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EXTRUSION BARREL TEMPERATURE EFFECT ON TEXTURAL AND PHYSICAL PROPERTIES OF READY-TO-EAT FOOD FROM CARDABA BANANA, AFRICAN YAM BEAN, AND DATES

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Abstract

This work incorporated underutilized crops (cardaba banana, African yam bean, and date fruit), into composite flour used in the extrusion process of Ready-To-Eat (RTE) foods processed at two different barrel temperatures (BT) of 120 and 130 ˚C using a twin-screw extruder. Date fruit flour (DFF) served as a sweetener and binder, with a constant percentage composition for all samples. The color, texture, and physical properties of the RTEs were determined using standard procedures and equipment.

Extrusion at 120 °C BT increased the incidences of L*, a*, b*, and chroma color saturation, while BT did not affect the hue color for all RTE foods. RTEs processed at high BT had higher values of chewiness, cohesiveness, gumminess, and stringiness, as well as higher force peak values. However, no significant difference ($p < 0.05$) was observed for the fracturability, springiness, and hardness of all the RTEs at both BTs. Lower extrusion BT resulted in increased values of weight, diameter, density, thickness, and porosity. Nevertheless, it was observed that the values for the spread ratio and volume of the RTEs increased at higher BTs. The desired textural properties for these RTE foods were achieved at a higher BT (130 ˚C), while physical properties were affected by the composition of the composite flours used.

Keywords: Cardaba banana, African yam bean, Date fruit, flour, Physical properties, Extrusion, RTE

Introduction

Extrusion cooking is a fast-growing technology in the food industry, although it is a complex yet flexible process (Singh *et al.*, 2019; Mironeasa *et al.*, 2023). It simultaneously incorporates multiple unit operations, such as mixing, kneading, cooking, conveying, pasteurization, cooling, shaping, and cutting (Pismag *et al.*, 2024), in the transformative process of converting a flour mixture into ready-to-eat (RTE) food. It is a High Temperature Short Time (HTST) process that alters the textural and physical properties of food via starch pre-gelatinization, resulting in a modified food material with improved digestibility, appealing appearance, and a welcoming flavor.

There are two types of extrusion cooking: hot and cold extrusion. Cold extrusion is applied in processing where only mixing of the flour and shaping of the dough are required, as in the production of pasta. Hot extrusion is more elaborate, incorporating heat treatment in addition to the mixing and shaping offered by cold extrusion. Products from hot extrusion cooking are thereby considered RTE foods. Extrusion technology enables the use of various materials at the feed inlet, with adjustable processing parameters, including feed inlet, Barrel Temperature (BT), screw speed, and moisture (Pismag *et al.*, 2024).

BT is the temperature involved in the starch gelatinization and protein denaturation process of extrusion cooking, and it is proportional to the Residence Time Distribution (RTD). Higher BT always implies a lower RTD, and vice versa, which helps prevent the loss of volatile nutrients during cooking. BT ranges from 80 – 150 ˚C for starch-based flour biomaterials, and 100 – 180 ˚C for protein-based biomaterials. According to Sue *et al.* (2015), BT is one of the factors responsible for the nature of RTE food, specifically its physical properties, color, oil, and water absorption indexes. Alemayehu *et al.* (2019) highlighted the importance of BT while reporting the appearance of RTE snacks from composite flour, corroborating the recommendation of Sue *et al.* (2015) that composite flour be used in RTE production.

Composite flour is described as a mixture of flour samples from multiple sources, including flour from cereals, flour from fruits, flour from tubers, flour from legumes, flour from vegetables, etc. (Udoh *et al.*, 2024). The different base materials offer composite flour its functionality, i.e., a combination of diverse and specific nutrients. Another merit of composite flour is the reduction of dependence on wheat importation. This study focuses on compositing from lesser-known biomaterials like cardaba banana, African yam bean, and date fruit.

Cardaba banana (*Musa acuminata × balbisiana)* is a crossbreed species of banana, distinguished by its resistant starch. It is abundant in Nigeria but mostly wasted due to its bland taste. Conversion to flour is expected to reduce wastage and provide a range of uses for the underutilized material. Udoh *et al.* (2024) observed the growing interest in African yam bean (*Sphenostylis stenocarpa*) due to the potentials it possesses, which include sustainability, diabetic therapeutic benefits, and a nutritious food source. Date (*Phoenix dactylifera*) fruits are natural sweeteners rich in bioactive compounds, they are abundant sources of carbohydrate, fibre, minerals, and vitamins.

