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Physicochemical, Functional, Sensory Properties and Nutritional Value of Developed Custard Blends

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Abstract: The general trend is towards adding by-products to make highly nutritious foods. This study aimed to develop custard powder by incorporating cassava starch and broken chickpea flour. Different amounts were used to make eight samples, which were then compared to commercial custard as a control sample, which assessed their composition, and physicochemical, functional, and organoleptic properties. There were insignificant differences in the moisture contents ($p>0.05$). The least lightness was observed in the blend with 50% broken chickpea flour and 40% cassava starch, while the highest was seen in the commercial sample. Blends had varying levels of total ash, fat, protein, fiber, and carbohydrate contents, and their highest values were found in the blend T8 (70% chickpea flour and 20% cassava starch). The highest total carotenoid content was obtained in T8 (70% broken chickpea flour and 20% cassava starch). An obvious decrease in the viscosity of different blends was accompanied by an increase in the broken chickpea flour percentage. Water activity values were the highest in the T1 sample. Significant differences were found in the least gelation, bulk density, water absorption capacity, swelling power, and gelatinization temperature. Significant differences in all sensory attributes were observed. The proposed blends are acceptable, particularly those with high levels of cassava starch and low chickpea flour. Blend (T8) was the cheapest, and 100g of this blend exceeded the required protein amounts, carbohydrates, and energy needs for children aged 4-8 years. According to the study's findings, the suggested custard was of high quality.

Key words: Quality evaluation・Custard powder・Broken chickpea flour・White fleshed cassava starch・Amino acid・Proximate composition・Minerals

INTRODUCTION

Custard is a popular food items worldwide made with various ingredients, including milk, sugar, colorants, and flavorings [1]. Legumes are appropriate for eating after processing and have a particularly unique nutritional niche that contributes significantly to the global population's diet [2]. Legumes are the second most significant food crop in the world after cereals and are a vital and affordable alternative source of protein [3]. Legume seeds offer a significant amount of carbohydrates, minerals, and vitamins in addition to their high protein and amino acid content [4]. Given the preference for custard, Awoyale *et al.* [5] endeavored to use local ingredients into its production, and funky materials into its manufacture, such as cassava starch in preparing custard with high nutritional value to add a certain value to the custard and support it with elements.

Reducing the consumption of animal foods is a key element in achieving healthy and sustainable diets [6]. As for custard, and environmental factors, consumers may avoid milk consumption due to milk allergy or lactose intolerance, which is a growing for alternatives [7].

Some locally available legumes that are a good source of protein but are underutilized are *Vigna unguiculata* (Cowpea), *Cicer ariethinum* (Chickpea), *Vigna radiate* (Mung bean), *Cajanus cajan* (Pigeon pea) [8].

The broken chickpea seeds are one of the by-products of the process of chickpea seeds from their dry

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horns. In Egypt, pulse losses were estimated to be 60,000 tons in 2018, up by 122.22 tons [9]. For example, broken (6%-13%), as low economic valued by-products, sold at low prices and are grossly underutilized [10,11]. These by-products sometimes represent about 25%-50% of the cotyledon, depending primarily on the characteristics of the pulse and the machinery used for dehulling [12].

Chickpea (*Cicer arietinum* L.), the third most important pulse crop is high in fiber, protein, vitamins, and essential minerals. Additionally, their glycemic index is low. Consequently, chickpea may be useful in either treating or preventing cancer, cardiovascular disease, diabetes, high cholesterol, and hypertension [13]. It was suggested that broken chickpea seeds could be utilized for developing nutrient-dense meals that would promote overall health and well-being [14]. Many of the research initiatives have shown that broken chickpea seeds can be used in product formulations as a basic ingredient for new products or as a functional food [15]. Chickpea protein has a digestibility range of 48 to 89.01% [16].

Broken chickpea is reasonably priced sources of minerals and vitamins, dietary fiber, and folate as well as protein, and carbohydrates. It also exhibits strong antioxidant activity action. Research indicates that the components of chickpeas may be beneficial in lowering the risk of several chronic illnesses [17].

