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Comparative Analysis of Nutritional Composition of Fresh to Sachet Tomato Paste and Dry Beans to Canned Beans

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Abstract
Different food processing techniques are in use for improving the shelf life of food, vegetables, and beverages. Some of these methods could have significant effects on nutritional composition of food products. Tomatoes and beans are globally used in households for a variety of meals due to their nutritional compositions and versatility. This work was carried out to compare the nutritional composition of fresh tomato to sachet tomato and dry beans to canned beans with the aim to identify possible change in nutritional composition that may occur during processing. Proximate, mineral, and vitamin analysis were conducted to that effect. Percentage moisture composition reduced from 91.8%±0.58 in fresh tomato to 76.17%±0.34 in sachet tomato while there was an increase from 14.37%±0.2 in dry beans to 61.07%±0.12 in canned beans. Sachet tomato had higher amounts of crude fat (7.57%±0.5), crude protein (2.89%±0.13), crude ash (1.67%±0.29), and carbohydrate (10.7%±0.64). On the other hand, dry beans had higher amounts of crude protein (22.06%±0.08), carbohydrate (45.59%±0.62), and crude fat (9.78%±0.31) with lower crude ash (4.8%±0.11) and crude fiber (3.4%±0.12) contents. Both fresh tomato and dry beans had higher amounts of all minerals than sachet tomato and canned beans respectively. Vitamin A was higher in fresh tomato than sachet tomato and higher in canned beans than dry beans, while reverse was the case for vitamin C. Our result indicated that processing could potentially reduce the nutritional composition in beans and improve some nutrients in tomato.

Keywords: Beans, Minerals, Nutritional composition, Tomatoes, Vitamins.

INTRODUCTION
Tomatoes (*Lycopersicum solanum*) are widely consumed vegetables with remarkable nutritional contents (Navarro-González I.,*et al* 2011). Physiological benefits are often derived from consuming tomatoes due to their richness in nutrients, secondary metabolites, such as vitamins, minerals, essential fatty acids, carotenoids, antioxidants, and other bioactive compounds (Ramos-Buenos *et al.*, 2017). Conversely, the legume Beans (*Phaseolus vulgaris L*) is an excellent protein source in addition to carbohydrates. Vitamins and minerals are also contained in significant amounts in beans (Hayat *et al.,* 2017). Both tomatoes and beans are highly valued for their versatility in food preparation, as they can be used in different foods from fresh salads to processed foods like sauces and soups. Information about the nutritional composition of both fresh and processed forms of these foods is essential for making informed dietary choices for effective nutritional and health benefits (Ali *et al.,* 2021).

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Vitamins, minerals, fibre, protein, essential amino acids, monounsaturated fatty acids, carotenoids, and phytosterols are among the common nutrients found in tomatoes (Abdullahi *et al.,* 2016; Elbadrawy and Sello, 2016). These nutrients carry out a number of biological functions, such as preventing constipation, lowering high blood pressure, boosting blood circulation, preserving bodily fluids and lipid profiles, detoxification of bodily pollutants, and preserving bone strength and structure. Tomato could thereby be an important part of a balanced diet due to its rich nutritional composition (Ali *et al.,* 2021).

The pods and seeds of beans are consumed globally due to their high protein composition and relative low cost compared to animal proteins, giving them the name "poor man's meat" (Semba *et al,* 2021). Beans are equally good source of carbohydrates as well as minerals and vitamins (Hayat *et al.,* 2011). However, the nutritional components are mostly contained in the bean seeds. A substantial amount of dietary fibre, which includes plant-derived carbohydrates such as lignin, pectin, oligosaccharides, cellulose, and hemicellulose are present in beans. These fibres have a wide range of positive health benefits on haemorrhoids, colon cancer, constipation, and protection against some gastrointestinal disorders (Ryan *et al.,* 2007).

