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Comparative and quality analyses of different tomato brands sold in major markets in Ibadan, Nigeria

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Tomato paste is consumed in many homes. It is a good source of lycopene and vitamin C. These are antioxidants which fight against free radicals and oxidative stress. It had been reported that tomato pastes imported into Nigeria were often substandard and adulterated with starch, but these claims have not been supported using evidence based study. The aim of the study was to assess the quality of different tomato brands made in Nigeria and those imported into the country using biochemical parameters. Twenty eight different tomato products were identified in the market. Of these numbers, sixteen were randomly selected. Five tins and sachets each of these products were purchased respectively and used for analyses. All the products sampled were registered with the National Agency for Food and Drug Administration and Control. There were significant differences in moisture, Lycopene, total sugar, starch, vitamin C and acidity among all products (P<0.05). Of all the tin tomato products analyzed, 14 (87.5%) contained sugar as against 2 (12.5%) which were sugar- free and 13 (81.25%) contained starch as against 3 (18.75%) which were starch- free. The starch contained in the tomato brands was not declared in over 75% of the products. The biochemical contents of tomato brand made in Nigeria were of comparable quality with those made in US and Italy (P>0.05). However, tomato brands imported from China were significantly higher in total sugar and starch, but significantly lower in lycopene (P< 0.05). Variations in content were observed between tin and sachet of the same brand and between different batches of the same product. This study provides scientific evidence that tomato products made in Nigeria are better in biochemical quality than products imported from China. The need to patronize and support local manufacturers while tightening regulatory and registration processes of products imported into the country becomes imperative.

Key words: Tomato, quality assurance, biochemical analysis, Free radicals, oxidative stress, antioxidants.

INTRODUCTION

Tomato is an annual vegetable commonly consumed in Nigeria. It is a widely distributed crop which can be consumed fresh, cooked or processed into a paste or syrup, otherwise called a tomato puree. Tomato crop can

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grow in several climates and this confers on the crop its ability to survive at various temperatures. More than 30% of global tomato is grown from the Mediterranean (Ahmet and Vedat, 2009). However, a greater percentage also comes from Turkey which is located in the East of the Mediterranean (Ahmet and Vedat, 2009). According to Powell et al. (2003), tomato is grown with a view to consuming it fresh or processing it into other forms such as paste or puree. A good number of tomato paste products currently sold in Nigeria are mostly supplied from China and other Asian Countries.

Studies had shown that lycopene from processed tomatoes were better absorbed than lycopene from fresh tomato (Anonymous, 1997). This suggests that processed tomato products such as tomato paste, tomato sauce and ketchup are better sources of this antioxidant. It has also been reported that lycopene from tomato paste is 2.5 times more bioavailable in humans than lycopene from fresh tomatoes especially when boiled with oil, a common medium in which tomato is prepared in this region of the world (Anonymous, 1997; Ahmet and Vedat, 2009). Recent reports have shown that lycopene helps prevent the development of some cancers, such as prostate cancer (Anonymous, 1997). This implies that commercially sold processed tomato paste should contain a good amount of this phytochemical which should be able to benefit humans when consumed. Several parameters have been used to assess the quality of tomato paste. These include: The consistency, total solids content, titratable acidity, pH and levels of sugar (Ahmet and Vedat, 2009, Lu et al., 2014).

Well- structured studies which examine the quality of different tomato brands sold in Nigeria are limited. However, available but unvalidated reports have repeatedly shown that many tomato brands imported into the country were adulterated with starch and colorants.

Umeofia (2016) a leading chief executive in one of the tomato manufacturing companies in Nigeria, has lamented that the country loses huge sums of money to importation of fake tomato products. He reported that a good number of tomato products imported into the country from Asia were often adulterated with starch which could have adverse effects on the health of Nigerians.

Shehu (2013) reported that Nigeria had turned into a dumping ground for fake and low quality tomato products imported from Asia. He further reported that the spate of importation of adulterated tomato sauce in the name of tomato paste was of grave concern to stakeholders in the tomato industry. The infiltration of poor quality tomato products into the country has been attributed to the activities of unpatriotic marketers conniving with unethical foreign companies to bring into the country tomato paste loaded with starch and treated with food colour additives in order to achieve the deep red colour. The premium placed by the National Agency for Food and Drugs Administration and Control (NAFDAC) on the scrutiny of drugs imported into the country to the detriment of food and cosmetics has also enhanced the activities of unpatriotic marketers of tomato products (Shehu, 2013).

The importation of fake tomato products is not only a problem in Nigeria. The Ghana Standards Board (Daniel, 2015) has reported that most tomato brands sold in Ghana contained starch and sugar which have raised eyebrows and safety concerns among the consumers of such products. The reports showed that the products had labels which indicated that they contained modified starch, tomato paste, sugar and some acidic component, but there were no indications of the relative quantities of those ingredients, a situation which has raised concerns over the quality of the products and the possible health implications related to their consumption.

The consequences of consuming fake and substandard products are better imagined than experienced. The effects and several deaths resulting from *My Pikin* teething powder episode in Nigeria can never be forgotten. The high prevalence of several diseases such as cancer, hypertension, diabetes, cardiovascular disorders, kidney and liver diseases are evident within the country. Several manufactures have been forced to close their businesses and companies due to preference of Nigerians to imported good even when such products are unhealthy and substandard when compared with local made products.

Nigeria is the biggest economy in Africa. Premised on her economic size and huge population, manufacturers all over the world have hinged on these to bring in several products into the country with a view to increasing sales and making more profit. The desire for imported goods has driven many Nigerians to relegate to the background several products manufactured locally; even when it has been hypothesized that local made goods were better than imported products. On this account, several manufactures from across the globe have brought in fake and substandard products into the country believing that since most Nigerians prefer cheap products to costlier ones, reducing the quality of such products could attract more purchase and patronage. This has predisposed the nation to become a dumping ground for several substandard, fake and unhealthy products. With poor regulatory systems, poor adherence to quality management systems and porous borders, there is no doubt that it is the responsibility of researchers to assess the quality of several products sold in the nation's markets with a view to generating evidence based data and information which could be helpful in strengthening regulatory agencies, formulate better polices that will benefit the nation, improve public health and quality of life of citizens.

Considering the lack of documented information on the quality assessment of imported and locally produced different tomato paste sold in the Nigeria market, this study was conducted to bridge this gap. The objectives of the study were to determine the biochemical parameters

contained in selected local and imported tomato brands, to ascertain if imported tomato brand was better than those manufactured and packaged locally, to determine if there were differences in content between tin and sachet of the same tomato brand and to ascertain if there were variations in content between different batches of the same tomato brand. The information generated would help consumers of tomato products to make an informed decision when choosing available products.

