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Comparative Study of the Physicochemical and Anti-Nutritional Properties of Branded and Laboratory-Produced Tomato Pastes with Added Hydrocolloid

[1,2*]**Ikegwu Theophilus Maduabuchukwu,**[2]**Rabiu Ibrahim Ajiya,**[2]**Akubor Peter Isah,**[3]**Agbo Anthony Ogbonna,**[1]**Okolo Chioke Amaefuna**

[1]Department of Food Science and Technology, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State

[2]Department of Food Science and Technology, Faculty of Agriculture and Life Sciences, Federal University Wukari, Taraba State

[3]Department of Science Laboratory Technology, Federal Polytechnic, Ohodo, Enugu State;
https://orcid.org/0000-0003-4131-4172

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Abstract

Purpose: This study compared laboratory-produced tomato pastes with added pectin (0.31-0.94%) to commercially available brands, assessing physicochemical and antinutritional properties.

Methodology: A completely randomized design was employed, and samples were analyzed for moisture, protein, fat, fiber, ash, carbohydrate content, pH, total soluble solids, starch components, viscosity, lycopene, β-carotene, vitamin C, phytate, glycoside, saponin, and tannin.

Findings: Moisture ranged from 66.06-72.50%, with branded pastes exhibiting higher moisture than pectin-added samples. The crude protein, fat, crude fibre and ash content of the samples ranged from 4.01 to 4.37%, 0.14 to 0.25%, 4.83 to 6.81%, and 3.26 to 3.84%, respectively. The carbohydrate content ranged from 12.98 to 18.93%. The total soluble solids, amylose, amylopectin, total starch and the dynamic viscosities of the tomato pastes differed significantly ($p<0.05$) and ranged between 81.56-89.28%, 0.14-0.64%, 99.37-99.86%, 6.54-7.46% and 28.45-45.16%, respectively. However, the laboratory pastes without pectin closely resembled branded products. Significant differences ($p<0.05$) were observed in pH (4.22-4.81), total soluble solids (81.56-89.28%), starch components, viscosity (28.45-45.16%), and nutritional compounds. Lycopene ranged from 14.32-15.55 µg/100g, β-carotene from 645.7-685.22 µg/100g, and vitamin C from 45.34-48.88 mg/100g. Antinutritional factors varied, with phytate between 0.22-0.35 mg/100g. Pectin addition increased viscosity, and all samples met quality standards.

Unique Contributions to Theory, Practice, and Policy: The study advances food chemistry by showing how pectin affects tomato paste's viscosity, starch composition, and nutrient retention. It supports theories on hydrocolloid behavior in moist foods and highlights how processing and fortification impact antinutritional factors (phytates, tannins, saponins, glycosides) and starch modification. It offers a practical guide for small and medium food processors to improve tomato paste quality using optimal pectin levels (0.31–0.94%) without additives. The comparison with commercial brands provides benchmarks for enhancing local products, supporting affordable, high-quality alternatives in tomato-growing areas. Findings support regulatory standards for viscosity, nutrient density, and antinutritional content in tomato products. They inform food labeling and fortification strategies and promote policies that encourage local production and reduce dependence on imports.

Keywords: *Tomato Paste, Hydrocolloids, Antinutrients, Quality Standard, Viscosity;*