Tomato products lose up to 30% of their initial mass during processing, with some of the nutrients retained in the waste products (Paulino *et al.,* 2020). The primary tomato waste products are the seeds and peel, which are high in lycopene, dietary fibre, protein, and bioactive substances (Lu *et al.,* 2019). The heating involved in canning process for beans helps to preserve nutrients like fibre and beans, which also makes them quick and easy to use for people with busy lives. Processed beans are stable pantry staples with shelf lives of up to five years (Njau, 2016).

Proximate and mineral analyses are essential techniques for evaluating the nutritional and chemical composition of food components, including tomatoes and beans. The main objectives of proximate analysis is to determine the moisture content, ash content, crude protein, crude fat, and carbohydrate (including fibre) composition of a food sample (Ramdath *et al.,* 2020). Micronutrients such as minerals and vitamins are essentially determined for their physiological roles in metabolism and regulation. For a variety of stakeholders, including food processing companies, dietitians, and consumers, such analyses provide important information on the nutritional value and safety of tomatoes, beans, and their products. Although fresh tomato has been previously compared to canned tomatoes there are no sufficient studies on Sachet tomatoes. Similarly studies comparing the nutritional compositions of local dry and canned beans are equally not sufficient.

MATERIALS AND METHODS

Sample Collection

Fresh tomatoes (*Solanum lycopersicum*), sachet tomato paste, and dry beans (*Phaseolus vulgaris L.*) were purchased from Katsina central market, Katsina State. The canned beans were purchased from Al Dusar Store, Katsina State.

Procedures

Fresh tomatoes were washed, and three pieces blended into paste for determination of moisture content. The remaining fresh tomatoes which have been washed were sliced, dried in oven, and crushed into fine powder for further analysis.

Sachet tomato paste, canned beans, and grounded dry beans were used for moisture determination while for the remaining analysis, all samples were dried in oven and crushed into fined powder.

Moisture Content Determination

An empty dish was dried in an oven for 3hrs at 105ºC and allowed to cool in a desiccator. Weight of the empty dish was then taken. After evenly spreading 3g of the sample inside the plate, it was dried in an oven set to 105ºC for 3hrs.. It was allowed to cool in the desiccator and weighed. It was then returned to the oven for another hour at 105ºC. Drying, cooling, and weighing was done repeatedly at hourly intervals until consistent weight was obtained (AOAC, 2000). Moisture content was calculated and expressed as a percentage of the weight loss of sample analyzed, given by the expression below:

Moisture (%) = $\frac{w1-w2}{w1} \times 100\%$

Where; W1 = Weight of sample before drying, W2 = Weight of sample after drying

Crude Fat Determination

A thimble-shaped filter paper was used to measure out 3g of the sample, which was then transfered into Soxhlet extractor. The Soxhlet was mounted on a weighed extraction containing 250mL of petroleum ether. The extractor was then connected with the cooling condenser and heating mantle switched on. The petroleum ether solvent was heated to a boil, evaporated, and then condensed into the extractor that held the thimble. The sample in the thimble was quickly submerged in the solvent, filling the reflux flask to the brim, and causing it to syphon over, transferring the oil extract to the boiling flask. After 4hrs of repeated cycles, the defatted sample was taken out and the solvent was recovered, while the oil extract remained in the flask (AOAC, 2000). To get rid of any remaining solvent, the flask containing the oil extract was dried at 80-90ºC in the oven until it dried out. The flask was allowed to cool and final weight taken. Percentage weight loss was calculated as expressed below;

Crude fat (%) = $\frac{W2-w1}{Weight\ of\ sample\ (3g)} \times\ 100\%$

Where; W1 = Weight of flask (g), W2=Weight of flask (g) + fat extract (g)

Crude Protein Determination

The total nitrogen was determined and multiplied with a factor of 6.25 to arrive at protein content according to AOAC (2000). In a digestion flask, 0.5g of the sample, 5g of Kjeldahl catalyst, and 200ml of concentrated H_2SO_4 were mixed. A similar mixture was prepared without the sample as blank. The mixtures were heated and boiled until the solution clears. The mixtures were cooled and gently diluted with 60ml of distilled water. The flask was swiftly connected to digestion bulb on condenser and immersed in standard acid with tip of condenser. To ensure complete mixing, 5-7 drops of indicator were added to the receiver while the flask was gently rotated. The flask was heated to distill NH_3 content. Receiver was removed, condenser tip was washed, and excess standard acid was titrated with distilled standard NaOH solution. %Protein was calculated following the expression given below.