The production of RTE food from this composite flour mixture, is expected to meet the growing populace's demand for safe, healthy, nutritious, and low-cost RTE food. RTE foods are foods for immediate consumption that require no further heat treatment. They are lightweight, shelf-stable, and nutritious, suitable for all age categories. However, the acceptability of RTE depends on their color, physical and textural properties, which are affected by the extrusion barrel temperature. This research work was aimed at determining the effect of barrel temperature on the physical, textural, and color properties of RTE food from cardaba banana flour (CBF), African yam bean (AYB) flour, and date fruit flour (DFF).

Materials

Cardaba banana fruits were purchased in situ from a local farm in Osogbo, African yam bean was purchased from a local market in Ilesha, and date fruits were purchased from a market in Osogbo. The trio was transported to the Food Science and Technology laboratory of Osun State University, where the entire experimental process, including flour processing, formulation, extrusion, and instrumental color analysis, was carried out. All activities were conducted under standardized laboratory conditions to ensure data reproducibility and scientific validity.

Methods

Preparation of Cardaba Banana Flour

Cardaba banana flour (CBF) was processed by slightly modifying the documented method of Babalola and Taiwo (2019). Fresh cardaba banana fruits were thoroughly washed, peeled, and sliced into thin slices (3.0 mm thickness). To minimize enzymatic browning, the slices were blanched at 60 °C for 10 minutes before drying. The slices were dried in a cabinet dryer set at a temperature of 65 °C (samples took 12 hours for complete drying). The dried slices were milled using a hammer mill and passed through a 500 µm sieve to obtain uniform flour. The flour was packed in polyethylene bags and stored in airtight containers at ambient temperature (27±2°C) to prevent moisture absorption.

Preparation of African Yam Bean Flour

The method for preparing African yam bean flour was adapted from Adegunwa *et al.* (2024). The African yam beans were manually cleaned to remove dirt, stones, and defective seeds. The cleaned beans were then soaked in water for 40 hours to soften the seed coats, making it easier to remove them manually during de-hulling. After de-hulling, the seeds were cleaned again, dried at 65°C for 10 hours (inside a cabinet drier) to reduce moisture, and then milled into flour, and sieved through a 500 µm mesh. The resultant flour was stored in airtight polyethylene-lined bags under dry conditions.

Preparation of Date Fruit Flour

The date fruit flour was produced according to the modified method of Ujong *et al.* (2024). Mature date fruits were first cleaned thoroughly with water while keeping them whole, after which they were dried in a cabinet dryer to reduce their moisture content. Dried dates were deseeded manually to remove the pits; the deseeded fruits were dried again at 60°C for 8 hours. The dried fruits were milled into fine powder using a high-speed grinder and passed through a 500 µm sieve. The flour was sealed in moisture-proof containers and kept in a cool, dark cupboard until further use.

Experimental Design

The composite flours were prepared according to the specification below;

Sample	CBF (%)	AYB (%)	DFF (%)	Extrusion (°C)	Temperature	Water (mL)
A	50.00	50.00	4.00	120.00		450.00
B	60.00	40.00	4.00	120.00		450.00
C	60.00	40.00	4.00	130.00		450.00
D	50.00	50.00	4.00	130.00		450.00

Extrusion Processing

Extrusion was carried out using a double-screw extruder equipped with a 3.0 mm circular die. The extruder was operated at two (2) different Barrel Temperatures (BT) of 120.00 and 130.00 °C, 450.00 mL of water was used in making the composite dough, and each flour blend was carefully fed into the extruder. The extrudates were collected at the die exit and air-cooled for 30 minutes and subsequently dried in a cabinet dryer (60 °C for 6 hours) to standardize moisture content for further testing. Final products were packaged in low-density polyethylene bags and labeled accordingly.

Instrumental Color Analysis

The instrumental color parameters L*, a*, and b* were measured using a Minolta CR-300 Colorimeter (Minolta Co. Ltd., Tokyo, Japan), calibrated with a standard white tile (L* = 97.63, a* = 0.31, b* = 0.44). Measurements were taken in triplicate on three separate points per sample to ensure accuracy and representativeness. Each sample was ground into powder and placed in a sample cup to eliminate surface variability.

