International Journal of Multidisciplinary Research and Growth Evaluation.

Proximate and nurtional composition of ketchup produced from two local tomato varieties (*Solanum lycopersicum*) stabilized with Okoho (*Cissus populnea)* gum extract

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Article Info

ISSN (online): 2582-7138
Volume: 04
Issue: 02
March-April 2023
Received: 20-02-2023;
Accepted: 13-03-2023
Page No: 264-267

Abstract
This study investigated the proximate and nutritional composition of ketchup produced from locally grown *Solanum lycopersicum* varieties, stabilized with either a *Cissus populnea* extract or a commercial stabilizer. The tomatoes were sorted, washed, chopped, cooked, milled, filtered, spiced, and concentrated to reduce moisture content. The *Cissus populnea* extract was produced by drying the roots, scraping, shredding, washing, and soaking in hot distilled water, then filtering to obtain a more viscous product. The ketchup was formulated by adding sugar, salt, vinegar, garlic, pectin or *Cissus populnea* gum extract to the tomato mixture, and then subjected to analysis for proximate and nutritional composition. The results showed that the moisture content ranged from 69.49% to 71.45%, ash from 1.06% to 1.94%, fat from 0.10% to 1.11%, fiber from 0.35% to 2.27%, protein from 0.62% to 3.31%, and carbohydrate from 23.39% to 26.44%. The vitamin A content ranged from 19.58% to 29.03%, vitamin C from 5.28% to 10.55%, and lycopene from 1.84µg/g to 3.36µg/g.

Keywords: Proximate, nurtional, *Cissus populnea*, *Solanum lycopersicum*

1. Introduction

Tomato is the edible berry of the plant *Solanum lycopersicum*, commonly known as a tomato plant (Anon, 2014) [5]. It originated in western South America, and domestication is thought to have occurred in Central America (Kimura and Sinha, 2008) [19]. Due to its importance as food, tomato has been bred to improve productivity, fruit quality, and resistance to biotic and abiotic stresses. Tomato has been widely used not only as food, but also as research material (Kimura & Sinha, 2008) [19].

According to Fleming (2013) [16], tomatoes are a significant source of umami flavor. Tomato is consumed in diverse ways, raw or cooked, in many dishes, sauces, salads, and drinks. They are the major dietary source of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart disease and cancer (Bjarnadottir, 2019) [12]. They contribute to a healthy, well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. Tomato contains much vitamin B and C, iron and phosphorus. They can be processed into purées, juices and ketchup.

Ketchup is a commonly consumed and popular foodstuff that has been more often discussed in recent years, particularly because of its lycopene content and related beneficial properties (Bednar *et al*., 2014) [11]. It is a sweet and tangy condiment made from tomatoes, sugar, and vinegar, with seasonings and spices.

The consistency and viscosity of tomato ketchup is a major quality component for consumer acceptance (Ghandi *et al*., 2008) [17]. During storage, tomato ketchup tends to lose its consistency due to hydrolysis and also there is some syneresis (serum seperation), both of which are not liked by the consumer (Gujral *et al*., 2007) [18]. To this problem, stabilizers are added to improve the body, texture, appearance, mouth feel and retards syneresis of ketchup (Abd El Gawad *et al*., 2002) [1]. The use of stabilizers to improve the sensory attributes of ketchup and enhance profitability in ketchup making has become common practice (Oguama, 2018) [21]. Presently commercial ketchup are mainly stabilized with exotic stabilizers such as guar gum, gelatin, pectin, carboxyl methyl cellulose (CMC), xanthan gum, among others. However, several local stabilizers such as *Cissus populnea* which is known for its numerous health benefits, medicinal remedies (Chukwuma & Soladoye, 2012) [14] and low cost can be used in place of these exotic ones.

2. Materials and Methods

The tomato fruit, salt, sugar, vinegar, pectin and other spices were sourced and purchased from Ogige market in Nsukka Local Government Area of Enugu, Nigeria. The local stabilizer, *Cissus poplunea* root was purchased from Nkwo Ibagwa market, Igbo-eze South, Local Government Area, Enugu State, Nigeria.