MATERIALS AND METHODS

Study area and site

Different brands of tomato paste sold in two major markets in Ibadan, Agbeni and Bodija were identified. In all, 28 different tomato brands were identified. Of these brands, 16 of them were selected at random. Five tomato tins each of selected brands were purchased from randomly selected retailers of the tomato products. Tomato brands, having corresponding sachet were also selected. This gave a total of 80 tins and 50 sachets of different tomato brands including Hunt, a tomato paste manufactured and approved by the United States Food and Drug Administration (USFDA). Both tins and sachets of selected tomato brands were all registered with the National Agency for Food and Drug Administration and Control (NAFDAC). Products endorsed by the Nigeria Industrial Standards (NIS) were noted and documented. The manufactured and expiry dates, country of origin and batch numbers of all products were noted and recorded.

Justification for market selection

Agbeni and Bodija markets are the melting points of major commercial activities not only for people living in Ibadan, but for many other states in the South West geo political zone. These markets are major commercial nerves for major distributors and consumers in Oyo state and other nearby South Western states. Majority of house hold products are deposited at these markets by different producers from where many retailers and users come to repurchase both for resale and household consumption.

Sample size calculation

Studies examining the quality of different brands of tomato paste sold in Nigeria are limited. One of the outcomes for the determination of the quality of tomato is the quantity of lycopene contained in the tomato paste. The study conducted by Maria et al. (2014) in Mexico on quality parameters and bioactive compounds of red tomatoes at different post-harvest conditions reported a standard deviation of 1.5 lycopene in tomatoes. Using this information, the number of tomato paste which we used for this study was calculated using the following formular (Fleiss, 1986):

$$N = \frac{2(Z_\alpha + Z_\beta)^2 \delta^2}{(\mu_1 - \mu_2)^2}$$

Where: Z_α = standard normal deviate corresponding to 2 sided level of significance of 5% =1.96; Z_β = standard normal deviate corresponding to 80% power = 0.84; N = number of samples; δ = standard deviation; $(\mu_1 - \mu_2)$ = assumed difference in means between the two groups considered significant. It is assumed to be 50% of the standard deviation.

Therefore, the minimum number of tomato samples used was calculated thus:

$$N = \frac{2 \times (1.96+0.84)^2 \times (1.5)^2}{(0.75)^2}$$

$$N = \frac{2 \times 7.84 \times 2.25}{0.56}$$

$$N = 62.72$$

Therefore the minimum number of tomato samples was 63. In order to make room for easy generalization of information, the sample size was increased to 130 tomato samples.

Selection criteria

The inclusion and exclusion criteria for all tomato brands used for the study were ass follows.

Inclusion criteria

1. Presence of NAFDAC number
2. Availability of Batch Number
3. Availability of Manufactured and Expiry Dates
4. Indication of country of production or packaging
5. Must either be in tin and/ or sachet

Exclusion criteria

1. Absence of NAFDAC Number
2. Non-availability of Manufactured and Expiry Dates
3. No inscription of country of origin
4. Absence of batch number

Laboratory analysis

All biochemical parameters associated with this study were analyzed at the Nigerian Institute of Science Laboratory Technology (NISLT) Samonda, Ibadan**.** The following analyses were performed in all the samples: Moisture content, total solids, lycopene, total sugar, starch content, vitamin C and total acidity. All parameters were measured using the approved and validated method of Association of Official Analytical Chemists (AOAC, 2000).

Laboratory methods

Analysis of starch and sugar

Protocol summary: Starch was first hydrolysed to sugar. The sugar was determined using the Lane and Eynon method. Result was expressed in g/100 g (w/w) of tomato paste. The level of starch was determined by multiplying the sugar value by a factor of 0.9. The value obtained was expressed in g/100 g of tomato paste. The presence of starch was qualitatively confirmed using the iodine method. (AOAC, 2000: 923.09). Ethical approval for this study was obtained from the Oyo State

Vitamin C

Protocol summary: Ascorbic acid was oxidized to dehydroascorbic

acid by bromine water in the presence of acetic acid. After coupling with 2, 4, Dinitrophenyl- hydrazine, DNPH, the solution was treated with 85% H_2SO_4 to produce a red complex. The colour formed was measured spectrophotometrically at 521 nm. The intensity of colour formed was directly proportional to the concentration of vitamin C present in the sample. The result obtained was expressed in mg/100 g of tomato paste (Rahman et al., 2006).

Total solids (AOAC, 2000)

Protocol summary: The total solids content is a measure of the amount of paste remaining after all the water has been evaporated in an oven. The mass of the residue is expressed as a percentage (%) of the original mass of paste. The Gravimetry, weight difference recorded after removal of moisture from the tomato paste by oven-drying is a function of the total solids. Data obtained was expressed in g/100 g (w/w) of paste (AOAC 2000).

Moisture (AOAC, 1995)

Summary of protocol: The moisture content was determined by measuring the mass of tomato paste before and after the water was removed by evaporation in an oven. The mass of the residue is expressed as a percentage (%) of the original mass of paste. Gravimetry, weight difference after removal of moisture by oven-drying was determined. Data was expressed in percentage (w/w) (AOAC, 1995).

Determination of total acidity (AOAC, 2000)

Protocol summary: The volume of 0.1 M solution of NaOH required to neutralize a standardized and measured amount of sample is the function of its acidic content. Since citric acid is the commonest acid present in fruits, volume of NaOH consumed is directly proportional to the citric acid present in the sample. The data obtained was expressed in g/L of citric acid (AOAC, 2000).

Spectrophotometric determination of lycopene

Protocol summary: Lycopene was extracted using hexane, ethanol and acetone mixture. The extract was measured spectrophotometrically at 503nm. The data obtained was expressed in mg/100 g (Anonymous, 2016).

Data analysis and management

Data collected from biochemical analysis were analyzed using SPSS version 20 statistical software. Data obtained were expressed as mean and ± standard deviation (±SD) for quantitative variables. Paired t-test was used to test the significance of the difference between mean values of laboratory results. One way Analysis of Variance (ANOVA) was used for comparison of means between groups. Where required, appropriate graphical application was used to express data and non-parametric analysis was used to determine the degree of significance between means.