Cassava flour has been one of the most popular foods from cassava roots [18]. The starch content of cassava roots is high roughly 60%. They are therefore an excellent source of dietary carbohydrates but they have a low protein content which can only be improved by adding high-protein crops such as chickpea, soybean, and cowpea to the mix [19]. Starch is a major carbohydrate storage product in all plants with green parts that contain chlorophyll. It is affordably obtained and frequently used to produce industrial goods for a variety of purposes. The unique qualities of starch that improve its application are gelation, biocompatibility, biodegradability, and modification based on intended use [20].

Milk powdered products are considered the best primary and live products that children require because they include both the vital nutrients found in milk and the nutritional supplements for healthy growth and development [21].

The majority of people in underdeveloped nations consume starchy diets, which causes malnutrition, with children being the most affected. Foods that have been enriched with protein will have higher nutritional content, which will assist in preventing protein deficiencies [22].

Functional food development and marketing are challenging and include complex, expensive, and particular needs. In addition, technical as well as legislative requirements should also be considered. Therefore, readily available ready-made functional foods will help consumers reap the benefits of functional foods for their general health as well as in developing a good self-image [23].

To turn processed broken pulses into higher-value products, the objective of the present study was to develop custard powder by combining broken chickpea flour with cassava starch and then assess its physicochemical, organoleptic, and functional properties.

MATERIALS AND METHODS

Materials: White fleshed cassava roots used to extract cassava starch were obtained from the Crop Intensification Research Section Field, Crops Research Institute, Agricultural Research Center, Giza, Egypt.

Broken chickpea seeds were obtained from the Crops Research Institute, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

Skimmed milk powder, colorant (curcumin), and flavoring (vanilla) were purchased from the local market at Giza Governorate, Egypt.

The commercial control sample (Dreem, custard) manufactured by Dreem Mashreq Foods-New Borg El-Arab, Alexandria City, Egypt, was also purchased from a local market in Giza, Egypt.

Chemicals: Sigma Aldrich Co. Ltd. (Dorset, UK) obtained all chemicals and solvents.

Preparation of Broken Chickpea Flour: The preparation of broken chickpea flour steps is shown in Fig.1.

Processing of Cassava Starch Powder: The white-fleshed cassava starch was prepared according to the method described by Oyewole and Obieze [24], with some modifications. Fresh cassava roots were washed and soaked in tap water for 12 hrs., peeled, and sliced (manual slicer, 2mm) into a bowl of water containing 1% sodium metabisulphite to avoid browning of the starch. The slices were then blended using a warring blender to obtain a paste, which was filtered with a muslin cloth, allowed to sediment for 4 hrs., and then decanted. Fresh water was added to the starch and very well stirred to allow any foreign material still in the starch to be loosened and float. The slurry after being allowed to sediment for

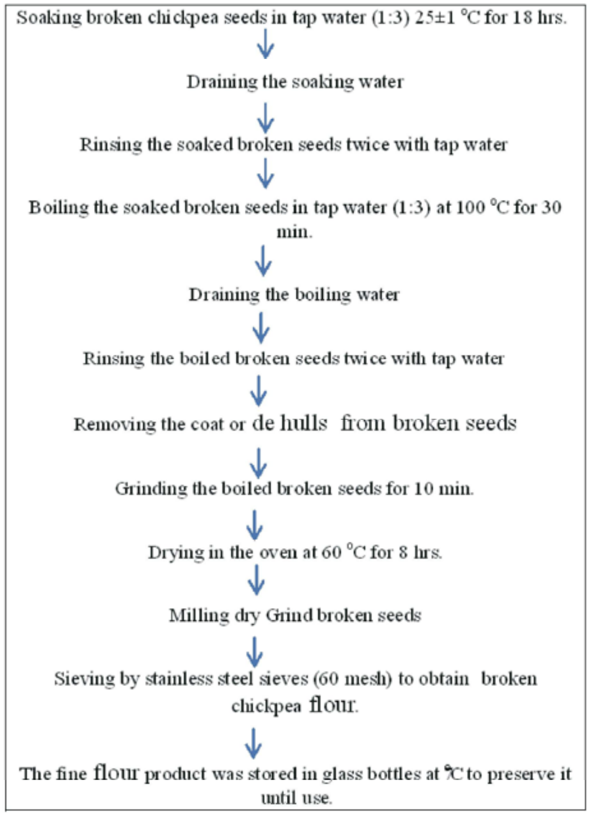

Fig. 1: Flowchart of preparation of broken chickpea flour.

another 4 hrs. was decanted, and the starch was dried using the hot air oven (70°C for 8 hrs.). After drying, the starch was milled to obtain a fine powder, which was stored properly in an airtight container before custard production (Fig. 2).