1.Introduction

Tomato (*Solanum lycopersicum*), a globally popular vegetable crop belonging to the Solanaceae family, is a significant source of dietary antioxidants (Collins et al., 2022). It's globally cultivated and consumed, with Nigeria experiencing a substantial increase in tomato production (Knoema, 2022). Besides being consumed raw in salads, tomatoes are widely processed into products like juice, paste, ketchup, and sauce, accounting for a major part of consumption (Viuda-Martos et al., 2014). The increasing popularity of tomatoes stems from their versatility and associated health benefits (Consonni et al., 2009). Tomatoes are rich in Vitamin C, calcium, lycopene, tocopherol, and are composed of roughly 94% water (Collins et al., 2022). Specifically, *L. esculentum* is an abundant source of lycopene, vitamin C, pro-vitamin A carotenoids, β-carotene, and vitamin E (Garcia-Closas, 2004). Lycopene, in particular, has been linked to anti-cancer properties and a reduction in insulin-like growth factors (Kapała et al., 2022; Li et al., 2024; Collins et al., 2022). Lycopene in tomatoes has antioxidant properties that had been shown to prevent the risk of many ailments, such as cancer, degenerative nerve diseases, cardiovascular diseases, and eye diseases. Additionally, tomato had been identified in roles that involve reducing insulin-like growth factor (IGF) levels in the blood, and for the regulation of the cellular pathways in cell proliferation and tumor spread, thereby serving as a potential a protective food against cancer (Jiménez Bolaño et al., 2024). The Vitamin C, phenolics, fiber, and ferulic acid are other beneficial constituents contributing to cancer prevention, and the alleviation of hypertension and cardiovascular diseases (Sass, 2024). Tomato processing addresses preservation needs and adds value, especially during off-seasons when fresh tomato availability is limited and prices are high. Tomatoes are perishable, with a significant percentage lost during post-harvest due to factors such as immaturity, mechanical damage, and inadequate handling (FAO, 2018). Their high moisture content makes long-term storage challenging. While short-term storage is possible under ventilated conditions (FAO, 2018), processing into tomato paste extends shelf life. Tomato paste contains at least 24% natural tomato soluble solids after the removal of seeds and skin (FAO, 2018). The quality of tomato paste is influenced by the raw materials characteristics, processing techniques, storage and time conditions (Farahnaky et al., 2010). Key quality parameters include color (attributed to carotenoids), flavor, viscosity, pH, soluble solids content, and acidity (FAO, 2018). Lycopene, a potent antioxidant responsible for the red color, remains relatively stable during heat processing, preserving its health benefits even in processed tomatoes. Regular consumption of tomatoes and tomato products has been linked to reduced risks of cardiovascular diseases, prostate cancer, and gastrointestinal diseases (Collins et al., 2022; FAO, 2022). This research aims to compare the physicochemical and anti-nutritional properties of commercial and laboratory-produced tomato paste samples, with a focus on the effect of varying amounts of pectin on laboratory processed tomato paste.

2.0 Materials and Methods

2.1 Procurement of Research Materials

Fresh samples of tomatoes (UTC variety) were purchased from Eke-Awka Market and taken to the Food Science and Technology Laboratory, Nnamdi Azikiwe University, Awka. Three branded commercial samples (GNO, CLP and TTM) were purchased from the same market. The reagents and equipment used were obtained from the Food Science and Technology Department Laboratory, Nnamdi Azikiwe University, Awka, Anambra State.

2.2 Processing of Tomato Paste

Tomato pastes were processed by the method described by Hayes *et al.* (1998) with slight modifications. The mature ripe tomatoes were sorted to select the quality ones and the unhealthy ones were discarded. It was washed with portable water to rid the tomatoes of micro-organisms and dirt's. Eight hundred grams (800 g) of tomatoes were weighed for each of the samples. The weighed tomatoes were cut into quarters with a clean knife and pre-heated at 60°C for cold break. The tomato seed and skin were removed and sieved and the juice and pulps were blended using an electric blender. The juice was concentrated for ten hours, and then, added pectin at varying concentrations to three of the samples. The concentrated tomato pastes were hot-filled, seamed and closed into a sterilized bottle. The tomato paste was pasteurized at 92°C for 10 min, then cooled before it was packaged and stored in a cool place.