Ethical issues

Ethical approval for this study was obtained from the Oyo State Ministry of Health Ethical Committee (Approval Reference AD13/479/1016 of February, 2016) All samples were blinded during the sampling and analytical phases of the study, but were unblinded during the reporting stage. This was performed to eliminate bias. Confidentiality of data was maintained in all stages of the study.

RESULTS

The mean concentration and comparative analysis of various biochemical contents among different tin tomato products is shown in Table 1. It was evident that there were significant differences in moisture, lycopene, total sugar, starch, vitamin C and acidity among all products ($P<0.05$). Figure 1 shows percentage tomato products that contained and those that did not contain sugar. Of all the tin tomato products analyzed, 14 (87.5%) contained sugar in varying degrees against 2(12.5%) which were sugar free. Of all the tin tomato products analyzed, 13 (81.25%) contained starch in varying degrees as against 3 (18.75%) which were starch free (Figure 2). Among the tomato brands which contained starch, such was not declared in a good number of the tomato products (Figure 3).

Figures 4 to 8 show the mean concentrations of lycopene, starch, sugar, total acidity and total solids contained in sachets of different tomato brands.

A comparative analysis in biochemical parameters between tomato products made in Nigeria and those imported from other countries such as China, Italy and USA using ANOVA showed that there were significant differences in moisture ($P= 0.008$), lycopene ($P=0.001$), total sugar ($P= 0.000$) and starch ($P=0.000$) (Table 2). Post Hoc analysis of tomato products made in Nigeria and those from other countries showed that tomato brands made in the country were of comparable biochemical quality in lycopene, total sugar and starch (if any) when compared with products from USA and Italy ($P>0.05$). Tomato products imported from China were consistently and significantly higher in total sugar, starch, but significantly lower in lycopene content ($P< 0.05$) respectively (Table 3). Comparative analysis of tins and sachets of the same tomato brand raveled that significant differences ($P<0.05$) were observed among some tomato brands. In Gino tomato paste, significant differences were observed in moisture, total sugar and starch content of the tomato brand ($P<0.05$; Table 4). In Hanno tomato paste, differences were observed in the starch and total acidity contents of the tomato product ($P<0.05$; Table 5). In Tasty Tom, significant differences were observed in total solid and total acidity contents of the tomato products ($P<0.05$; Table 6). In Derica, there was significant difference in the lycopene content between tin and sachet of the same product ($P<0.05$; Table 7). There was no significant difference in both the tin and sachet of Ric Giko and Promo tomato brands ($P>0.05$; Tables 8 and 9) respectively. Comparative biochemical analysis between different batches of the same tomato brand showed that in Gino and Derica tomato brands, there were significant differences in total solid content of the tomato brands ($P= 0.002$, Tables 10 and 11) respectively.

Table 1. Comparative analysis of various biochemical contents among different tin tomato products.

Parameter	Tomatoes (N=80) For all products ** Products Packaged in Nigeria								F-Value	P-value
	*RG	BR	DOCK	HAN	GIN	ROS	*TAI	ST..Rit		
Moisture (g/100 g)	70±.09	72±2.07	71±2.19	70±3.21	73±3.16	70±3.36	71±2.82	69±2.68	2.03	0.027*
T Solid g/100 g)	30.49±6.6	28.85±6.02	22.62±3.35	25.25± 14.01	23.55± 7.70	28.74± 5.01	24.23±9.51	26.00±7.76	1.49	0.13
Lycopene (mg/100 g)	9.88±1.38	6.50±0.73	7.83±2.09	6.71± 2.70	8.79±1.26	8.57±1.53	9.25±1.08	7.74±1.00	2.23	0.007*
T. Sugar (g/100 g)	0	21.9± 2.55	27.32± 2.55	29.58±1.48	11.88± 1.02	30.9± 1.29	21.32± 1.82	20.92± 0.96	287.1	0.000*
Starch (g/100 g)	0	19.76±0.73	24.62±2.32	26.04±0.23	10.74±0.91	27.88±1.16	19.24±1.62	18.88±0.84	354.27	0.000*
Vit C (mg/100 g)	30.00±2.60	23.44± 4.05	16.64±3.4	20.74±1.14	21.84±1.85	25.26±2.18	20.86±3.47	17.88±4.22	8.44	0.000*
T.Acidity (g/L)	0.24±0.16	0.18±0.01	0.16±0.03	0.17±0.02	0.28±0.02	0.18±0.00	0.17±0.03	0.19±0,030	3.39	0.000*

Parameter	Tomatoes (N=80) For all products ** Products Packaged in Nigeria								F-Value	P-value
	DER	DE-G	L79	TT	POM	CIA	*LUN	HUN		
Moisture (g/100 g)	73±3.11	69±2.51	70±3.03	71±3.51	73±3.40	71±2.68	73±3.78	76±3.03	2.03	0.027*
T Solid g/100 g)	30.67±10.44	28.49±5.77	26.58±5.21	39.03±10.66	28.05±3.84	21.69±6.75	24.56±2.15	20.53±2.31	1.49	0.13
Lycopene (mg/100 g)	8.49±1.87	7.54±0.80	7.07±2.11	9.11±1.25	8.63±1.25	8.56±0.72	9.85±0.98	9.49±1.47	2.23	0.007*
T. Sugar (g/100 g)	0	31.1±1.80	21.16±1.27	31.23±1.80	0.46±0.35	21.88±2.12	12.62±1.31	12.00±0.00	287.1	0.000*
Starch (g/100 g)	0	28.02±1.61	19.08±1.13	28.13±2.73	0.14±0.31	19.72±1.92	11.58±1.18	0	354.27	0.000*
Vit C (mg/100 g)	17.84±2.85	27.30±3.24	13.3±2.77	27.23±3.35	22.82±7.29	16.28±5.51	17.84±2.22	26.26±2.26	8.44	0.000*
T.Acidity (g/L)	0.26±0.06	0.29±0.09	0.31±0.11	0.22±0.06	0.30±0.03	0.25±0.05	0.33±0.01	0.22±0.08	3.39	0.000*

*P<0.05 (Significant); RG = Ric; Giko; BR = Brisk; DOCK= Docker; HAN = Hanno; GIN = GINO; ROS = Rosa; TAI =Taima; St.Rit = St Rita; DER = Derica; DEG = De Gold; L79 = L79; TT =Tasty Tom; POM = Pomo; CIA; Ciao; LUN = Luna; HUN = Hunt.