Preparation of Various Custard Blends: Eight samples with different ingredients and proportions were prepared with broken chickpea flour (10 - 70%) together with white cassava starch by mixing the required amounts (Table 1).

Analytical Methods:

Chemical Analysis of Samples:

Proximate Analysis: Proximate analysis of raw materials and custard samples were carried out according to AOAC [25]. Carbohydrate content was determined by difference, 100 - (% moisture + % protein + % fat + % ash + % crude fiber). Total calories were calculated according to the following equation:

Total calories = 4 (protein + Carbohydrates) + 9 (fat).

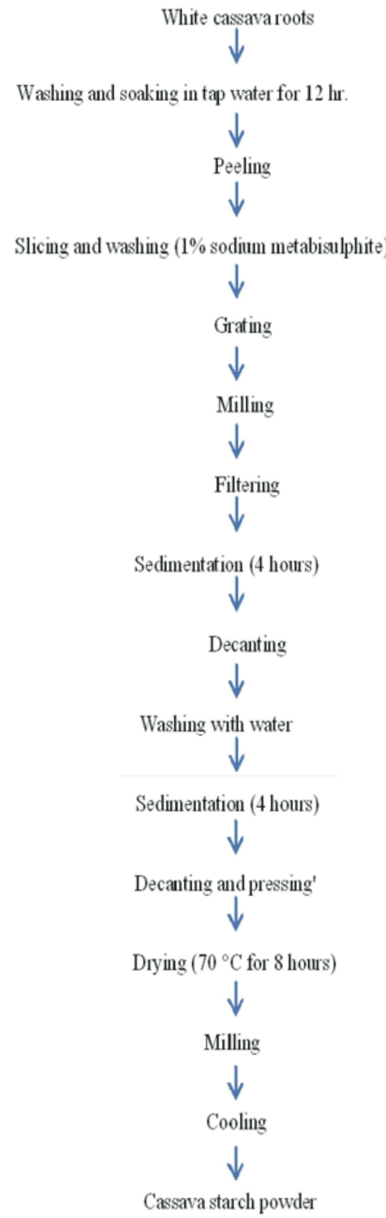

Fig. 2: Cassava starch production powder.

The contents of minerals (Ca, P, Mg, Fe, Zn, Cu, Na, and K) in commercial control and prepared custard samples were determined according to the method described in AOAC [25]. The amino acids content of the best acceptable custard samples (T1, T2, T3, and T4) were determined by using a High-Performance Amino Acid Analyzer.

Computed protein Efficiency Ratio (C-PER): C-PER was assessed as outlined by Alsmeyer *et al.* [26] following the equation:

Table 1: Ingredients used for prepared custard blends (%).

	Custard blends							
	T1	T2	T3	T4	T5	T6	T7	T8
Ingredients	0:90	10:80	20:70	30:60	40:50	50:40	60:30	70:20
Broken chickpea flour	-	10	20	30	40	50	60	70
Cassava starch	90	80	70	60	50	40	30	20
Skim milk powder	6	6	6	6	6	6	6	6
Vanilla	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Curcumin	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Total	100	100	100	100	100	100	100	100

$$\text{C-PER} = -0.684+0.456\,(\text{Leucine}) - 0.047\,(\text{proline}).$$

Computed Biological Value (BV): Biological value was assessed as defined by Oser, [27] according to the next equation:

$$\text{BV} = 49.9 + 10.53\,\text{C-PER}.$$

Carotenoids Content: The total carotenoid content was determined according to the method described by Rodriguez-Amaya [28].

Physicochemical Properties:

Color: The color attributes L* (brightness; 100: white, 0: black), a* (+: red, -: green), and b* (+: yellow, -: blue) of samples were evaluated using a Hunter colorimeter (Hunter ultra-Scan. VIS).