Protein (%) $= \frac{(A-B)\times N\times 1.4007\times 6.25}{W}$

Where;

A = Volume (ml) of 0.2N HCL used in sample titration

B = Volume (ml) of 0.2N HCL used in blank titration

N = Normality of HCL

W= Weight (g) of sample

14.007 = Atomic weight of nitrogen

6.25 = The protein-nitrogen conversion factor for fish and its by-products

Crude Fiber Determination

For 30 minutes under reflux, 5g of the sample was heated in 150mL of 1.25% H_2SO_4 solution.. The boiled sample was washed in several portions of hot water using a two-fold cloth to trap the particles. It was returned to the flask and boiled again in 150mL of 1.25% NaOH for another 30 minutes under similar condition. After washing in several portion of hot water the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 150ºC to a constant weight. It was thereafter taken to muffle furnace where it was heated at 550ºC until it turned to ash. The weight of the fiber was determined by difference and calculated as a percentage of the weight of sample analyzed.

Fiber (%) $= \frac{Weight\ of\ fiber}{Weight\ of\ sample} \times 100$

Crude Ash Determination

The crucible was cleaned and weighed before 5g of the sample was added.. The sample was heated to ashes overnight in a muffle furnace at 550ºC with the lid open. When it has completely ashes, it was cooled in desiccator and weighed. After heating the lid was covered and sample allowed to cool down in the desiccator (AOAC, 2000). The weight of ash obtained was determined by difference and calculated as percentage of the weight of sample analyzed.

Ash (%) $= \frac{Weight\ of\ ash}{Weight\ of\ sample} \times 100$

Carbohydrate Determination

The carbohydrate content of the sample was estimated as the difference obtained after subtracting the value of organic protein, ash content, fat, crude fiber, and moisture content from 100. That is 100-(ash (%) + crude protein (%) + crude fat (%) + crude fiber (%) + moisture content (%).

Mineral Analysis

Grounded samples were analyzed for concentration of each minerals such as Calcium (Ca), Sodium (Na), Magnesium (Mg) at Umaru Musa Yar'adua Central laboratory by flame photometry.

Vitamin Analysis

Vitamin A was determined based on the addition of ethanol to break up the complex, permitting partitioning of vitamin A into heptanes. The nearly colorless retain is measured spectrophotometrically at 450nm (Latimer, 2007).

Vitamin C was determined based on the formation of a green colored complex on reaction with phototung state (PR) which is measured spectrophotometrically at 700nm (Rutkowski and Grzegorczyk, 1998).

Statistical Analysis

Analyses were carried out in triplicates with results presented as mean ± SD. Data was subjected to one-way Analysis of variance (ANOVA) and considered significant where P<0.05.

RESULTS

Proximate Analysis Comparing Fresh to Sachet Tomato Paste and Dry Beans to Canned Beans

Fresh tomato contained high amount of moisture (91.8%±0.58) that was significantly higher (P<0.05) than that of sachet tomato paste (76.17%±0.34). Conversely, sachet tomato contained higher amounts of fat (7.57%±0.5), protein (2.89%±0.13), ash (1.47%±0.2), and carbohydrate (10.7%±0.64) than fresh tomato. Fiber contents were higher in fresh tomato (1.3%±0.13) than sachet tomato (1.00%±0.07).

Moisture content in the dry beans (14.37%±0.2) was significantly lower (P<0.05) than that of the canned beans (61.07%±0.12). Canned beans also showed higher levels of fat (12.66%±0.36) and ash (5.24±0.21). Protein, carbohydrate, and fiber contents were 22.06%±0.18, 45.59%±0.62, and 3.4%±0.12 respectively in dry beans while the values stood at 15.44%±.0.22, 2.89%±0.17 and 2.7%±0.14 respectively in canned beans.