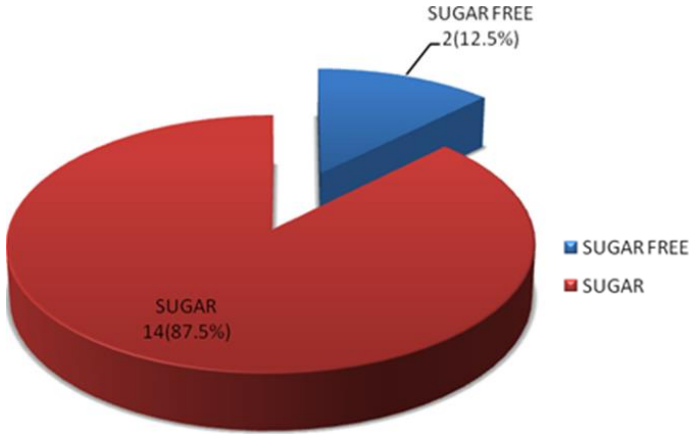

Figure 1. Chart showing percentage tomato products that contained and those that did not contain sugar.

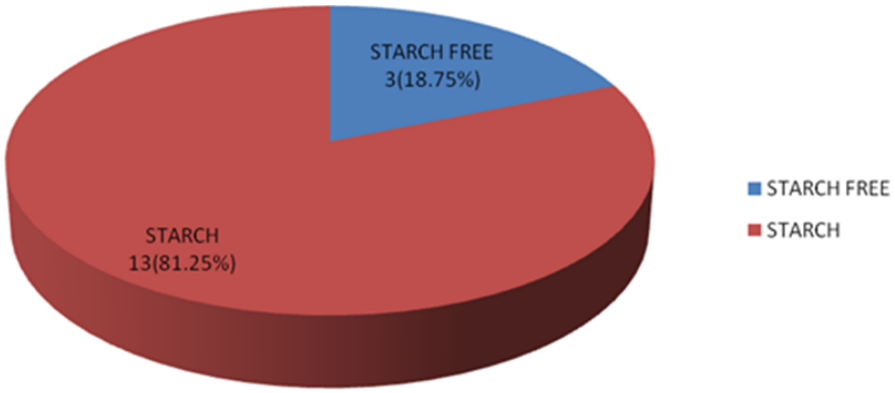

Figure 2. Chart showing tomato products that contain and those that did not contain starch.

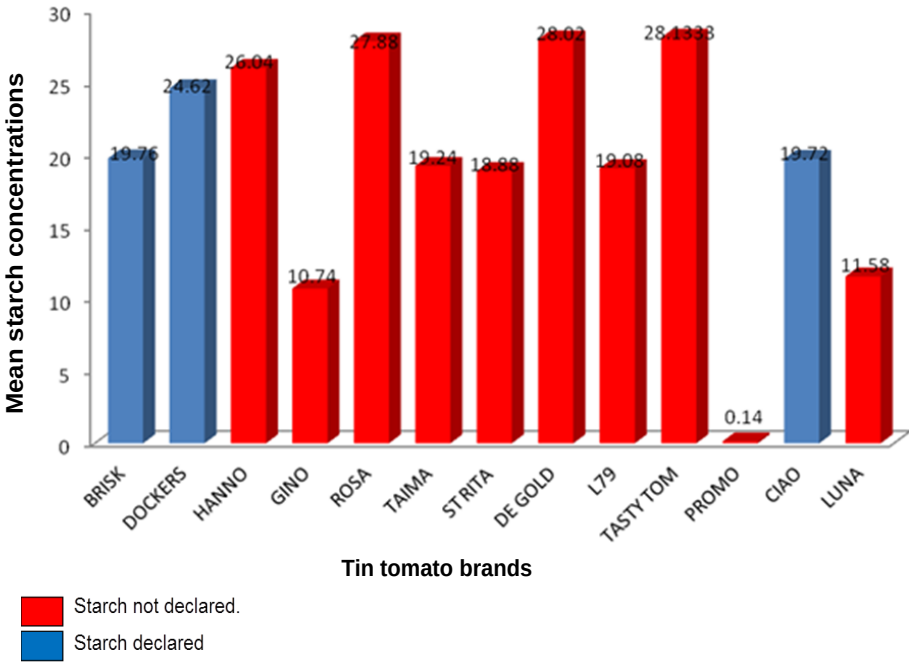

Figure 3. Declaration of starch contained in different tomato brands.

In Ric-Giko tomato brand, there was no observed significant batch variations in biochemical parameters (P>0.05) (Table 12). In Dangote tomato brand, significant differences were observed in total solid (P= 0.025), vitamin C (P= 0.011) and total acidity (P= 0.001) (Table 13).

DISCUSSION

Tomato pastes are often consumed everyday by many homes including those in South West Nigeria. They are good sources of lycopene and vitamin C, phytochemicals which have been implicated in the fight against cancer and other disorders initiated by oxidative stress. Premised on their high demand, it becomes imperative that tomato products sold in markets should be of the best international and acceptable standards.

Several biochemical parameters have been used to assess the quality of tomato. This includes the total acidity, sugar, moisture and total solids. However, it is expedient that all tomato pastes solely produced from pure tomato seed should contain a high percentage of lycopene and vitamin C. Our study showed that the various tomato brands investigated contained various levels of these biochemical substances. This could imply