Water Activity (^{a}w): An electronic hygropalm water activity meter (Model Aw-Win, Rotronic, equipped with a Karl-Fast probe, Rotronic, Hong Kong, China) was used to determine water activity and the measurements were performed in triplicate [29].

Viscosity: Viscosity (Cp) measurement was carried out by the Brookfield Digital Viscometer Model DV-II+A. the temperature-controlled water bath was used to regulate the temperature of the samples according to Pastor *et al.* [30].

Functional Properties:

Least Gelation Concentration (LGC) : The least gelation concentration was determined by the method described by Onwuka [31].

Bulk Density: The method described by Oladele and Aina [32] was used to determine the bulk density.

Water Absorption Capacities (WAC): The samples' water absorption capacities (WAC) were determined by the modified method of Beuchat [33].

Swelling Power: Swelling power was determined as described by Onwuka [31].

Gelatinization Temperature: The gelatinization temperature was determined according to the method described by Onwuka [31].

Sensory Evaluation: The sensory properties of the commercial and proposed custard samples were evaluated by ten members from the Department of Crops Technology Research at the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. A nine-point hedonic scale was used for scoring the following quality attributes: color, aroma, mouth feel, taste, consistency and overall acceptability [34]. The following are the individual's scores: 5 is neither like nor dislike, 1 is extreme dislike, and 9 is extreme like. The mean total scores were subjected to an analysis of variance with a 5% significance level.

Percent Daily Values of Custard Samples: The percentages of protein, fat, fiber, carbohydrates, and total calories in custard samples relative to a child's recommended daily allowance (RDA) [35] for ages 4 to 8 were calculated using the following formula:

$$\text{Nutrient adequacy of custard} = \frac{\text{Nutrient in custard sample}}{\text{Nutrient requirements}} \times 100$$

The calorie contribution of custard to the energy requirement for children (4-8) years old, as stated in RDA [35], was calculated by the following formula:

$$\text{Calorie adequacy of custard} = \frac{\text{Calories in custard sample}}{\text{Recommended Calories}} \times 100$$

Production Costs of Custard Blends: Production costs of custard blends were calculated according to Harper *et al.* [36].

Statistical Analysis: The results were expressed as mean ± standard deviation of three parallel replicates. The data were statistically analyzed by one-way analysis of variance (ANOVA) using statistical software (SPSS, version 25.0), and the means were separated at the degree of confidence ($p \leq 0.05$) [37].

RESULTS AND DISCUSSION

Chemical Composition of Raw Materials: The data in Table 2 show the approximate chemical composition of raw materials used for custard powder samples.

The presented data in Table 2 shows that skim milk powder and broken chickpea flour had considerably higher protein contents of 36.33% and 22.61%, respectively compared to cassava and corn starch 1.43% and 0.20%. The highest values of fat, crude fiber, and total calories were also higher in broken chickpea flour. No significant differences were noticed among the moisture contents of the used ingredients (within 5.00%).

The skimmed milk powder samples' high protein and ash values were attributed to their high solid contents [38]. The protein content obtained in this study was similar to literature values for chickpea flour [39, 40]. However, the carbohydrate contents of the cassava and corn starch (94.38, 91.63%) were significantly higher than the other ingredients, demonstrating similar findings of Jennings, [41] and Oladunmoye *et al*. [42].

Chemical Composition of Custard Blends: The proximate composition of the proposed custard blends powder are shown in Table 3.

No significant differences in the moisture content of the custard powder samples as shown in Table 3. A high moisture content may indicate a limited shelf life for the custard since the moisture might cause microbiological deterioration.

Table 3 illustrates that the chemical compositions of different blends significantly vary depending on which materials are used. Carbohydrate amounts decreased while protein, ash, and fiber contents increased significantly when the percentage of broken chickpea flour in the blends increased. T8 had the lowest level of carbohydrates (66.68%), and the highest protein, fat, and total calorie (21.06%, 5.45%, and 400.01 kcal) contents. However, the control custard displayed the reverse pattern, having the highest carbohydrate content and the lowest levels of protein, fat, and ash. In contrast, the custard sample (T2) made from 10% broken chickpea flour had the highest ash content (1.29%).