From the primary color parameters, the Chroma (C*) and Hue Angle (h°) were computed (Equation 1) as follows: Chroma

$$C^* = \sqrt{(a^2 + b^2)} \qquad \text{Equation 1}$$

Hue Angle (h°) = arctangent (b*/a*)

Physical Analysis

The samples were analyzed for their weight, thickness, volume, diameter, spread ratio, density, and porosity using the analytical method Ubbor *et al.* (2022) reported. The sectional expansion Index and Expansion Ratio were calculated using the diameter of the extrudates and the diameter of the die as shown in equations 2 and 3 below:

$$\text{Expansion Ratio} = \frac{\text{Diameter of the Extrudates}}{\text{Diameter of the die}} \qquad \text{Equation 2}$$

$$SEI = (ER)^2 \qquad \text{Equation 3}$$

Where Diameter of the die = 4.0 mm

Textural Characteristics

Textural analysis was carried out using a Textural Profile Analyzer by utilizing the analytical methods described by Oladeji *et al.* (2024). The samples were analyzed for Adhesiveness, Cohesiveness, Gumminess, Fracturability, chewiness, stringiness, springiness, and hardness.

Statistical Analysis

All analysis was done in triplicate, data obtained were subjected to statistical analysis using SPSS Version 25. One-way Analysis of Variance (ANOVA) was performed to determine significant differences ($p > 0.05$) among the different sample formulations for each physical parameter. Duncan's Multiple Range Test (DMRT) was applied to separate means.

Results and Discussion

Color is one of the most critical quality attributes of food products, especially extrudates, as it strongly influences consumer perception (Spence, 2015), marketability (Kardas *et al.*, 2024), and acceptance (Ercik *et al.*, 2023). The color properties of the extrudates, including L* (lightness), a* (redness/greenness), b*(yellowness/blueness), Chroma (color saturation), and Hue (color tone) were evaluated to determine the visual impact of flour composition and extrusion temperature. The results of the color analysis are presented in Table 1, showing L* (15.66 to 17.07), a* (2.11 to 2.66), b* (7.04 to 27.90), Hue (1.23 to 1.47), and Chroma (7.46 to 28.06), which are implications of the effect of percentage composite mixture and barrel temperature (BT) on the RTE.

It could be established that the constant 4.00 percentage of DFF had a higher and dominating effect on the lightness value of the extrudates. The heat in the extrusion process could have also resulted in the non-enzymatic browning reactions, like Maillard and Caramelization. Extrusion processing at 120 °C BT increased the incidences of the L*, a*, b*, and chroma color saturation.

The L* values show the lightness on the scale of 0 to 100, with values closer to 100 exhibiting lightness than values closer to 0. The values obtained for this work are closer to 0 than to 100, indicating the darkness rather than the lightness of the RTEs. The a* (redness or greenness) values obtained for this work were all positive, meaning that the color attributes of a* for these RTEs are red. The yellowness of the RTEs was ascertained with the positive b* values obtained for all the RTEs, which ranged from 7.38 to 27.90. Similar results were recorded by Kardas *et al.* (2024) for beetroot and tomato juices.

The high heat applied in the extrusion processing at a BT of 130 ˚C could be responsible for the lower lightness values obtained because high BT often results in irreversible chemical changes that darken the color of food materials. The results of this work agree with the work of Pismag *et al.* (2024), who reported that when starch-based biomaterials degrade into sugars, with subsequent interactions with free amino acids during extrusion processes, the effects are non-enzymatic reactions like caramelization and Maillard reactions. Color influences the consumer's perception of the product (Pismag *et al.,* 2024), it is decisive to the acceptability of RTE food products.