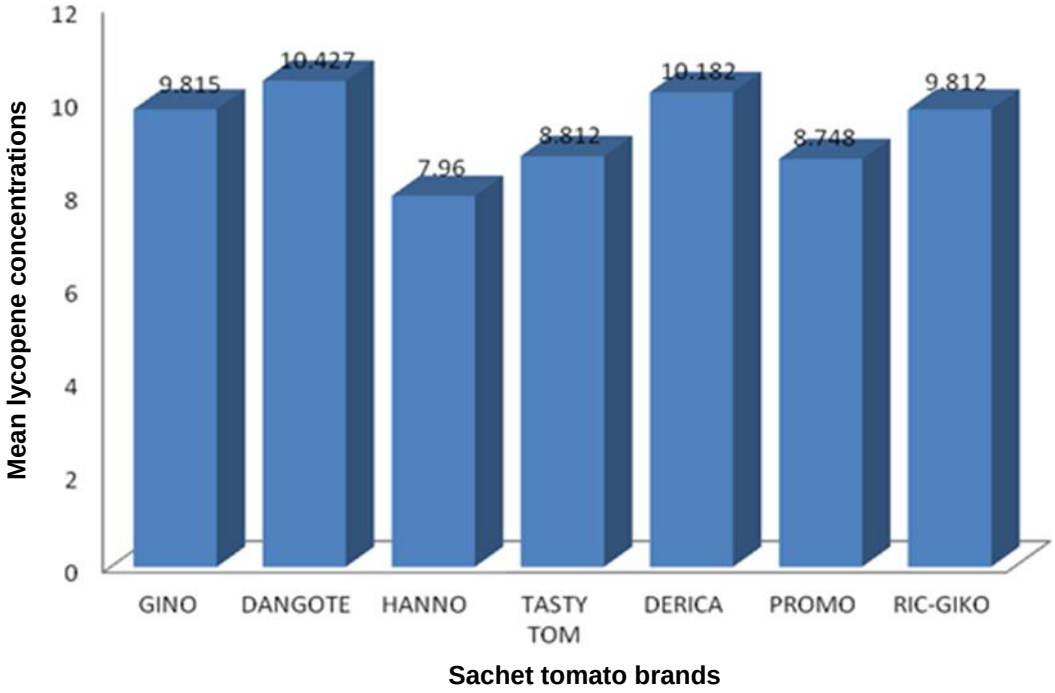

Figure 4. Mean concentration of Lycopene (mg/100 g) in sachets of different tomato brands.

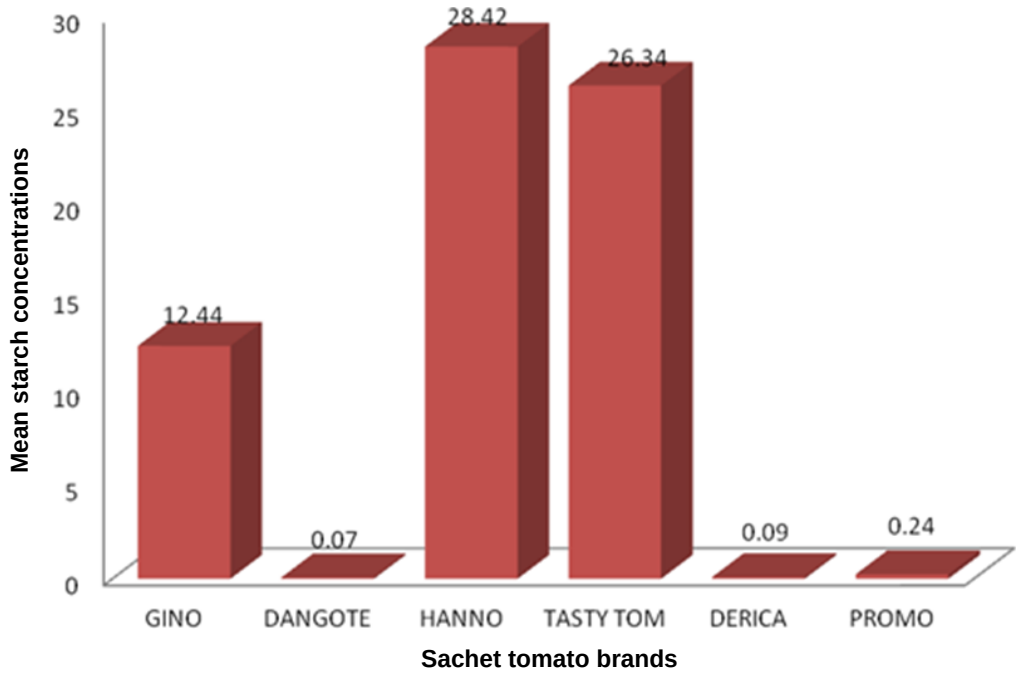

Figure 5. Mean concentration of Starch in (g/100 g) sachets of different tomato brands.

that each of the tomato brands was made from different tomato seed which, depending on region and level of ripening, could contain varying levels of these biochemicals. Of all the tomato tin brands investigated, all contained sugar except Rick Giko and Derica tomato products. It is important to note that the Sugar and Starch contained in Promo tomato brand was negligible and could be as a result of contamination during the

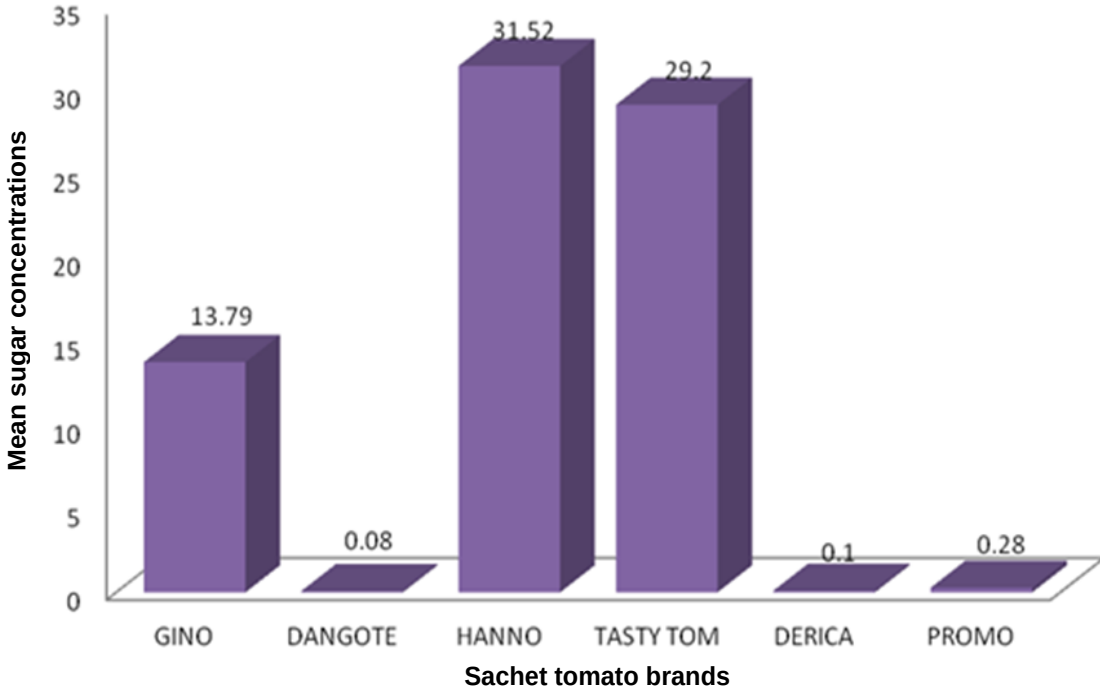

Figure 6. Mean concentration of Sugar (g/100 g) in sachets of different tomato brands.