These findings coincide with studies conducted by Alake *et al*. [43] and Ahmed *et al*. [40] on cassava-based products supplemented with soybean flour, which indicated that chickpea flour's high level of protein provided a beneficial protein supplement.

Similar results were obtained by Thongram, *et al.,* [8] where the addition of legume flour containing a good amount of fat, which contributes to the overall quality and texture improvement of the product.

Since corn starch has a relatively low fiber level, commercial custard had the lowest fiber content, which is consistent with earlier studies [44, 45]. In this respect, Salomé *et al*. [46] observed that while replacing milk, and dairy desserts with corresponding plant-based

Table 2: Chemical composition of raw materials.

Raw material	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrates (%)	Total Calories (Kcal)
Cassava starch	5.68±0.18[a]	1.43±0.74[c]	0.45±0.12[c]	0.81±0.02[c]	0.00±0.00[b]	91.63±0.97[a]	376.29±0.56[b]
Skim milk powder	5.00±0.01[a]	36.33±0.58[a]	1.47±0.06[b]	6.50±0.00[a]	0.00±0.00[b]	50.70±0.61[c]	361.32±0.31[c]
Broken chickpea flour	5.68±0.46[a]	22.61±0.01[b]	6.67±0.09[a]	1.27±0.16[b]	1.31±0.11[a]	63.77±0.22[b]	405.53±1.68[a]
Corn starch	5.02±0.02[a]	0.20±0.10[d]	0.17±0.02[d]	0.23±0.15[d]	0.00±0.00[b]	94.38±0.11[a]	379.83±0.59[b]

Values are means ± SD (n=3), mean numbers in the same column bearing different superscript letters are significantly different at $p < 0.05$.

Table 3: Proximate composition of the blend's custard powder on a dry weight basis.

Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrates (%)	Total Calories (Kcal)
C	5.59±0.38[a]	1.93±0.06[h]	1.09±0.11[f]	0.48±0.11[d]	0.00±0.00[g]	90.91±0.54[a]	381.17±1.37[e]
T1	5.98±0.29[a]	3.91±0.14[g]	1.75±0.09[e]	0.55±0.02[d]	0.12±0.00[f]	87.81±0.35[b]	382.63±1.33[d]
T2	5.39±0.17[a]	8.82±0.46[f]	1.35±0.33[f]	1.29±0.05[a]	0.31±0.09[ef]	83.15±0.91[c]	380.00±0.15[e]
T3	5.12±0.01[a]	9.24±0.47[f]	2.13±0.20[cd]	1.16±0.01[c]	0.45±0.02[e]	82.35±0.52[c]	385.56±1.02[c]
T4	5.52±0.44[a]	11.36±0.22[e]	2.43±0.06[c]	1.18±0.05[bc]	0.69±0.03[d]	79.51±0.24[d]	385.35±1.26[c]
T5	5.53±0.35[a]	14.25±0.54[d]	2.03±0.01[de]	1.18±0.02[bc]	0.95±0.03[c]	77.01±0.76[e]	383.34±1.39[cd]
T6	5.79±0.31[a]	16.24±0.27[c]	4.42±0.13[b]	1.21±0.05[abc]	0.99±0.04[c]	72.35±0.45[f]	394.11±1.70[b]
T7	5.82±0.78[a]	18.92±0.16[b]	4.37±0.26[b]	1.21±0.04[abc]	2.61±0.25[a]	69.68±0.71[g]	393.72±2.31[b]
T8	5.56±0.48[a]	21.06±0.47[a]	5.45±0.30[a]	1.25±0.01[ab]	1.80±0.26[b]	66.68±1.18[h]	400.01±1.14[a]

C1: commercial control, T1: 90% cassava starch. T2: 10% Broken chickpea flour and 80% cassava starch, T3: 20% Broken chickpea flour and 70% cassava starch, T4: 30% Broken chickpea flour and 60% cassava starch, T5: 40% Broken chickpea flour and 50% cassava starch, T6: 50% Broken chickpea flour and 40% cassava starch, T7: 60% Broken chickpea flour and 30% cassava starch, T8: 70% Broken chickpea flour and 20% cassava starch.

alternatives enhanced the moderation score, the effects on adequacy were inconsistent because the nutrient adequacy profile was altered, except those that contained legumes, that had a beneficial effect. Still, several minerals need to be taken into account, including iodine and calcium [47].

