EFFECTS OF THERMAL AND NON-THERMAL PASTEURIZATION ON SHELF LIFE OF PROCESSED TOMATOES (*Solanum lycopersicum*)

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Abstract
This study investigated the effects of thermal and non-thermal pasteurization methods on processed tomato paste using vitamin C as a critical indicator. The effects on some physical properties namely colour, texture/smoothness, shelf-life/storage length, weight and lycopene content were assessed. It also assessed the step-by-step methods of tomato paste production under thermal pasteurization (heat treatment) and non-thermal pasteurization (oil filtration and refrigeration) methods. Furthermore, it provides an overview of the effects of thermal and non-thermal pasteurization. The results indicated that the processing of tomato paste by thermal pasteurization could help to enhance the storage length of the stored product. Thermal pasteurization, with the use of vitamin C as the critical indicator significantly preserved the amount of vitamin C content found in the processed tomato (x_2 = 15.32; df = 10; P > 0.003) with average mean values of 25.05Mg and 18.42Mg respectively compared to the amount of vitamin C content of 15.68Mg and 16.12Mg found in the processed tomato paste of non-thermal pasteurization.

Keywords: Thermal, Non-Thermal, Pasteurization, Shelf Life, And Tomatoes

Introduction
The word 'tomato' originates from the Nahuati (Aztec language) word *tomato*, literally known as "the swelling fruit" (Encyclopaedia Britannica, 2018). Tomato is the edible, often red, fruit of *Solanum Lycopersicum*, commonly known as a tomato plant. The tomato plant belongs to the nightshade family, which is called *Solanaceae*. Nigeria ranks as the second-largest producer of tomato in Africa, second only to Egypt, and 13th in the world. Nigeria produces 6million tonnes of tomato annually before 1990 (Erinle, 1989). However, the scale of tomato production in 2008-2009 seasons is evaluated to be between 1-2million tonnes (UNCTAD, 2012). This little fall required the importation of processed tomato worth ₦11.7billion ($75.5million) yearly; this makes Nigeria one of the primary importers of tomato globally.

The production of tomatoes in Nigeria in 2010 was about 1.8millon metric tonnes, which accounts for about 68.4% of West Africa, 10.8% of Africa's total output and 1.28% of world output. Unfortunately, the country still experiences a deficiency in critical inputs, lack of improved technology, low yield and productivity, high post-harvest losses and lack of processing and marketing infrastructure. The demand for tomato and its by-products far outweighs the supply due to lack of inadequate storage facilities for post-harvest processing, lack of improved technology and low yield and productivity.

The two major processing forms of tomato which can yield diverse products are the dehydration (drying; oven drying and sun drying) and wet milling method. The most important methods used are concentration (to a paste or puree) and drying either to fruit, pieces or to a powder (Dale *et al*, 1982). The by-products of dehydration are dried tomato slices and powdered tomato, while wet milling has a variety of by-products like; tomato paste, tomato puree, tomato jam, juice, ketchup, etc. Annual losses of fruits and vegetables in Nigeria is quite alarming at the rate of 40-50% due to mostly poor preservation and processing method (Okunoya, 1996).

Tomato (*Solanum lycopersicum*) as one of the major vegetable crops produced in Nigeria has a limited shelf life due to its perishable nature. During its short production season, there is oversupply, thereafter it becomes scarce and expensive during its off-production season. Tomato's inadequate preservation and storage, perishable nature and inadequate processing results in revenue loss for farmers. Climatic conditions for the agro-ecological zone for tomato's optimum production falls in Kano and some other states in Nigeria like Katsina, Jigawa, Zamfara, Bauchi, Sokoto and Taraba states. Hence, the call for investment into the opportunities available in processing tomatoes will minimize the annual mass wastage in the aforementioned regions to the barest minimum.