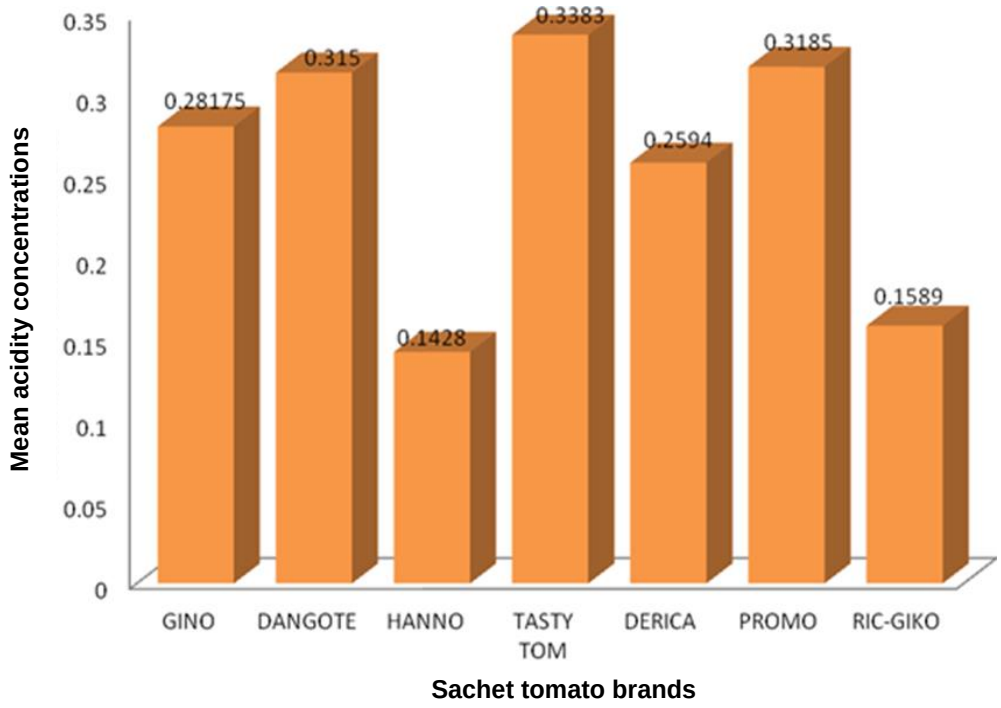

Figure 7. Mean concentration of total acidity (g/L) in sachets of different tomato brands.

production process. Since most of the tomato products contained starch, it is possible that the presence of sugar could either be as a result of hydrolysis of starch or deliberately added during the manufacturing process with a view to improving quantity and taste. This is however subject to further investigation for proper elucidation. The

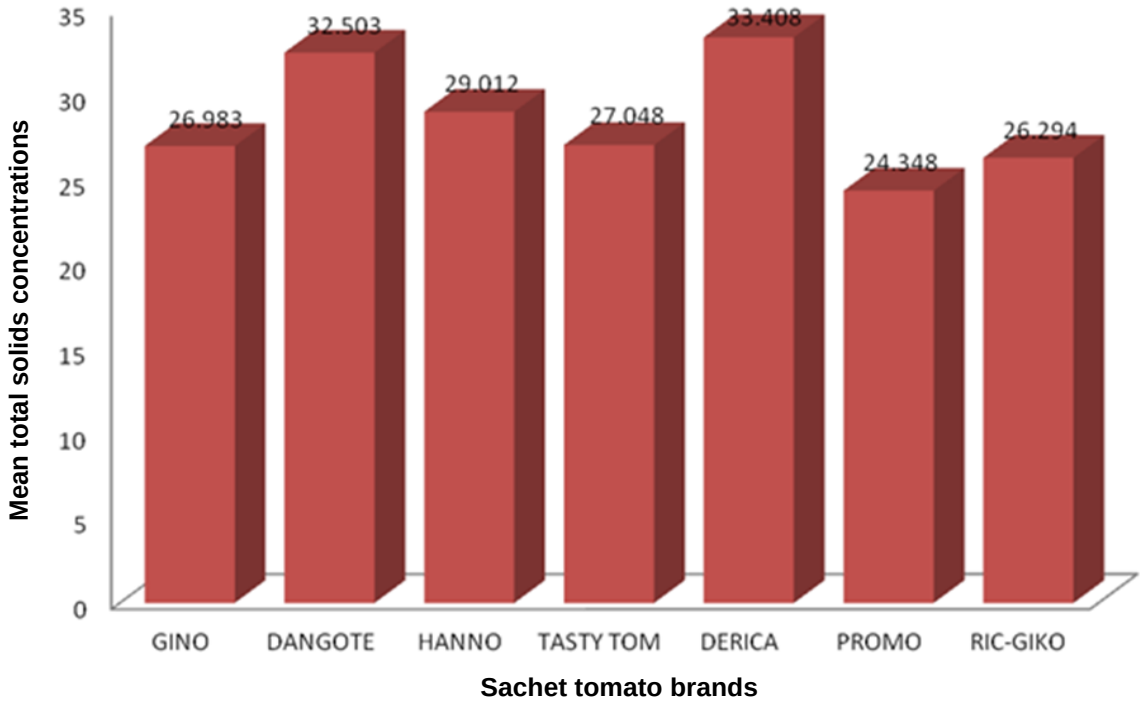

Figure 8. Mean concentration of total solid (g/g) in sachets of different tomato brands.

Table 2. Biochemical parameters between tomato products made in Nigeria and products from other countries (China, Italy and USA).

Parameter	Tomatoes (N=80) For all products				F-value	P-value
	NIG =15	CHINA =53	ITALY=5	USA=5		
Moisture	71.13± 3.45	70.66 ± 3.14	73.20±3.11	75.23± 3.05	4.260	0.008*
T Solid	26.43± 6.97	26.72± 7.67	30.76± 10.44	20.53± 7.61	1.571	0.204
Lycopene	9.66± 1.12	7.87± 1.62	8.49±1.87	9.49± 1.47	6.189	0.001*
T. Sugar	11.31± 9.13	22.22± 9.31	0.000	12.00± 0.00	14.838	0.000*
Starch	10.27± 8.25	19.97± 8.33	0.000	0.000	20.926	0.000*
Vit C	22.90± 5.95	20.92± 5.64	17.84± 2.85	26.26± 2.26	2.534	0.063
T.Acidity	0.25± 0.11	0.23± 0.07	0.26± 0.06	0.22± 0.10	0.418	0.741

*P<0.05 (Significant).

sugar contained in Hunt and brisk tomato products were declared, while the starch contained in other products were not declared. Hunt is a tomato paste made and approved by the USFDA. It is a regulatory requirement in US that all products made and sold in the United State should declare all chemicals known or unknown before being approved by FDA. Furthermore, brisk tomato paste be made for export to US market which necessitated the declaration of the sugar contained in the paste.