It should be noted that in most developing countries where access to high-protein food is limited, the high protein content of chickpea custard would be nutritionally relevant in the fight against malnutrition.

Mineral Contents of Custard Blends: The mineral contents of custard blends powder are presented in Table 4. The quantities of identified minerals in all the developed blends were higher than those in the control sample. Table 4 demonstrates that T8 has the highest levels of all determined minerals among the produced blends. Similar findings about the Fe and Zn content of chickpea seeds were previously noted by Diapari *et al.* [48].

The high quantities of calcium, magnesium, and phosphorus found in chickpea flour are in line with the findings of Bampidisa and Christodoulou [49], Dandachy *et al*. [50], and Asker and Mousa [51].

Minerals are essential for some physicochemical processes that are required for human existence [52, 53]. Compared with traditional custard, legumes are a plant-based food source are rich in nutrients, proteins, and minerals, and have a low glycemic index. Compared to conventional products, it is still a healthier option with less of an environmental impact than common products [54].

Physicochemical Properties of Custard Blends: Table 5 shows the measured color parameters, carotenoid content, viscosity, and water activity for the prepared custard blends.

A perusal of Table 5 indicates that as the enrichment levels of broken chickpea flour increased, color parameters a* and b* showed trends toward green (negative values) and yellowness (positive values), respectively. While L* values decreased, the lowest L* value was observed for the custard blend (T6), whereas the highest was found for the commercial custard powder used as the control. Concerning the color parameter b*, it is interesting to observe a direct relation between broken chickpea flour concentration and a yellowness increase [55].

Different levels of broken chickpea flour enrichment of the custard powder affected the color of the custard. A significant increase in total carotenoids was observed by increasing the addition of broken chickpea flour

Table 4: Mineral contents of prepared custard blends.

Custard blends*	Mineral contents (Mean values and standard deviation mg /100g)							
	Ca	P	Mg	Fe	Zn	Cu	Na	K
C	2.03 ± 0.25^{i}	12.75 ± 1.15^{i}	3.17 ± 0.57^{i}	0.47 ± 0.02^{h}	0.06 ± 0.01^{i}	0.05 ± 0.03^{h}	9.17 ± 1.76^{g}	3.03 ± 0.45^{i}
T1	78.39 ± 2.26^{h}	71.60 ± 1.51^{h}	10.76 ± 0.75^{h}	0.75 ± 0.09^{h}	0.28 ± 0.01^{h}	0.01 ± 0.002^{i}	40.67 ± 0.60^{f}	126.53 ± 2.50^{h}
T2	88.99 ± 2.50^{g}	107.20 ± 2.25^{g}	21.83 ± 1.76^{g}	1.32 ± 0.09^{g}	0.62 ± 0.03^{g}	0.09 ± 0.01^{g}	42.13 ± 0.65^{ef}	214.19 ± 3.25^{g}
T3	99.26 ± 1.25^{f}	142.47 ± 2.50^{f}	33.23 ± 2.25^{f}	1.92 ± 0.07^{f}	0.97 ± 0.03^{f}	0.18 ± 0.02^{f}	43.37 ± 2.26^{def}	301.53 ± 3.50^{f}
T4	109.53 ± 2.001^{e}	177.57 ± 2.50^{e}	44.30 ± 2.25^{e}	2.49 ± 0.20^{e}	1.30 ± 0.10^{e}	0.27 ± 0.02^{e}	45.17 ± 2.20^{cde}	389.19 ± 4.25^{e}
T5	119.79 ± 3.75^{d}	212.20 ± 1.75^{d}	55.53 ± 2.50^{d}	3.09 ± 0.10^{d}	1.65 ± 0.05^{d}	0.36 ± 0.05^{d}	46.53 ± 2.00^{bcd}	476.53 ± 3.50^{d}
T6	130.23 ± 3.25^{c}	248.10 ± 2.01^{c}	66.76 ± 1.25^{c}	3.61 ± 0.40^{c}	1.99 ± 0.02^{c}	0.44 ± 0.01^{c}	48.03 ± 3.00^{abc}	564.69 ± 5.03^{c}
T7	140.33 ± 2.25^{b}	283.20 ± 3.02^{b}	77.83 ± 2.75^{b}	4.22 ± 0.23^{b}	2.36 ± 0.03^{b}	0.53 ± 0.02^{b}	49.00 ± 2.29^{ab}	651.19 ± 4.51^{b}
T8	150.76 ± 3.25^{a}	318.13 ± 2.83^{a}	89.23 ± 3.75^{a}	4.93 ± 0.51^{a}	2.69 ± 0.05^{a}	0.62 ± 0.03^{a}	50.37 ± 2.51^{a}	739.69 ± 5.03^{a}

