauce, some process units might can be merged further.

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