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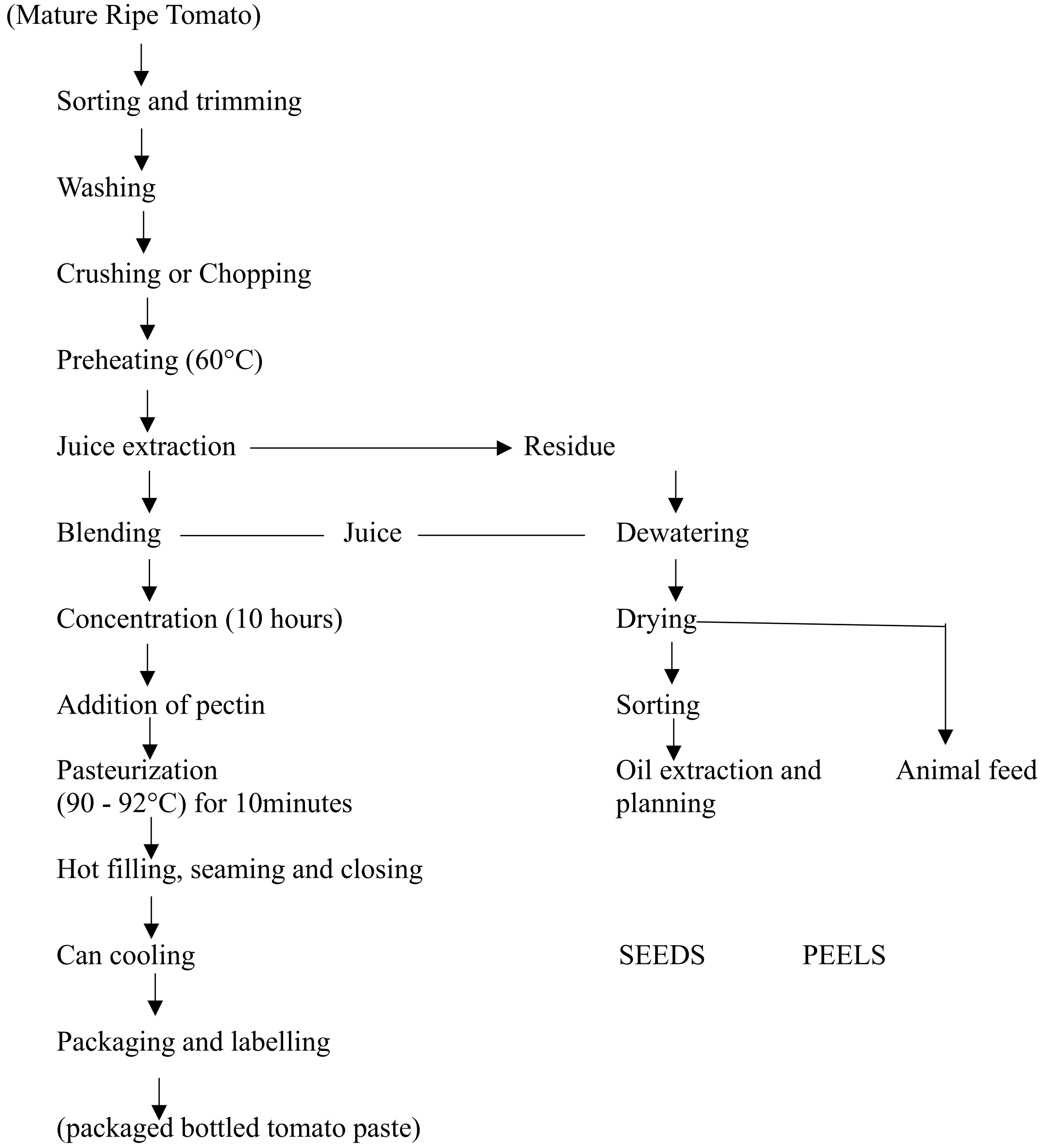

Figure 1: Flow diagram of tomato paste production (Source: Hayes *et al*, 1998)

2.3 Experimental Design

The research was designed using Completely randomized Design. Pectin was added to three samples of the tomato pastes at varying proportions (0.31%, 0.63% and 0.94%), while one of the samples was processed without pectin addition. The laboratory-produced samples were compared to three brands of tomatoes pastes randomly purchased from the Eke-Awka Market, Awka, Anambra State.

Table 1: Experimental design

Samples	Tomato (g)	Pectin (%)
WTP	800	-
TP6	800	0.31
TP8	800	0.63
TP9	800	0.934

The randomized samples were subjected to laboratory analyses for comparative evaluation.

2.4 Determination of Proximate Compositions

2.4.1 Moisture Determination

The moisture, fibre, ash, crude protein, fat and crude fibre contents were determined using AOAC (2023) methods, while the carbohydrate content was determined by difference.

3.5 Determination of the Physical Properties

2.4.2 Determination of total soluble solids

The gravimetric method (AOAC, 2023) was used for the determination of the total soluble solids. The dynamic viscosity was determined using AOAC (2023). The pH of the tomato paste was determined using the electrode of a standard pH meter (Hanna meter model H196107).

2.6 Vitamins Determination

2.6.1 Determination of Ascorbic Acid (Vitamin C)

The method AOAC (2023) was used for the determination of vitamin C. The lycopene and β-carotene were determined using the Spectrophometric method described by Barros *et al.* (2011).

2.7 Determination of Starch Content

2.7.1 Determination of amylose and amylopectin

The method of AOAC (2023) was used for the determination of the amylose, amylopectin and total starch contents of the tomato pastes.