Table 1: Proximate Composition of Fresh Tomato, Sachet Tomato Paste, Dry Beans and Canned Beans

Parameter	Fresh tomato	Sachet tomato	Dry beans	Canned beans
Moisture content (%)	91.8 ± 0.58[a]	76.17 ± 0.34[b]	14.37 ±0.2[b]	61.07±0.12[a]
Crude fat (%)	2.61±0.29[b]	7.57±0.5[a]	9.78±0.31[b]	12.66±0.36[a]
Crude protein (%)	2.19 ± 0.1[b]	2.89 ±0.13[a]	22.06±0.18[a]	15.44±0.22[b]
Crude fiber (%)	1.3±0.31[a]	1.00±0.07[b]	3.4±0.12[a]	2.7±0.14[b]
Crude ash (%)	1.34±0.15[a]	1.47±0.2[a]	4.80±0.11[a]	5.24±0.21[a]
Carbohydrate (%)	3.54±0.58[b]	10.7±0.64[a]	45.59±0.62[a]	2.89±0.17[b]

Data are presented as mean ± SD, values with different superscripts are significantly different at P< 0.05.

Mineral Analysis Comparing Fresh Tomato to Sachet Tomato Paste and Dry Beans to Canned Beans

Fresh tomato showed significantly (P<0.005) higher amounts of calcium (Ca), magnesium (Mg) and sodium (Na) at 0.98ppm±0.3, 0.0728ppm±0.0007, and 1.58ppm±0.44 respectively than sachet tomato at 0.61ppm±0.0011, 0.0603ppm±0.001, and 1.14±0.31 respectively. The levels of Na, Ca, and Mg were all significantly higher in dry beans at 1.35ppm±0.5, 0.75ppm±0.37, and 0.0655ppm±0.0011 respectively than in canned beans at 1.03ppm±0.47, 0.56±0.33, and 0.0412±0.002 respectively.

Table 2: Mineral Composition of Fresh Tomato, Sachet Tomato Paste, Dry Beans and Canned Beans

Mineral	Fresh tomato	Sachet tomato	Dry beans	Canned beans
Na (ppm)	1.58±0.44[a]	1.14±0.31[b]	1.35±0.5[a]	1.03±0.47[b]
Ca (ppm)	0.93±0.3[a]	0.61±0.28[b]	0.75±0.37[a]	0.56±0.33[b]
Mg (ppm)	0.0728±0.0007[a]	0.0603±0.001[b]	0.0655±0.0011[a]	0.0412±0.002[b]

Data are presented as mean ± SD, values with different superscripts are significantly different at P< 0.05.

Vitamin Analysis Comparing Fresh Tomato to Sachet Tomato Paste and Dry Beans to Canned Beans

Vitamin A levels were found to be higher in Fresh tomato (2.48mg±0.42) than sachet tomato (2.2mg±0.26) while they were higher in canned beans (0.62mg±0.3) than dry beans

(0.18mg±0.1). Vitamin C showed higher concentrations in fresh tomato (14.7mg±0.9) than sachet tomato (22.9mg±1.02) and higher concentrations in dry beans (1.22mg±0.79) than canned beans (0.43mg±0.11).

TABLE 3: Vitamin Composition of Fresh Tomato, Sachet Tomato Paste, Dry Beans and Canned Beans

Vitamin	Fresh Tomato	Sachet Tomato	Dry Beans	Canned Beans
Vitamin A (mg)	2.48±0.42[a]	2.2±0.26[b]	0.18± 0.05[b]	0.62 ± 0.13[a]
Vitamin C (mg)	14.7 ± 0.9[b]	22.9 ±1.02[a]	1.22 ± 0.79[a]	0.43 ± 0.11[b]

Data are presented as mean ± SD, values with different superscripts are significantly different at $P< 0.05$.