2.1 Processing of *Cissus populnea* Root

Cissus populnea root extract was obtained by method described by Alakali *et al.* (2009) [2] with a slight modification. The roots were dried, scrapped, shredded, washed and soaked in hot distilled water for 12 hours at 80 °C. At the end of the soaking, it was kneaded for 10 minutes to facilitate leaching of the water soluble polysaccharide and filtered using a muslin cloth to obtain the mucilage. The mucilage was concentrated by boiling at 30 °C for 20 minutes to remove excess moisture and obtain a more viscous product (the extract). It was then cooled and stored in a refrigerator.

2.2 Formulation of Tomato Ketchup Sample

The modified method according to Okafor (2019) [22] was adopted. One kilogram ripe red quality tomatoes were sorted, washed and chopped. The pulp was transferred into a thick pot and cooked for 20 minutes. The seeds and skin of the tomatoes were removed by churning and filtering immediately using a blender and muslin cloth. The mixture was placed into an open pan, one-third of the sugar was added and allowed to boil for 15 minutes. The spices were weighed and tied with a muslin cloth (onion and garlic were chopped) and dropped into the vessel of the tomato pulp. The mixture was then heated on a hot plate, set at a moderate temperature, and stirred continuously until the mixture reached the desired temperature of 80 °C and was allowed to boil for 20 minutes. Pectin was blended with the remaining two-third of the sugar and salt which were added at the later stage to prevent burning and further cooked for 10 minutes. Vinegar was added last and the sauce was finally brought to doneness after 5 minutes. At the end of cooking process, the ketchup was allowed to cool to a temperature not lower than (40 °C), hot filled into sterilized bottle and tightly closed. The ketchup was cooled to room temperature and stored away from sunlight in a cool place.

3. Experimental Design and Statistical Analysis

The study adopted the completely randomized design (CRD). Data generated from the study was analyzed using one-way analysis of variance (ANOVA) using Statistical Package for Service Solution (SPSS) version 25 and the means separated using Duncans New Multiple Range Test and level of significance accepted at $p < 0.05$ (Steel and Torrie, 1980) [25].

3.1 Analysis

3.1.1 Proximate Composition

The proximate composition of each sample was determined based on the standard method of the Association of Official Analytical Chemists (AOAC, 2010). The analysis carried out on the ketchup samples were moisture content, ash, fat, crude fibre and crude protein (Kjeldahl method). Carbohydrate was determined by difference.

3.1.2 Nutritional Composition

Vitamin A content was determined according to procedure of Prentice and Langridge (1992) [24]. Vitamin C content was determined according to the method of Olokodona, (2005) [23]. Lycopene content of tomato ketchup samples were determined with the method described by Barros *et al.* (2008). The absorbance of the extract was measured at 487 nm using a spectrophotometer (model no. 754N, Search Tech).

4. Results and Discussion

4.1 Proximate Composition of the Ketchup Samples

The result for the proximate composition of the ketchup samples are shown in Table 1. N Moisture content of the samples ranged from 68.49 - 71.45 % with all samples (except SB and SE) significantly ($p<0.05$) different from each other. SD had the highest moisture content (71.45 %) while SA had the lowest (68.49 %). This difference was as a result of the different varieties of tomatoes used in the production of the samples. Product having high moisture content has minimum shelf stability (Ayub *et al*., 2005) [7]. The results obtained for moisture content were similar to that of Okafor (2019) [22] but that of Anandsynal *et al*. (2019) was different as their moisture content decreased.

The ash content of the given samples ranged from 1.06 - 2.18 %. There was no significant ($p>0.05$) in SA and SC, also, in SB, SD and SE. Maximum ash content was found in SD (2.18 %) and the minimum in SA (1.06 %). The variations in ash contents of the samples may be attributed to the varieties of tomatoes used. Results obtained for the ash content were similarly reported for the ash content of nutritionally enriched ketchup (Nutri-Ketchup) from acerola and tomato which ranged from 1.81 - 3.37 % by Baskaran *et al*. (2016) [10] while that of Anandsynal *et al*. (2019) were not within range.

Fat content of the samples ranged from 0.10 - 1.11%. SB had the highest fat content (1.11 %) while SE had the lowest fat content (0.10 %). There was no significant ($p>0.05$) difference between SA and SB and also between SC and SD. This significance and variation may be attributed to the addition of *Cissus populnea* gum extract to the samples. The above result was similar to values reported by Okafor (2019) [22] which ranged from 0.48 - 4.98 %. He observed an increase in the fat content which was brought about by the addition of Ehuru and Uziza to the samples.