2.8Determination of Anti-nutritional content

The phytate was determined by the method described by Rahman *et al.* (2020). The method reported by Sheel *et al.* (2014) was for the glycoside content determination. The Method described by Obadoni and Ochuko (2002) was used for the determination of the saponin content, while phytate was determined according to the method described by Ejikeme *et al*. (2014).

2.9 Statistical Analysis

The results obtained from the laboratory analyses were analysed using Statistical Package for Social Sciences (SPSS) in a Randomized Complete Design (RCD) and mean differences were was by Duncan separation at $p<0.05$.

3.0 Results and Discussion

The proximate composition of various brands of commercial tomato pastes and laboratory-processed tomato paste are presented in Table 4.1. The moisture content of the tomato pastes samples ranged from 66.86% to 72.50%, with sample TP9 exhibiting the least moisture content, while the GNO sample had the highest. The samples showed significant variation ($p<0.05$) in moisture content. The WTP sample recorded the highest moisture content at 18.42%. It is anticipated that samples with higher moisture content would deteriorate more rapidly under identical environmental conditions. Conversely, increased moisture content contributes to the bulk of the product, potentially leading to unfair trade practices among manufacturers. According to Abdullahi et al. (2016), reduced moisture content increases the solid matter required by consumers, while geographical differences may also generate interest in variations in the moisture content of the product. The results obtained in this research align with the findings of other researchers (Abdullahi et al., 2016), whose studies on fresh and canned tomatoes indicated that moisture content ranged from 71.80% to 93.80%. Han et al. (2023) noted that the presence of moisture or water may help slow down the heat transfer of tomato products, potentially reducing the heat transfer of the product.The crude protein content of the tomato pastes samples ranged from 4.01% to 4.37%. Sample TP9 had the lowest protein content, while CLP exhibited the highest. The percentage of crude protein varied significantly ($p<0.05$) among the samples. Notably, there was no significant difference ($p<0.05$) in crude protein content between samples WTP and CLP, indicating that the laboratory control sample ranked similarly to CLP tomato paste in protein content. Additionally, the crude protein content of TP6 and GNO was ranked the same. Therefore, it can be concluded that most commercial tomato paste samples ranked similarly to the commercial tomato pastes. The percentage of crude protein content of the samples fell within the acceptable range reported by USDA (2012) for tomato paste but was higher than the results obtained by other researchers (Abdullahi et al., 2016; Yaroson et al., 2018). It is important to note that the processed laboratory samples were within the USDA (2012) standard for tomato pastes and could be favorably compared with the commercial tomato paste samples used in this study.

Table 2: Proximate compositions (%) of different brands of tomato paste

S/N	Samples	%MC	% CP	% FAT	% CF	% ASH	% CHO
1	*GNO	72.50±0.03[a]	4.10±0.03[d]	0.16±0.01[a]	4.83±0.02[g]	3.26±0.01[f]	15.15±0.03[d]
2	**CLP	71.35±0.02[d]	4.37±0.01[a]	0.14±0.01[c]	6.14±0.01[d]	3.72±0.03[b]	14.28±0.02[e]
3	***TTM	72.46±0.03[b]	4.28±0.03[b]	0.24±0.01[b]	5.65±0.03[f]	3.48±0.02[e]	13.89±0.02[f]
4	WTP	72.38±0.01[c]	4.35±0.02[a]	0.20±0.01[g]	6.53±0.02[b]	3.56±0.03[d]	12.98±0.03[g]
5	TP6	69.98±0.02[e]	4.13±0.03[d]	0.25±0.01[f]	6.05±0.03[e]	3.59±0.04[cd]	16.00±0.03[c]
6	TP8	68.05±0.02[f]	4.22±0.02[c]	0.22±0.01[e]	6.81±0.02[a]	3.84±0.02[a]	16.86±0.01[b]
7	TP9	66.06±0.03[g]	4.01±0.05[e]	0.19±0.01[d]	6.31±0.03[c]	3.62±0.03[c]	18.93±0.03[a]

Values are Means ± Standard deviation (n = 2). Values in the same column with different superscripts are significantly different ($p<0.05$). *GNO = branded tomato paste; **CLP = branded tomato paste; ***TTM = branded tomato paste, WTP = Laboratory-produced tomato paste without pectin; TTP6 = Laboratory-produced tomato paste with 0.31% pectin addition by weight; TPP8 = Laboratory-produced tomato paste with 0.63% pectin addition by weight; TPP9 = Laboratory-produced tomato paste with 0.93% pectin by weight.