DISCUSSION

Table 1 compared the proximate composition of fresh tomato to sachet tomato and dry beans to canned beans, showing notable differences in some nutrients. Although moisture remained the highest constituent in both fresh and sachet tomato, the heating involved in processing sachet tomato lowers moisture content, which is necessary for reducing microbial viability and improving its shelf-life (Shina and Tambai, 2018). However, salt and water which are both supplemented when processing canned beans cause a dramatic increase in moisture as observed in contrast to dry beans (Adams and White, 2015).

Factors including variety, tomato cultivar, extraction techniques, analytical techniques, and environment affect the nutritional composition of tomatoes (Yaroson *et al.,* 2018: Ali *et al.,* 2021). Hence, variety and method of processing in addition to increased solid matter are possibly responsible for lower amounts of protein, fat, and ash contents in fresh tomato compared to sachet tomato (Ismail *et al.,* 2016; Yaroson *et al.,* 2018). Some nutrients in tomato are essentially lost as waste when processing tomato products including proteins, dietary fibres, lycopene, and bioactive compounds. Despite a contrasting value in our results for protein, crude fiber content in fresh tomato was higher than sachet tomato (Lu *et al.,* 2019).

Bean is an excellent source of protein and carbohydrates, whose protein composition is particularly estimated to range between 15% and 30% (De Almeda *et al.,* 2006). The protein in beans mainly include globulins and albumin which also provides the essential amino acids cysteine, methionine, and lysine (Kotue *et al.,* 2018). Dry beans contained reasonably high amounts of both protein and carbohydrates. However, the protein level in canned beans was slightly lower than average protein contents in beans accompanied with a dramatic decline in carbohydrate contents. Cooking, salts, water, and preservatives added to canned beans could possibly affect the protein and carbohydrates level as such. Despite a long shelf-life attributed to canned beans, it may notably come at the cost of protein, carbohydrate, and fiber contents, although the effect not as dramatic in the fiber contents. Nevertheless, the canned tomato still showed a positive potential in its fat and ash contents.

In Table 2, the results indicated higher amounts of all the minerals in the raw food samples (fresh tomato and dry beans) compared to the processed food samples (Sachet tomato and canned beans). This also corresponds with claims that nutrient is lost along with the wastes in processing tomato despite increase in dry matter (Paulino *et al.,* 2020). Although conversely, we associate the slight decline in mineral composition of the canned beans to the reduced dry matter caused by added water.

Finally, Table 3 shows that vitamin A was higher in fresh tomato than sachet tomato but higher in canned beans than dry beans. Previous reports have shown that heating could alter vitamin A levels both ways, thereby either increasing or decreasing its concentrations although the determining factor remains unclear (Yang *et al.,* 2022: Johnson *et al.,* 2023). Hence, although the resulting effects were notably different, it is possible that both vitamin A decline in sachet tomato and increase in canned beans are related to the heating or partial cooking the processed products were subjected to. Vitamin C levels were found to be higher in sachet tomato than fresh tomato and higher in dry beans than canned beans, which could be attributed to tomato variety and reduced dry matter respectively (Abdullahi *et al.,* 2016).

CONCLUSION

This study recognizes the need to identify nutritional changes that accompany processing of tomatoes and beans into preserved products, as such products have become widely accepted. Despite widespread acceptance, there remains elements of uncertainty with regards to their safety and overall nutritional value. Sachet tomato, however, had higher amounts of proximate parameters as well as vitamin C, while fresh tomato contained higher amounts of minerals and vitamin A. The overall nutritional composition of the sachet tomato paste renders it good enough to be considered a suitable alternative for long-term use. A more dramatic decrease in nutritional composition was observed in the beans, particularly protein and carbohydrate composition for which the legume is most known for.

The scope of this study has only been able to cover proximate parameters with selected vitamins and minerals. Changes in phytochemical composition, minerals, and B vitamins would be worthwhile. Furthermore, a toxicological study would provide good insight into the safety of processed beans and tomatoes.

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