*See Table 3. Values are means ± SD (n=3), mean numbers in the same column bearing different superscript letters are significantly different at $p < 0.05$.

Table 5: Physicochemical properties of custard blends.

Custard blends*	L*	a*	b*	Carotenoid content (μg/g)	Viscosity (C.p)	Water activity (%)
C	109.01 ± 1.09^{a}	-0.89 ± 0.05^{a}	9.27 ± 0.25^{e}	21.04 ± 0.34^{e}	4000 ± 3.00^{a}	0.49 ± 0.01^{b}
T1	78.21 ± 5.47^{b}	-2.16 ± 0.30^{b}	17.88 ± 3.69^{cd}	23.43 ± 0.57^{d}	4000 ± 4.00^{b}	0.50 ± 0.01^{a}
T2	68.09 ± 2.29^{c}	-0.83 ± 0.23^{a}	16.21 ± 0.23^{d}	26.32 ± 0.49^{a}	3200 ± 4.00^{c}	0.47 ± 0.01^{d}
T3	65.72 ± 3.33^{cd}	-1.34 ± 0.26^{a}	17.27 ± 2.20^{cd}	26.90 ± 0.54^{b}	2800 ± 6.00^{d}	0.47 ± 0.01^{d}
T4	62.90 ± 0.29^{cd}	-1.49 ± 0.25^{a}	21.50 ± 0.72^{bc}	29.45 ± 1.91^{b}	2400 ± 1.00^{e}	0.47 ± 0.01^{cd}
T5	66.49 ± 7.98^{c}	-2.76 ± 0.73^{bc}	24.47 ± 4.61^{b}	29.76 ± 1.84^{b}	2000 ± 8.00^{f}	0.47 ± 0.01^{cd}
T6	56.27 ± 10.30^{d}	-1.43 ± 0.40^{a}	17.04 ± 1.55^{cd}	30.23 ± 1.59^{c}	1600 ± 2.00^{g}	0.46 ± 0.01^{e}
T7	64.19 ± 0.85^{cd}	-2.53 ± 0.16^{bc}	29.34 ± 0.20^{a}	31.72 ± 0.40^{b}	1200 ± 1.00^{h}	0.48 ± 0.01^{c}
T8	63.48 ± 5.36^{cd}	-2.97 ± 0.60^{c}	30.69 ± 4.72^{a}	33.06 ± 0.65^{c}	800 ± 5.00^{i}	0.46 ± 0.01^{e}

See Table 3. L (Brightness; 100: white, 0: black), a* (+red, - green), and b* (+yellow, - blue) Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$.

from 10 to 70%. Total carotenoids were the highest content in T8, which included 70% broken chickpea flour and 20% cassava starch), and the lowest in the commercial control.

The data in Table 5 demonstrate that the viscosity of the different prepared custard samples significantly decreased as the proportion of broken chickpea flour increased. On the other hand, the addition of broken chickpea flour decreased the viscosity of the products contributing to the viscoelastic properties. The custard's flow characteristics demonstrated non-Newtonian behavior that was consistent with the flow models observed by Aguilar-Raymundo and Vélez-Ruiz [55]. The viscosity of dairy beverages containing 50% liquid whey in their formulation was increased by increasing the corn starch concentration from 0.5 to 1% [56].