Tomato *(Solanum lycopersicum)* is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, salads, and drinks. While tomatoes are botanically berry-type fruits, they are considered culinary vegetables, being ingredients of savoury meals. The need to preserve tomato for home use (for stews, soups, sauces, curries, salads, etc) out of its season or add value to extra income. However, demand for this product is increasing daily in all regions of the country that is; every home's good, hostels and restaurants daily use, apart from the local markets; investors can also export.

The word pasteurization ‖ was originally named after the French scientist, Louis Pasteur, who invented the process of heating liquids (wine and beer) at a relatively mild temperature (about 55°C) for a short time to prevent spoilage (Silva *et al*., 2014; Wilbey, 2014). This quick heat method was known as pasteurization and was later applied to milk to kill pathogenic microbes and reduce the number of spoilage organisms.

Thus, traditional pasteurization refers to heat treatment of food (usually below 100°C) to destroy micro-organisms of public health significance. Pasteurization processes used in the food industry do not kill all micro-organisms in foods; they only target pertinent pathogens and lower levels of spoilage organisms that may grow during storage and distribution (Silva and Gibbs, 2010). Nowadays pasteurization has been widely accepted as an effective preservation method for killing pathogens in food products, with minimal loss of desired food quality. New technologies that can satisfy the goals of pasteurization have grown rapidly in recent years. The development of these emerging technologies calls for a broadening of the definition of pasteurization. However, there does not appear to be a universally accepted definition for pasteurization (NACMCF, 2006).

Material and Method

The experiment was carried out at the Forest Technology laboratory of Federal College of Forestry, Jericho, Ibadan. The college is situated at Jericho hill, under North West Local Government Area, Oyo State. The area lies in between the latitude 7S and 9N and longitude 3W and 58E of Greenwich Meridian Time (G.M.T). The climate condition of the area is dominated by rainfall pattern ranging from 1300 – 1500mm. the average temperature is about 37.2C and average relative humidity of 27 – 100%. There are two distinct seasons namely; dry season which commences from November – March and rainy season which commences from April – October (FRIN, 2015).

Materials Used

The materials used for the experiment are as follows;

- Ripe matured tomato fruit (*Solanum lycopersicum*), Water, Grinding machine, Plastic bowls, Cooking pots (2), Gas cooker, Vegetable oil (4 litres), Foil paper, Lemon, Sieve Calibrated Laboratory thermometer, Spatula or stirrer, Sensitive scale (Weighing balance), Meter rule, Airtight containers (12)

Data Collection

The tomato fruit (*Solanum lycopersicum)* used for this research work was procured from Sasa Market, Sasa, Ibadan, likewise the lemon. The airtight containers, plastic bowls, vegetable oil, sieve, spatula, weighing balance, thermometers, and foil paper was procured from Ogunpa Market, along Dugbe, Ibadan. The experiment was carried out at the Forestry Technology Laboratory of Federal College of Forestry, Jericho, Ibadan.

Result and Discussion

The result obtained from the processed tomato paste shows distinct significant differences in the content of vitamin C present in the processed tomato paste. Non-thermal pasteurization as stated in table 1 has more vitamin C content of 25.05Mg and 18.42Mg present in processed tomato paste but for thermal pasteurization, the result of its vitamin C content is less when compared with non-thermal pasteurization with the values of 15.68Mg and 16.12Mg of vitamin C content present in its tomato paste. This loss occurred in thermal pasteurization at the beginning of the thermal treatment (Elez – Martinez and Martin – Belloso, 2007; Koo *et al,* 2008; Torregrosa *et al,* 2006).Vitamin C is highly needed in the human diet; therefore, I suggest that non-thermal pasteurization did best in the preservation and retention of its vitamin C (South pacific foods, 1995).