Table 1: Results of the color analysis of the RTE products at 120 and 130 ˚C

Sample	L*	a*	b*	Hue	Chroma
A	16.84±2.53 [a]	2.48±0.18 [b]	27.90±2.19 [a]	1.48±0.06 [a]	28.01±2.09 [a]
B	17.07±2.22 [a]	2.66±1.64 [a]	7.42±0.55 [b]	1.23±0.01 [d]	7.88±0.62 [b]
C	16.53±0.20 [b]	2.37±0.31 [b]	7.38±0.85 [b]	1.26±0.02 [c]	7.75±0.97 [c]
D	15.66±1.34 [c]	2.11±0.70 [c]	7.04±0.24 [c]	1.28±0.07 [b]	7.35±0.29 [d]

Values reported are mean ± standard deviation of triplicate determinations. Mean values with different superscripts within the same column are significantly (P > 0.05) different.
Key:**A**: (50.00 CBF:50.00 AYB at 120 ˚C BT)
B: (60.00 CBF:40.00 AYB at 120 ˚C BT)
C: (60.00 CBF:40.00 AYB at 130 ˚C BT)
D: (50.00 CBF:50.00 AYB at 130 ˚C BT)
CBF: Cardaba Banana Flour
AYB: African Yam Bean Flour

Textural properties of the RTE foods

The result of the textural properties of the RTE food is presented in Table 2. The texture parameters analyzed in this study include adhesiveness, chewiness, cohesiveness, fracturability, gumminess, hardness, springiness, stringiness, and force peak. These parameters provide insights into how the RTE products respond to mechanical stress during consumption and handling. RTEs processed at high BT had higher values of chewiness, cohesiveness, gumminess, stringiness, and force peak values.

Adhesiveness can be described as the work required to overcome the force of attraction between surfaces, it is a reflection of the stickiness or tackiness of a food product. The adhesiveness of these RTEs was affected by the extrusion BT, RTEs extruded at low BT had higher adhesiveness values compared to RTEs extruded at high BT. Adhesiveness is an essential parameter in RTEs because it affects the mouthfeel and ease of handling, packaging, and consumption. Excessively adhesive products may be perceived as unpleasant or too sticky by consumers (Ajayi and Omodara, 2022).

Chewiness is defined as the resistance of a food product to mastication, it reflects the internal bonding of the food matrix. Cohesiveness is the degree to which a food product can withstand second deformation relative to the first, it is equally a reflection of the internal bonding strength of the food material. Gumminess is described as the work required to deform a food to a swallow-able state, also a reflection of the internal strength. Low values of chewiness, cohesiveness, and gumminess are therefore desirable in RTE foods, for good acceptability for all age brackets, because it will allow for easier breakdown during mastication (Daiz, 2021). The chewiness, cohesiveness, and gumminess were all affected by the extrusion BT, RTEs extruded at high BT had higher values of chewiness, cohesiveness, and gumminess.

Similar trends of values were recorded for the fracturability and the hardness of the RTE foods; the values were low, ranging from 10.175 to 10.465 N. Fracturability is the force needed to break RTE food under compression, it describes the product's crispness or brittleness. Hardness is also a force, it is required to accomplish specific deformation during compression, it affects mouthfeel and bite strength (Ikujenlola *et al.,* 2022). Low values of fracturability and hardness are desirable for RTE foods, because they mean softer foods consumable to all. No significant difference ($p < 0.05$) was observed for the fracturability and the hardness of all the RTEs. This means that the extrusion BT did not affect the fracturability and hardness of the RTEs.

Stringiness influences the perception of mouthfeel, it is described as the resistance of RTE food to breaking apart during deformation. Negative values were obtained for the springiness of the RTE foods, the values ranged from -7.611 to -11.499 mm, likewise, negative values ranged from -59.37 to -105.34 N.s were recorded for the adhesiveness of the RTE foods. Both stringiness and adhesiveness involve the resistance of RTE foods during separation, and low values of both properties are desirable in RTE foods. Low adhesiveness is desirable in RTE foods, as it provides a perception of freshness, offers ease of consumption. Dias-Faceto and Conti-Silva (2022) also reported that low adhesiveness helps RTE food retain crispness when milk is added.

RTEs extruded at high BT had higher values than the RTEs extruded at low BT, implying that higher extrusion BT hastens and accelerates the continuity of the starch-protein-sugar interactions (Akinwande *et al.,* 2022) in RTE foods. At low extrusion BT, starch might not be fully gelatinized, leading to insufficient breakdown of granules (Zhang *et al.*, 2011), whereas, extruding at high extrusion BT, results in products with denatured proteins (Singh *et al.*, 2007), which can interact with starch, and of reduced stickiness.