The crude fibre content of the samples ranged from 0.35 - 2.75 % with SA and SC having the highest values and SD, the lowest. This can be attributed to the variety of tomato used and it indicates that San marzano has more fibre than better boy. There was no significant ($p>0.05$) difference between samples SA and SC and between SD and SE. The result obtained was similar to values reported by Anandsynal *et al*. (2018) [3] and Kumar and Ray (2016) [20] which ranged from 0.54 - 2.73 % and 2.61 - 2.80 % respectively.

Most of the common fruits are low in protein. Tomato contains very little amount of protein (0.9 %) as fresh fruits (USDA nutrient database, 2010). The proteins from the ketchup samples ranged from 0.62 - 3.31 % with all samples signigicantly ($p<0.05$) different from each other. The inclusion of *Cissus populnea* gum extract to samples SA and SB led to the increase in their protein contents. Result observed in this study for SA, SB, SC and SD on protein content were within range with that reported for the protein content in tomato-mushroom mixed ketchup (2.45 - 4.21 %) by Kumar and Ray (2016) [20]. The protein contents of the samples increased as the quantity of mushroom added increased.

Carbohydrate content of SE (26.44 %) was found to be higher than the other samples. This may be attributed to low content of the fat, fibre, ash and protein of the sample as carbohydrate was calculated by difference. The carbohydrate content ranged from 23.39 - 26.44 % with no significant ($p>0.05$) difference between SA and SB. According to Okafor (2019) [22], the carbohydrate content of the ketchup samples ranged from 16.94 - 25.07 % which was similar to that obtained in this study. Anandsynal *et al*. (2018) [3] reported values contrary to the above results.

Table 1: Proximate composition of ketchup samples stabilized with *Cissus populnea* root and pectin

Parameters	Treatment SA	SB	SC	SD	SE
Moisture (%)	$68.49^a\pm0.21$	$70.41^c\pm0.18$	$69.18^b\pm0.24$	$71.45^d\pm0.31$	$70.43^c\pm0.27$
Ash (%)	$1.06^a\pm0.22$	$1.94^b\pm0.11$	$1.08^a\pm0.25$	$2.18^b\pm0.23$	$1.93^b\pm0.18$
Fat (%)	$1.04^c\pm0.01$	$1.11^c\pm0.03$	$0.16^a\pm0.08$	$0.41^b\pm0.16$	$0.10^a\pm0.03$
Crude Fibre (%)	$2.63^d\pm0.24$	$0.63^b\pm0.03$	$2.75^d\pm0.15$	$0.35^a\pm0.14$	$0.48^b\pm0.03$
Crude Protein (%)	$3.31^d\pm0.16$	$2.52^c\pm0.08$	$1.65^b\pm0.13$	$1.36^b\pm0.13$	$0.62^a\pm0.11$
Carbohydrate (%)	$23.47^a\pm0.25$	$23.39^a\pm0.28$	$25.18^c\pm0.19$	$24.25^b\pm0.23$	$26.44^d\pm0.20$

Samples with different superscripts are significantly different at $p<0.05$

Key: SA = San marzano + *Cp* root; SB = Better boy + *Cp* root; SC = San marzano + pectin; SD = Better boy + pectin; SE = Control; *Cp* = *Cissus populnea*

4.2 Nutritional Composition of the Ketchup Samples

Result for the nutritional composition of the ketchup samples stabilized with *Cissus populnea* root and pectin are presented in Table 2. The provitamin A content of the samples ranged from 19.58 - 29.03 µg/g. All the samples were significantly ($p<0.05$) different. The highest value was observed in SE, commercial ketchup while the least was observed in SD, Better boy + pectin. The difference in the provitamin A content of the samples may be attributed to the varieties of tomato used. According to the USDA (2010), 100 g of ketchup contains 513 IU of provitamin A and 1g of ketchup contains 5.13 IU or 3.08 µg. Therefore, it can be seen that the result obtained from the analysis has higher provitamin A content than the speculated amount.