The findings from this study showed that most of the products investigated contained starch except Ric Giko, Derica, Dangote and Hunt tomato products. It is also worthy of note that majority of such tomato brands were those imported from China for Nigeria Market. Previous reports have shown that different tomato brands especially those manufactured and imported from China contained starch (Shehu, 2013; Daniel, 2015; Umeofia and Umeofia, 2016]. This study supports their claims.

Derica and Hunt tomato brands were products made from Italy and US respectively. Products from these countries are highly regulated and should conform to regulatory requirement prior to marketing. This finding also implies that Rick Giko tomato brand is consistent with Hunt, Derica and Dangote tomato products in content and quality.

Starch should not be a component of quality tomato

Table 3. Post Hoc analysis of tomato products made in Nigeria and those from other countries.

Variable	Country of origin	Country	Mean difference	P-value
Moisture	NIGERIA (Mean SD) 71.13± 3.45	China (70.66±3.14)	0.473	1.00
		Italy (73.20±3.11)	-2.067	1.00
		USA (75.23±3.05)	-4.467	0.053*
Lycopene	NIGERIA 9.66± 1.12	China (7.87±1.62)	1.791	0.001*
		Italy (8.49±1.87)	1.170	0.887
		USA (9.49±1.47)	0.172	1.000
Total sugar	NIGERIA 11.31± 9.13	China (22.22± 9.31)	-10.907	0.000*
		Italy (0.000)	11.31	0.088
		USA (12.00± 0.00)	-0.6866	1.000
Starch	NIGERIA 10.27± 8.25	China (19.97± 8.33)	-9.704	0.000*
		Italy (0.000)	10.273	0.081
		USA (0.000)	10.273	0.081

*P< 0.05 (Significant).

Table 4. Comparative analysis between gino Tin vs Gino sachet.

Variable	Tin (N=5)	Sachet (N=10)	T test	P value
Moisture	73.0±3.16	76.5±2.17	-2.536	0.025*
Total Solid	23.5±7.7	26.98±5.28	-1.0213	0.326
Lycopene	8.79±1.26	9.47±2.23	-0.8196	0.427
Total Sugar	11.88±1.02	13.79±1.20	-3. 0337	0.010*
Starch	10.74±0.98	12.44±1.09	-2.9681	0.011*
Vitamin C	21.84±1.85	26.18±5.12	-1.8076	0.094
Total Acidity	0.28±0.02	0.28±0.03	0.1790	0.861

*P< 0.05 (Significant).

Table 5. Comparative analysis between Hano Tin vs Hano Sachet.

Variable	Tin (N=5)	Sachet (N=5)	T test	P value
Moisture	70.4 ± 3.20	70.2± 3.11	1.000	0.3739
Total solid	25.25± 14.0	29.01±5.28	-0.9030	0.417
Lycopene	6.71± 2.70	7.96± 2.26	-0.7950	0.471
Total sugar	29.58±1.48	31.52± 1.89	-2.4334	0.0717
Starch	26.04± 0.23	28.42± 1.69	-2.8623	0.0458*
Vitamin C	20.74± 1.14	20.67± 1.56	0.128	0.9039
Total Acidity	0.17±0.21	0.14±0.11	7.3232	0.001*

*P< 0.05 (Significant).

paste. Nevertheless, when they form part of the biochemical components, regulatory processes should mandate that such be declared so that consumers are adequately informed about their content before making an informed decision. From this study, the starch content of many of the tomato products was not declared.

This presents the products as though they only contained tomato paste, thus creating a wrong impression to the buyers of such products. In situation where manufacturers have declared the quantity of starch

Table 6. Comparative analysis between Tasty Tom Tin vs Tasty Tom sachet.

Variable	Tin (N=5)	Sachet (N=5)	T test	P value
Moisture	70.67± 3.51	75.7±2.51	-2.343	0.058
Total Solid	39.03± 10.66	27.04±2.23	2.555	0.043*
Lycopene	9.11± 1.25	8.81±2.63	0.1819	0.862
Total Sugar	31.23± 3.02	29.2± 1.16	1.398	0.211
Starch	28.13± 2.73	26.34± 1.03	1.3735	0.219
Vitamin C	27.23±3.35	16.44± 1.68	-0.5053	0.6314
Total Acidity	0.22±0.06	0.33±0.05	-2.4732	0.048*

*P< 0.05 (Significant).

Table 7. Comparative analysis between Derica Tin vs Derica sachet.

Variable	Tin (N=5)	Sachet (N=10)	T test	P value
Moisture	73.2± 3.11	76.0± 2.40	1.934	0.075
Total Solid	30.67± 10.44	33.4± 10.68	0.471	0.646
Lycopene	8.49± 1.87	10.18±0.60	2.663	0.020 *
Total Sugar	0.00±0.00	0.1±0.2	1.016	0.328
Starch	0.00±0.00	0.09±0.19	1.033	0.320
Vitamin C	17.84±2.85	18.25± 2.23	0.306	0.764
Total Acidity	0.26±0.06	0.26±0.07	-0.253	0.804

*P< 0.05 (Significant).

Table 8. Comparative Analysis between Promo Tin vs Promo Sachet.

Variable	Tin (N=5)	Sachet (N=5)	T test	P value
Moisture	73.2± 3.96	75.2±2.95	-1.291	0.266
Total Solid	28.05± 3.84	24.34± 4.78	1.204	0.295
Lycopene	8.63±1.25	8.74±1.63	-0.113	0.916
Total Sugar	0.16±0.35	0.28±0.38	-0.429	0.690
Starch	0.14±0.31	0.24±0.33	-0.412	0.702
Vitamin C	22.82±7.29	14.78±2.27	2.244	0.08
Total Acidity	0.30±0.03	0.31±0.27	-1.0330	0.360

*P< 0.05 (Significant).

Table 9. Comparative analysis between rick giko tin vs Ric Giko sachet.