The force peak values obtained for the RTE foods ranged from 22.950 to 68.465 N. It was observed that RTEs extruded at high BT had higher force peak values, and vice versa. Force peak could be described as the maximum force recorded during the first compression cycle of a Texture Profile Analysis, which is an indication of how hard (with a higher force peak) or how soft (lower force peak) the RTE product is. Both low and high force peak values are acceptable, but distinguish the targeted consumers: a low force peak is an indication of soft/ easy to bite RTE (edible for the elderly and infants), and a high force peak indicates that the RTE food is good for crunchy (Brennan and Tudorica, 2008).

Table 2: Textural properties of RTE foods

Samples	Adhesiveness (N.s)	Chewiness (N)	Cohesiveness	Fracturability (N)	Gumminess (N)	Hardness (N)	Springiness	Stringiness (mm)	Force Peak (N)
A	-63.59 ± 1.47^{b}	5.390 ± 0.02^{d}	0.47 ± 0.00^{d}	10.18 ± 0.08^{a}	4.95 ± 0.02^{bc}	10.18 ± 0.08^{a}	1.10 ± 0.00^{b}	-11.50 ± 0.24^{c}	32.45 ± 0.19^{c}
B	-59.37 ± 2.49^{a}	5.42 ± 0.08^{c}	0.48 ± 0.00^{c}	10.26 ± 0.00^{a}	5.06 ± 0.04^{bc}	10.26 ± 0.00^{a}	1.09 ± 0.00^{b}	-11.33 ± 0.23^{c}	22.95 ± 0.25^{d}
C	-70.56 ± 0.12^{c}	6.77 ± 0.12^{a}	0.58 ± 0.00^{a}	10.23 ± 0.08^{a}	5.99 ± 0.07^{a}	10.23 ± 0.08^{a}	1.10 ± 0.01^{b}	-7.61 ± 0.42^{a}	39.53 ± 0.33^{b}
D	-105.34 ± 1.91^{d}	5.91 ± 0.09^{b}	0.53 ± 0.01^{b}	10.47 ± 0.02^{a}	5.33 ± 0.07^{b}	10.47 ± 0.02^{a}	1.10 ± 0.00^{b}	-10.97 ± 0.21^{b}	68.47 ± 0.11^{a}

Values reported are mean ± standard deviation of triplicate determinations. Mean values with different superscripts within the same column are significantly (P > 0.05) different.
Key:**A**: (50.00 CBF:50.00 AYB at 120 ˚C BT)
B: (60.00 CBF:40.00 AYB at 120 ˚C BT)
C: (60.00 CBF:40.00 AYB at 130 ˚C BT)
D: (50.00 CBF:50.00 AYB at 130 ˚C BT)
CBF: Cardaba Banana Flour
AYB: African Yam Bean Flour

Physical Properties of the RTE foods

The results of the physical properties of the RTE foods are presented in Table 3. The physical properties analyzed include the sample's weight, thickness, volume, diameter, spread ratio, density, and porosity. Extrusion at low BT resulted in higher values of weight, diameter, thickness, and density of all the RTEs.

The effect of the extrusion BT on the weight, diameter, thickness, and density of all the samples was negligible and dependent on the composition proportion. It was observed that RTE samples with low CBF and high AYB were higher in weight, diameter, and density, and this might be due to increased puffing and expansion, likewise bulkiness caused by the higher protein content. Jia *et al.* (2021) reported that puffing is enhanced by high protein content, which forms a tighter elastic network, resisting water desorption. Higher density is an indication of less expanded but bulkier product.

The low values obtained for weight, diameter, and density in RTEs with high CBF and low AYB, could be due to the fact that the fibre resist puffing. The thickness of the samples ranged from 7.76 to 11.22 mm, the effect of BT was infinitesimal and dependent on the proportion composition of the composite flour, samples with low CBF, high AYB had higher thickness. This might be due to the high quantity of starch in CBF, that enhanced swelling, thereby increasing the vertical puffing. Thickness, according to Ibrahim and Oladipo (2024), is a measure of the vertical expansion, an indication of the extent of puffing achieved during extrusion cooking.