The percentage of fat content in the tomato paste samples varied significantly ($p<0.05$), with values ranging from 0.14% to 0.25%. The results indicated that the sample with the lowest fat content was CLAP, while the highest value was found in the TP6 sample. Some researchers (Marcos et al., 2017; Ismail et al., 2016) reported that the fat content of tomato paste was 0.81%, 0.14%, and 0.28%, respectively. Additionally, USDA (2012) reported a fat content of 0.05%, while Yaroson et al. (2018) obtained a value as low as for 0.23% laboratory processed tomato paste although the commercially produced paste was found to be 6.68%. The high fat content in tomato paste may be undesirable due to lipid peroxidation, which increases the rate of rancidity in the product. Therefore, a reduced fat content would make the tomato paste a healthier food option, mitigating the effects of cholesterol deposition in adipose tissues and arteries. The crude fibre content of the tomato pastes samples ranged from 4.83% to 6.81%, with GNO exhibiting the least fibre content and TP8 the highest. Some laboratory results fell outside the value established by USDA (2012) as the standard for tomato paste (4.1%). However, other researchers (Musa et al., 2024) asserted that the fibre contents ranged from 1.30 to 3.40%. Increased fibre content in diets reduces the incidence of constipation, enhances gut microorganism activity, and improves bowel syndrome. The percentage of ash content in the tomato paste samples ranged from 3.26% to 3.84% and showed significant differences ($p<0.05$) among the samples. The laboratory samples exhibited higher ash content compared to the commercial products, with TP8 having the highest ash content, followed by samples CLAP, TP9, WTP, TP6, TTM, and GNO. These results significantly differed from those obtained by Adubofour et al. (2010), whose average ash content ranged from 0.14% to 0.18%, and Suleiman et al. (2011), who reported that the ash content of tomato pastes ranged from 0.2% to 0.4%. Conversely, the results aligned with the findings of Ismail et al. (2016), who reported values ranging from 2.48% to 3.83%. However, FAO (2012) indicated that tomato paste samples should have an ash content of no less than 2.86%.The carbohydrate content of the tomato paste samples is significantly different ($p<0.05$) and ranges from 12.98% to 18.93%, with WTP having the lowest value and TP9 the highest. This finding aligns with the results obtained by Ismail et al. (2016), which reported a carbohydrate content ranging from 13.70% to 15.18%, and falls within the standard set by the USDA (2012), which states that tomato paste should have a carbohydrate content of 14.80%. Other researchers have reported significantly varied results, such as Yaroson et al. (2018), whose studies showed carbohydrate contents of 8.75% and 69.84%, respectively. The low carbohydrate values position the tomato paste as a low-density energy food product.

3.2 Physiochemical Properties of Tomato Paste Samples

The physicochemical composition of various brands of commercial tomato pastes and laboratory-processed tomato pastes is presented in Table 4.2. The pH of the tomato pastes samples ranged from 4.22 to 4.81, indicating an acidic food. Campos et al. (2006) noted that pH is a critical factor in determining tomato quality and tomato paste. A pH of 4.5 or below is suitable for tomato paste, while higher values are undesirable as they do not inhibit the proliferation of microorganisms in the final product. The pH of the samples aligned with this statement, except for samples TP6, TP8, and TP9, which exhibited higher values and are therefore more susceptible to microbial growth. The tomato pastes samples WTP, TP6, TP8, and TP9 varied significantly ($P<0.05$), while GNO, CLP,and TTM samples showed no significant variation ($P>0.05$).The total soluble solids of the tomato paste samples ranged from 81.56% to 89.28%. The results indicated that the control (WTP), which contained no starch or additives, had the least score compared to the other samples that included pectin or other additives such as potatoes starch.