Vitamin C content of the ketchup samples ranged from 5.28 - 10.55 mg/100g with SB having the highest values and SE, the lowest. There was no significant ($p>0.05$) difference between SA and SB. This may be due to the addition of *Cissus populnea* gum extract to the samples. These results were in contrast with Baskaran *et al.* (2016) [10] who gave values ranging from 14.6 - 45.7 mg/100g and with Bahlol *et al*. (2005) [8] whose values raged from 8.11 and 60.04 mg/100g.

Lycopene is a major dietary carotenoid protecting cells against oxidative damage to lipids, proteins, and DNA (Dziedzic, *et al*., 2020) [15]. Its content in the samples ranged from 1.84 – 3.86 (µg/g) with significant ($p<0.05$) differences observed between the samples. The highest value was observed in SA which was stabilized with *Cissus populnea* gum extract which had a reddish-brown colour. The observed results were in contrast with Borojevic *et al*. (2019) [13] who reported 9.20 (µg/g) for the lycopene content. The more the lycopene, the more is the ripened tomato content (Anon, 2019) [4]. Low levels of lycopene indicate the use of either less or unripe quantity of tomato pulp or poor quality of tomatoes (Anon, 2019) [4].

Table 2: Nutritional composition of the ketchup samples stabilized with *Cissus populnea* root and pectin

Parameter	Treatment SA	SB	SC	SD	SE
Provitamin A (µg/g)	$19.76^b\pm0.05$	$21.40^c\pm0.04$	$25.11^d\pm0.02$	$19.58^a\pm0.06$	$29.03^e\pm0.02$
Vitamin C (mg/100g)	$10.50^d\pm0.03$	$10.55^d\pm0.40$	$6.52^b\pm0.29$	$7.20^c\pm0.13$	$5.28^a\pm0.04$
Lycopene (µg/g)	$3.86^e\pm0.05$	$3.22^d\pm0.05$	$2.65^c\pm0.04$	$2.31^b\pm0.02$	$1.84^a\pm0.13$

Samples with different superscripts are significantly different at $p<0.05$

Key: SA = San marzano + *Cp* root; SB = Better boy + *Cp* root; SC = san marzano + pectin; SD = Better boy + pectin; SE = Control; *CP* = *Cissus populnea*

5. Conclusion

According to the study conducted, it was found that our local tomatoes can be used to produce high-quality ketchup that is acceptable to consumers. The researchers analyzed the properties of ketchup made from two different tomato varieties, SA (San Marzano) and SB (Better Boy), which were stabilized with *Cissus populnea* gum extract. The results revealed that these two types of ketchup had a significantly higher quality standard compared to the control product, SE. Moreover, the addition of *Cissus populnea* gum extract as a stabilizer to the ketchup significantly improved its proximate composition, vitamin C, and Lycopene content. This finding is particularly significant because Lycopene is a powerful antioxidant that has been linked to numerous health benefits, including a reduced risk of cancer and heart disease. Notably, the study demonstrated that ketchup made from local tomatoes can be of high quality and that the addition of *Cissus populnea* gum extract as a stabilizer can further enhance its nutritional value. This information could be useful for food manufacturers and farmers interested in producing high-quality ketchup from locally sourced tomatoes.

6. Recommendation

According to the findings of the study, the ketchup made with *Cissus populnea* is highly recommended for consumption due to its exceptional antioxidant content and potential medicinal benefits. The *Cissus populnea* plant, which is known for its various health benefits, has been proven to be an excellent ingredient for producing ketchup that is not only tasty but also health-promoting. However, it is important to note that the samples stabilized with *Cissus populnea* root had an increased fat content compared to the commercial ketchup which had lower fat content. Therefore, for individuals who are concerned about their weight, it may be more beneficial to consume the commercial ketchup.

In addition, the study suggests that the production of *Cissus*

populnea gum should be exploited to enhance its utilization in the food industry. This would not only increase the availability of the plant for food processing but also provide a new source of income for farmers who cultivate the plant.
To further promote commercial production of *Cissus populnea*, farmers should be encouraged and educated on the benefits of cultivating this plant. This would ultimately make it more readily available for use in the food industry and possibly result in new food products that harness the health-promoting properties of this plant. Overall, this study highlights the potential benefits of using *Cissus populnea* in food processing and the need to further explore its utilization in the food industry.

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