The density value ranges obtained for these RTE foods agree with those of Ali *et al.* (2024), density values decrease with higher BT. This is an effect of the expansion of the RTE food, higher expansion, implies that the density will be lower because it occupies more space (higher volume). Volume could be described as a measure of the puffing expansion, and it is the total space occupied by the RTE food. RTEs (D and C) processed at high BT (130 ˚C) had higher volumes than RTEs (A and B) processed at low BT (120 ˚C). This result agreed with the findings of Sahu *et al.* (2022) on soy protein enriched maize based extruded snack. However, Boakye *et al.* (2023) and Karun *et al.* (2023) reported that the flour composition is another determinant factor that affects the volume of RTE foods.

Spread ratio is a distinctive property of extruded products, it is described as the ratio of diameter to thickness. This dimensionless property is usually used to evaluate the shape and the expansion characteristics of RTE foods (Sherif *et al.,* 2025). The spread ratio of the RTEs ranged from 0.89 to 1.18, it was observed that the effect of BT (Deepak Mudgil *et al.*, 2017) was dependent on the proportion composition (Ikade *et al.*, 2024) of the samples, RTEs with high CBF had higher spread ratio than RTEs with low CBF.

The values obtained for the RTEs porosity ranged from 51.01 to 53.38, and BT affected the porosity values of the samples. Samples processed at 120 ˚C BT had higher porosity values compared to samples processed at 130 ˚C BT. The result of this work does not agree with those of Sahu *et al.* (2022) and Ali *et al.* (2024), who reported that increasing the processing BT increased the porosity of the RTE food. This might be due to the moisture content and the constituents of the flour composition (Lotfi Shirazi *et al.*, 2020).

Table 3: The Physical properties of the RTE food

Samples	Weight (g)	Thickness (mm)	Volume (mL)	Diameter (mm)	Spread Ratio	Density (g/mL)	Porosity (%)
A	1.52±0.03 [a]	11.23±0.02 [a]	1.17±0.21 [d]	11.32±0.03 [a]	1.01±0.00 [c]	1.31±0.20 [a]	52.90±0.68 [b]
B	1.25±0.06 [b]	11.14±0.02 [b]	1.27±0.15 [c]	10.00±0.03 [b]	0.90±0.00 [d]	0.98±0.14 [b]	53.39±0.86 [a]
C	0.70±0.00 [d]	7.77±0.03 [d]	1.33±0.21 [b]	8.56±0.02 [d]	1.10±0.00 [b]	0.53±0.09 [d]	51.01±0.31 [c]
D	0.90±0.00 [c]	8.10±0.02 [c]	1.4s0±0.20 [a]	9.59±0.01 [c]	1.18±0.00 [a]	0.64±0.09 [c]	52.37±0.94 [b]

Values reported are mean ± standard deviation of triplicate determinations. Mean values with different superscripts within the same column are significantly (P > 0.05) different.
Key:**A**: (50.00 CBF:50.00 AYB at 120 ˚C BT)
B: (60.00 CBF:40.00 AYB at 120 ˚C BT)
C: (60.00 CBF:40.00 AYB at 130 ˚C BT)
D: (50.00 CBF:50.00 AYB at 130 ˚C BT)
CBF: Cardaba Banana Flour
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Extrusion expansion effect on quality and safety of RTE foods

Expansion Ratio (ER) and Sectional Expansion Index (SEI) (Figure 1) are important parameters that suggest the quality and safety of the RTE food. The ER reflects the extent of radial puffing, while SEI amplifies these differences by capturing cross-sectional changes (Okpala *et al.*, 2023). Sample A was observed to have the highest ER (2.829) and SEI (7.998). This indicates superior puffing of the extrudates occurred at 120 ˚C using 50% Cardaba banana flour, 50% African yam bean flour and 4% date flour. It implies enhanced porosity, and desirable crispness of the product. This expansion indicates an effective starch gelatinization and uniform thermal–mechanical treatment, thereby minimizing the possibility of undercooked cores and contributes positively to food safety. This simply means that Sample A will have a longer shelf life compared to other samples. On the contrary, Sample C recorded the lowest ER (2.141) and SEI (4.583). This results in denser texture and lower porosity of the product. This under-expansion can be interpreted to be insufficient cooking or reduced mechanical energy input. These conditions can compromise textural acceptability and increase moisture retention. This will impact microbial stability and shelf life of the product negatively. Sample C will have a short shelf life because it has high tendency of absorbing moisture. Samples B and D demonstrated intermediate expansion values. This suggest acceptable but less optimal performance. Overall, Sample A is considered the best sample in terms of textural quality and safety assurance, while Sample C represents the least desirable product. Samples containing 50% Cardaba banana, 50% African yam bean and 4% date flour were well cooked at 120 and 130 ˚C BT. Chou and Hsu (2021) also observed that there was change in expansion properties of RTE from corn at 110 - 130 ˚C BT, which was similar to the findings in this study. These results highlight the critical role of extrusion parameters, particularly barrel temperature, in achieving consistent quality in ready-to-eat foods. The efficiency of the barrel temperature used for the production of RTE food is composition and component dependent.