Table 3: Physiochemical compositions of different brands of tomato pastes

S/N	Sample	pH	TSS (%)	Amylose (%)	Amylopectin (%)	Total Starch (%)	Viscosity (cp)
1	GNO	4.26±0.03^{e}	89.28±0.03^{a}	0.16±0.02^{de}	99.85±0.02^{ab}	6.59±0.02^{d}	28.45±0.02^{f}
2	CLP	4.22±0.02^{e}	88.34±0.02^{c}	0.19±0.01^{d}	99.81±0.01^{b}	6.62±0.02^{d}	28.54±0.02^{e}
3	TTM	4.26±0.02^{e}	88.54±0.03^{b}	0.14±0.01^{e}	99.86±0.01^{a}	6.63±0.01^{d}	28.56±0.02^{e}
4	WTP	4.54±0.02^{d}	81.56±0.02^{g}	0.19±0.02^{de}	99.82±0.02^{ab}	0.54±0.06^{e}	45.16±0.02^{a}
5	TPP6	4.65±0.02^{c}	86.35±0.02^{f}	0.48±0.02^{c}	99.53±0.02^{c}	6.80±0.01^{c}	33.48±0.02^{b}
6	TPP8	4.73±0.02^{b}	87.27±0.03^{e}	0.57±0.01^{b}	99.43±0.01^{d}	7.13±0.01^{b}	32.27±0.02^{c}
7	TPP9	4.81±0.01^{a}	88.04±0.04^{d}	0.64±0.02^{a}	99.37±0.02^{e}	7.46±0.01^{a}	30.45±0.01^{d}

Values are Means ± Standard deviation (n = 2). Values in the same column with different superscripts are significantly different ($p<0.05$). *GNO = branded tomato paste; **CLP = branded tomato paste; ***TTM = branded tomato paste, WTP = Laboratory-produced tomato paste without pectin; TTP6 = Laboratory-produced tomato paste with 0.31% pectin addition by weight; TPP8 = Laboratory-produced tomato paste with 0.63% pectin addition by weight; TPP9 = Laboratory-produced tomato paste with 0.93% pectin by weight.

The samples exhibited significant differences ($p<0.05$), likely due to the level of additives in the product. However, these results were ten times higher than the values reported by other researchers (Mohammed et al., 2017) and twenty times higher than those obtained by Adubofuor et al. (2010). These discrepancies may be attributed to variations in the moisture content of the samples, which could have caused a dilution effect, as well as species differences and environmental factors.Total soluble solids measure the moisture content in food products and can serve as an index for the market acceptability of certain items. Furthermore, the results obtained in this study were unusually high compared to the findings of other researchers, which ranged from 15.15% to 68.90% (Eke-Ejiofor, 2015). Nevertheless, the USDA has established a standard of 30% to 50% total solids for tomato pastes. Lycopene is the primary carotenoid responsible for the appealing coloration of fruits and vegetables, particularly in tomato paste (Maiani et al., 2009). Nguyen & Schwartz (1998) noted that mechanical treatment, homogenization, and heating enhance the release of lycopene from the tomato matrix. The β-carotene content of the tomato pastes samples ranged from 645.7 µg/100g to 685.22 µg/100g. The TP9 sample had the lowest β-carotene content, while the GNO sample exhibited the highest. Variations in β-carotene content may be attributed to processing treatments and storage conditions. Seybold et al. (2004) found that the loss of water during the thermal processing of tomatoes resulted in an increase in β-carotene content on a wet basis. On a dry basis, the lycopene content varied depending on the origin of the tomato fruits used, while β-carotene levels either decreased or remained relatively stable. Significant differences ($P < 0.05$) were observed among the samples analyzed. The amylose content of the tomato pastes samples ranged from 0.14% to 0.64%, with TTM exhibiting the lowest amylose content while TP9 had the highest. The samples were significantly different ($P<0.05$), except for the WTP and GNO samples. The presence of high amylose in food enhances texture, while amylopectin improves structural conformation. The amylose content of the laboratory samples was found to be significantly higher ($p<0.05$) compared to the commercial samples. The percentage of amylopectin content in the tomato paste samples ranged from 99.37% to 99.86%, with TP9 having the lowest score and Tasty Tom the highest. The GNO and WTP5 samples were not significantly different ($p>0.05$) from each other, while the other samples differed significantly ($p<0.05$).The total starch content of the tomato pastes samples ranged from 0.54% to 7.46%, with the control having the lowest value and TP9 the highest. As observed, the control, which had no added starch, had the lowest score, while the other samples with added starch exhibited higher starch content. The commercial samples did not vary significantly ($p>0.05$) from each other, while the laboratory samples varied significantly ($p<0.05$). The viscosity of the tomato pastes samples ranged from 28.45 cp to 45.16 cp, with the control having the highest value and Gino the lowest value. Viscosity could be a crucial factor that indicates the quality of tomato paste and may be associated with the content of substances that are insoluble in alcohol, as well as proteins and polysaccharides. Sobowale et al. (2011) also noted that the viscosity of tomato products is influenced by protein, fat, fiber, and total solids. Consistency remains a key determinant of customer acceptability for tomato products and is an essential component of the quality grading standard. All samples exhibited significant variation ($P<0.05$), except for the CLP and TTM samples, which showed no significant difference ($P>0.05$) between them but differed significantly ($P<0.05$) from the other samples.