Variable	Tin (N=5)	Sachet (N=5)	T test	P value
Moisture	69.8± 4.08	71.0±0.70	0.753	0.493
Total Solid	30.49±6.62	26.2± 4.92	-2.0687	0.107
Lycopene	9.88± 1.38	9.81± 0.22	-0.129	0.903
Total Sugar	0.00±0.00	0.00±0.00	-	-
Starch	0.00±0.00	0.00±0.00	-	-
Vitamin C	30.00±2.6	29.2±3.57	-0.748	0.496
Total Acidity	0.24±0.16	0.20±0.11	-1.086	0.338

P< 0.05 (Significant).

Table 10. Comparative analysis between Gino tomato products of different batches.

Variable	Batch 1 (N=5)	Batch 2 (N=5)	T test	P value
Moisture	76.4±3.21	76.6±0.55	-0.126	0.906
Total Solid	22.40±1.39	31.56±2.92	-7.214	0.002*
Lycopene	8.27±2.99	11.36±0.33	-2.289	0.083
Total Sugar	13.36±0.99	14.22±1.34	-0. 985	0.380
Starch	12.06±0.93	12.82±1.22	-0.944	0.398
Vitamin C	29.34±5.56	23.02±1.78	2.409	0.074
Total Acidity	0.27±0.03	0.29±0.04	-2.217	0.091

*P< 0.05 (Significant).

Table 11. Comparative analysis between Derica tomato products of different batches.

Variable	Batch 1 (N=5)	Batch 2 (N=5)	T test	P value
Moisture	75.2±3.11	76.8±1.30	-1.000	0.374
Total Solid	23.93±4.73	42.88±3.13	-7.681	0.002*
Lycopene	10.28±0.86	10.08±0.25	0.551	0.611
Total Sugar	0.20 ±0.28	0.00±0.00	1.581	0.189
Starch	0.18±0.25	0.00 ±0.00	1.616	0.181
Vitamin C	16.74 ±2.04	19.76±1.18	-2.689	0.055
Total Acidity	0.22±0.09	0.30±0.03	-1.780	0.149

*P< 0.05 (Significant).

Table 12. Comparative analysis between Ric –Giko tomato products of different batches.

Variable	Batch 1 (N=5)	Batch 2 (N=5)	T test	P value
Moisture	71.0±0.71	69.8±4.09	0.735	0.493
Total Solid	26.29±4.93	30.49±6.63	-2.069	0.107
Lycopene	9.81±0.23	9.89±1. 39	-0.129	0.903
Total Sugar	0.00 ±0.00	0.000±	-	-
Starch	0.00±0.00	0.00 ±0.00	-	-
Vitamin C	29.2±3.57	30.0±2.60	-0.747	0.496
Total Acidity	0.16±0.02	0.24±0.16	-1.086	0.339

*P< 0.05 (Significant).

Table 13. Comparative analysis between Dangote tomato products of different batches.

Variable	Batch 1 (N=5)	Batch 2 (N=5)	T test	P value
Moisture	74.6±5.86	77.0±0.71	-0.862	0.438
Total solid	26.24±5.59	38.77±2.79	-3.485	0.025*
Lycopene	10.81±2.65	10.04±0.12	0.664	0.543
Total sugar	0.00 ±0.00	0.16±0.36	-1.000	0.374
Starch	0.00±0.00	0.14 ±0.31	-1.000	0.374
Vitamin C	16.54±1.48	11.64±1.48	4.406	0.011*
Total Acidity	0.34±0.01	0.29±0.02	7.913	0.001*

*P< 0.05 (Significant).

contained in their tomato paste, it is the responsibility of the buyer to make an informed decision before purchasing such products. Approving products which contained high concentration of starch and reduced concentration of Vitamin C and lycopene is highly inimical to consumers' health. Several diseases have been linked to obesity and excessive generation of free radicals. It is possible that consumption of tomato paste loaded with starch and lower in lycopene and vitamin C could be contributing to this high incidence of obesity and associated medical problem prevalent in the country. This is subject to further investigation using a well-structured clinical study. All the products which contained starch had NAFDAC registration and endorsement, but without NIS endorsement. This could imply that products with NIS endorsement could be more consistent in quality and safety. This requires further investigation.

It is worrisome that the nation's regulatory agency should approve and register products which could be inimical to people's health without adequately evaluating such products for quality and safety using established and acceptable guidelines. From this study, the need for reviewing, strengthening and tightening regulatory processes for registration of tomato products imported into the country becomes very evident.

In every manufacturing process especially for food industry, it is expected that manufacturers adhere strictly to the principles of good manufacturing practice while putting in place good quality assurance measures. From our finding, it was evident that there were variations in tin and sachet of the same tomato brand except those of Ric-Giko.

Consistency in tin and sachet of the same tomato product usually do imply that such products might have been processed following good manufacturing practice guideline which are in consistent with good quality assurance measures. In products that showed variation in tin and sachet of the same tomato brand, this could be attributed to either differences in manufacturing process, limited to lack of or poor implementation of established quality assurance measures. It could also be attributed to different locations where the tin and sachet of the same tomato brand were produced. It is possible that many of the sachet tomato brands sold in Nigeria are packaged locally while the tin of the same brand is packaged overseas before they are imported into the country for sales. This could account for the difference observed in tomato brands which exhibited such variations. Lack of variations observed among different batches of the same tomato product could also be attributed to good consistency in quality in various batches of the same tomato brand.

Conclusion

Based on the objectives of this study and the biochemical information obtained, it was evident that the quality of tomato brand made in Nigeria compared relatively well with tomato brands made in United States and Italy. Imported tomato brands especially those from China were of poorer quality than those manufactured and packaged within the country. However, in most tomato products investigated, there were variations in content between tin and sachet of the same brand and between different batches of the same product.

This study provides scientific evidence that local made tomato products are better in quality and consistency in biochemical parameters than products imported from China. It was also very evident that Ric-Giko tomato products showed good consistency between batches as well as between tin and sachet of the same product. Unlike Ric Giko tomato products which had both NAFDAC and Nigerian Industrial Standards (NIS) endorsement, many of the products which were of poor quality had only NAFDAC registration, but lacked NIS endorsement. The need to patronize, encourage and support local manufactures while tightening regulatory processes in the registration of products imported into the country becomes very imperative and this should not be compromised if the health, consumer right and well-being of the people are to be preserved.

Conflict of interest

This study is free from all forms of conflict of interest. It was performed with a view to assessing the quality of different tomato products sold and consumed by many Nigerians. Mentioning of products in this article was solely for providing scientific information. It is not intended to disapprove any product, but to provide information which could strengthen regulatory processes and enable consumers have adequate information to make informed decision.

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