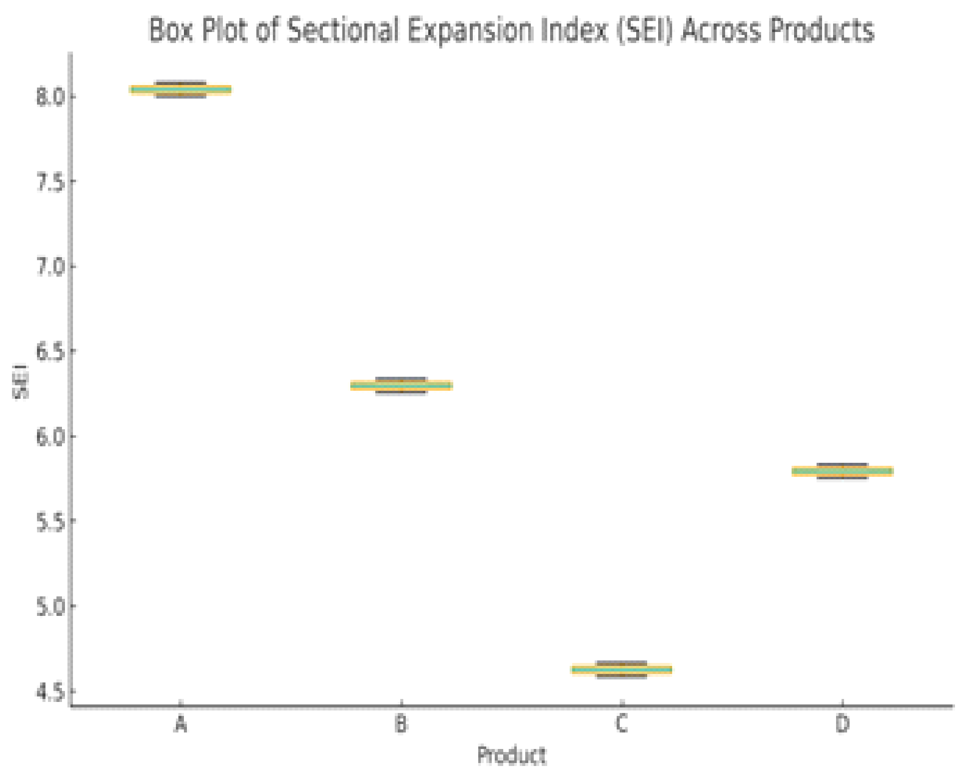

Figure 1: Box Plot of Sectional Expansion Index (SEI) Across Products
Key:A: (50.00 CBF:50.00 AYB at 120 ˚C BT) **B:** (60.00 CBF:40.00 AYB at 120 ˚C BT)
C: (60.00 CBF:40.00 AYB at 130 ˚C BT) **D:** (50.00 CBF:50.00 AYB at 130 ˚C BT)
CBF: Cardaba Banana Flour AYB: African Yam Bean Flour

Conclusion

The barrel temperature influenced the textural properties of the RTE foods from cardaba banana, African yam bean and date. Higher BT produced desired adhesiveness, chewiness, cohesiveness and gumminess for RTE foods. However, the physical properties of the RTE foods from cardaba banana, African yam bean and date were not affected by the BT, but was rather affected by the composition of the composite flours. Low quantity of cardaba banana and high quantity of African yam bean achieved the desired thickness for RTE foods. In order to obtain desired textural properties for these RTE foods, high BT (130 ˚C) should be considered.

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