3.3 Lycopene, Carotenoid, and Vitamin C Contents

The lycopene, beta-carotene, and vitamin C compositions of various brands of commercial tomato paste and laboratory-processed tomato paste are presented in Table 4.3. The lycopene content of the different tomato samples ranged from 14.32 µg/100g to 15.55 µg/100g, with TP9 having the lowest value while GNO recorded the highest. The TPP6 and TPP8 samples did not show significant variation (P>0.05) from each other, but significant differences were observed between them and the other samples. Lycopene is the primary carotenoid responsible for the appealing coloration of fruits and vegetables, particularly in tomato paste (Maiani et al., 2009). Mechanical treatment, homogenization, and heating enhance the release of lycopene from the tomato matrix. The β-carotene content of the tomato pastes samples ranged from 645.7 µg/100g to 685.22 µg/100g. The TP9 sample had the lowest β-carotene content, while the GNO sample exhibited the highest. Variations in β-carotene content may be attributed to processing treatments and storage conditions. Seybold et al. (2004) found that the loss of water during the thermal processing of tomatoes resulted in an increase in β-carotene content on a wet basis. On a dry basis, the lycopene content varied depending on the origin of the tomato fruits used, while β-carotene levels either decreased or remained relatively stable. Significant differences (P < 0.05) were observed among the samples analyzed.

Table 4: Lycopene, β-carotene and Vitamin C compositions of different brands of tomato paste

S/N	Samples	Lycopene	β-carotene	Vitamin C
1	GNO	15.55 ± 0.02^{b}	685.22 ± 0.01^{a}	$48.88\pm0{,}02^{a}$
2	CLP	15.49 ± 0.02^{bc}	679.32 ± 0.02^{b}	48.55 ± 0.02^{c}
3	TTM	15.47 ± 0.01^{c}	673.12 ± 0.03^{c}	48.78 ± 0.02^{b}
4	WTP	15.84 ± 0.03^{a}	654.58 ± 0.02^{d}	45.34 ± 0.02^{g}
5	TP6	14.52 ± 0.01^{d}	650.65 ± 0.02^{e}	47.12 ± 0.02^{f}
6	TP8	14.46 ± 0.03^{d}	648.74 ± 0.02^{f}	47.76 ± 0.02^{e}
7	TP9	14.32 ± 0.05^{e}	645.97 ± 0.02^{g}	47.99 ± 0.02^{d}

Values are Means ± Standard deviation (n = 2). Values in the same column with different superscripts are significantly different (p<0.05). *GNO = branded tomato paste; **CLP = branded tomato paste; ***TTM = branded tomato paste, WTP = Laboratory-produced tomato paste without pectin; TTP6 = Laboratory-produced tomato paste with 0.31% pectin addition by weight; TPP8 = Laboratory-produced tomato paste with 0.63% pectin addition by weight; TPP9 = Laboratory-produced tomato paste with 0.93% pectin by weight.

The Vitamin C (ascorbic acid) content of the tomato pastes samples ranged from 45.34 mg/100g to 48.88 mg/100g. The control sample exhibited the lowest value, while the GNO sample had the highest. The samples varied significantly (P<0.05) from one another. Tomato fruit is a good source of Vitamin C, which prevents scurvy, boosts the immune system, and enhances rapid healing (Bakhru, 2007). Studies have shown that the degradation of Vitamin C is directly related to temperature and exposure to air (Carlo, 2002). Studies have shown that the degradation of Vitamin C is directly related to temperature and exposure to air which are the primary factors contributing to the loss of ascorbic acid during tomato processing. Increase in temperature is expected to lead to a greater loss of ascorbic acid.

3.4 Anti-nutrient Properties

The anti-nutrient composition of the various brands of commercial tomato pastes and laboratory-processed tomato paste is presented in Table 4.4. The phytate content of the different tomato paste samples ranged from 0.22 mg/100g to 0.35 mg/100g. The TP9 sample ranked lowest, while the control had the highest phytate content. The GNO, TTM, CLP, TP8, and TP9 samples did not differ significantly (P>0.05) from each other, while significant differences (P<0.05) were observed between them and the other samples.