Table 1. Laboratory Result of Vitamin C Content in the Processed Tomato Paste

Pasteurization Methods	Samples	Vitamin C (Mg/100g)	Mean (Mg/100g)
Non-Thermal Pasteurization	1	25.45	25.05
	1	24.85	
		24.85	
	1		
	2	18.54	18.42
	2	18.54	
	2	18.18	
Thermal Pasteurization	1	15.76	15.68
	1	15.51	
		15.76	
	1		
	2	16.00	16.12
	2	16.00	
	2	16.36	

Table **2** shows the total weight of the tomato fruits used for the non-thermal pasteurization. The weight was measured to determine the average amount of moisture in the fruits before milling. After milling, the juice was left hanging to the drain. This took time because of the amount of moisture in the fruit and the size of the sieving mesh.

Table 2. Weight of Tomato Fruit for Non -Thermal Pasteurization

Types of Pasteurization	Weight of Individual Tomato Fruit (g)	Total Weight Per Container (Tw) g	Mean (Tw/6) g
NON-THERMAL PASTEURIZATION	106	652	108.67
	105		
	89		
	117		
	126		
	109		
	122	662	110.33
	136		
	104		
	102		
	121		
	77		

Table **3** shows the total weight of the fruit used for processing the tomato paste with thermal pasteurization. The weight of tomato fruit in container 1 (422g) is more than what was in container 2 (385g) weight compared to. Unlike non-thermal pasteurization, the thermal pasteurization method is not having the draining of ground tomato fruit that is the tomato juice being subjected to draining during processing. Therefore, the tomato juice spent more time while heating to dryness.

Table 3. Weights of Tomato Fruit for Thermal Pasteurization

Types of Pasteurization	Weight of Individual Tomato Fruit (G)	Total Weight Per Container (Tw) G	Mean (Tw/6) G
Thermal Pasteurization	82	422	70.33
	48		
	72		
	63		
	92		
	65		
	66	385	64.17
	77		
	67		
	39		
	81		
	55		

Table **4** shows that Non-thermal Pasteurization has pale red colour of processed tomato paste which is the nearest to the ideal colour of processed tomato paste, the most ideal and in agreement to the lycopene or colour pigment is Thermal Pasteurization of processed tomato paste.

Both non-thermal pasteurization and thermal pasteurization are ideal for the processed tomato paste according to the texture of the tomato paste. The texture characteristics of processed tomato paste were evaluated by sensory method but an instrumental method can also be used. The sensory evaluation offered the opportunity to obtain a complete analysis of the textural properties of the paste as perceived by the human sense (Bourne, 1982; Abbott, 2004).

Both non-thermal pasteurization and thermal pasteurization lasted for more than two (2) months according to this project. The shelf life of the tomato paste as it seems is defined as the period for which a product remains safe and meets its quality specifications under expected storage and use conditions (ECFF, 2006). The product shelf life is influenced by several factors which only the manufacturer is responsible for determining it via the raw materials quality, product formulation (pH), hygiene during manufacturing, preservative treatments, cooling methods applied to products, type of package, and storage temperature (CAC, 1999).

Table 4. Physical properti es of the Processed Tomato Paste

Treatment	_	Colour	Texture	Storage Length
NTP	T_1T_1	Pale Red	Smooth	2 Months
	T_1T_2	Pale Red	Smooth	˃ 2 Months
TP	T_2T_1	Red	Smooth	˃ 2 Months
	T_2T_2	Deeply Red	Smooth	˃ 2 Months

Conclusion

The study reveals the appropriate pasteurization method in terms of high available content of 25.05mg and 18.42mg of vitamin C in non-thermal pasteurization of processed tomato paste and low-value content of 15.68mg and 16.12mg of available vitamin C in thermal pasteurization. It was revealed that the lycopene content in the processed tomato paste that underwent thermal pasteurization maintained their colour while for non-thermal pasteurization, their colour deteriorated from the original colour at the point of processing and during storage. The texture of both types of pasteurization did not change. The storage length of both types of pasteurization exceeded two (2) months.

Recommendation

Based on the result obtained in this study, it is therefore recommended that thermal pasteurization referred to as heat treatment is optimum for the pasteurization of processed tomato paste.

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