Table 5: Antinutrients compositions of different brands of tomato paste

S/N	Samples	Phytate	Glycoside	Saponin	Tanin
1	GNO	0.24 ± 0.02^{b}	0.15 ± 0.01^{bc}	1.52 ± 0.01^{cd}	0.89 ± 0.02^{b}
2	CLP	0.25 ± 0.02^{b}	0.16 ± 0.01^{b}	1.50 ± 0.01^{d}	0.92 ± 0.02^{ab}
3	TTM	0.23 ± 0.01^{b}	0.15 ± 0.02^{bc}	1.45 ± 0.02^{e}	0.88 ± 0.02^{b}
4	WTP	0.35 ± 0.06^{a}	0.25 ± 0.01^{a}	1.33 ± 0.01^{f}	0.96 ± 0.02^{a}
5	TP6	0.29 ± 0.01^{ab}	0.16 ± 0.02^{b}	1.55 ± 0.01^{c}	0.77 ± 0.02^{c}
6	TP8	0.27 ± 0.02^{b}	0.14 ± 0.01^{bc}	1.62 ± 0.02^{b}	0.73 ± 0.02^{c}
7	TP9	0.22 ± 0.03^{b}	0.11 ± 0.01^{c}	1.73 ± 0.01^{a}	0.66 ± 0.03^{d}

Values are Means ± Standard deviation (n = 2). Values in the same column with different superscripts are significantly different (p<0.05). *GNO = branded tomato paste; **CLP = branded tomato paste; ***TTM = branded tomato paste, WTP = Laboratory-produced tomato paste without pectin; TTP6 = Laboratory-produced tomato paste with 0.31% pectin addition by weight; TPP8 = Laboratory-produced tomato paste with 0.63% pectin addition by weight; TPP9 = Laboratory-produced tomato paste with 0.93% pectin by weight.

The glycoside content of the tomato pastes samples ranged from 0.11 mg/100g to 0.25 mg/100g. Sample TPP9 exhibited the lowest value, while the control sample had the highest. The glycoside content of all the samples was significantly different (P<0.05), except for samples CLP and TPP6, which showed no significant difference (P>0.05) between them.The saponin content of the tomato paste samples ranged from 1.33 mg/100g to 1.73 mg/100g. The control sample had the lowest value, while sample TP9 exhibited the highest. All tomato pastes samples showed significant variation from one another (p<0.05). The tannin content of the tomato pastes samples ranged from 0.73 mg/100g to 0.96 mg/100g, with the control sample having the highest value and TP8 the lowest. The control, CLP, and TP9 samples were significantly different, while the others were not.

4.0 Conclusion

This study compared the physicochemical and anti-nutritional compositions of commercial brands of tomato paste with laboratory-processed tomato pastes (whole tomato paste and tomato paste with varying quantities of pectin). It is evident that the laboratory whole tomato paste was more acceptable than the other brands analyzed based on the data obtained. It important to state that fresh tomatoes used for producing tomato paste should be of high quality to ensure the final product's quality. Storage studies should be conducted on laboratory-processed tomato paste to determine its shelf stability, while the use of pectin should be in low concentration to avoid the growth of moulds.

5.0 Recommendations

1. Additional studies should investigate the bioavailability of nutrients as well as the sensory acceptability of tomato pastes enhanced with pectin in consumer experiments.
2. The long-term stability during storage and the microbial safety of laboratory-made pastes containing hydrocolloids ought to be assessed, while local food producers should utilize natural

hydrocolloids such as pectin during paste manufacturing to enhance texture and nutrient preservation.

3. Furthermore, industries may consider implementing the optimized concentration range of 0.31–0.94% pectin to achieve a balance between functional efficiency and economic feasibility. Policymakers should encourage the incorporation of natural functional ingredients (like hydrocolloids) through subsidies or technical training for small-scale food producers, and they should also advocate for the labeling of functional components and nutritional values on tomato paste products to enhance consumer transparency and awareness regarding nutrition.
4. In quality control, it is essential to incorporate viscosity standards, starch composition analysis, and antinutrient profiling in the regular quality evaluations of tomato pastes. Similarly, all brands, whether local or imported, must meet the physicochemical and antinutritional standards to ensure public safety.

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