The T1 and C (Table 5) displayed the highest values of water activity. These results are consistent with observations by Aguilar-Raymundo and Velez-Ruiz [55] about the interactions that occur between starch, milk, and water, wherein the structure of the system is affected by an increase in the dispersion phase's volume % that contains hydrated starch granules. Less water absorption from more starch granules leads to a more uniform and inflexible structure resulting from more starch granules absorbing less water.

The addition of the dry ingredients caused a noticeable change in the sample's microstructure by increasing the concentration of solids and forming polysaccharide networks. These findings may be attributed to the increase in solids content, along with the polysaccharides' (carrageenan and carboxymethylcellulose) ability to promote the development of networks [57].

Functional Properties of Custard Blends: The functional properties of formulated custard powder samples obtained from the blending of broken chickpea flour and cassava starch are shown in Table 6. The samples differed significantly in some parameters (least gelation, bulk density, water absorption capacity, swelling power, and gelatinization temperature).

The functional attributes of formulated custard blends are significantly affected by the interaction between chickpea flour and cassava starch.

The least gelation concentration (LGC) is used to measure the ability of the protein to form a gel, whereby a lower least gelation concentration suggests a better gelling capacity [58]. (LGC) value for the samples ranged from 6.00 to 18.00%. The commercial custard had the lowest least gelation concentration (6.00%) showing that a lower amount of it will be needed to form a gel our results agree with Okocha *et al*. [44] who reported that the commercial custard had the lowest (4.00%). (LGC) % of custard samples significantly increased ($p<0.05$) from 12 to 18 as chickpea flour enrichment increased from 0 to 30%.

Most of the underutilized legumes have been reported to show good functional properties of solubility, emulsification, gelation, and forming properties [59]. Legume flours contain high protein and starch content, and the gelation capacity of flours is influenced by real competition for water between protein gelation and starch gelatinization [60].

The range of bulk density is 0.52-0.61 g/cm^3. Sample T7 had the highest bulk density, whereas the commercial custard had the lowest value. On the other hand, Okocha *et al.* [44] reported that the control (commercial) sample had the highest bulk density.

In a previous study on whole flour made from various beans, the bulk density of chickpea flour was 0.57 g/ml, which was close to the proposed custard [61]. Our findings are in line with those of Kaur and Singh [62], who noted that the bulk densities ranged from 0.54 g/mL to 0.57 g/ml for various chickpea cultivars.

Table 6: Functional properties of formulated custard powder blends.

Treatment*	Least gelation (%)	Bulk density (g/cm^3)	WAC (%)	Swelling power (%)	Gelatinization temperature (°C)
C	6±0.36^e	0.52±0.04^b	99.98±0.95^i	18.86±0.35^g	81.50±0.05^a
T1	12±0.63^c	0.56±0.00^{ab}	162.14±0.51^h	18.70±0.47^g	80.00±1.00^{ab}
T2	14±0.72^b	0.56±0.01^{ab}	183.18±1.33^g	21.67±0.17^f	78.00±0.00^{bc}
T3	16±0.81^{ab}	0.58±0.02^a	192.55±1.16^f	22.46±0.45^f	72.00±4.00^d
T4	18±0.91^a	0.58±0.03^a	226.59±4.18^e	23.32±0.81^e	73.75±2.25^d
T5	16±0.82^{ab}	0.58±0.02^a	243.38±0.21^d	24.94±0.60^d	72.50±2.50^d
T6	14±0.71^b	0.56±0.01^{ab}	252.18±1.55^c	26.83±0.42^c	74.00±1.00^d
T7	12±0.63^c	0.61±0.03^a	259.63±5.94^b	29.38±0.26^b	79.50±1.50^{ab}
T8	10±0.72^d	0.57±0.07^{ab}	281.64±0.72^a	30.64±0.39^a	75.50±0.50^{cd}

*See Table 3. WAC: water absorption capacity. Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$.

The samples' water absorption capacities (WAC) ranged from 99.98 to 281.64%. Sample T8, which contained 20% cassava starch and 70% broken chickpea flour, had the highest WAC, while the WAC of the commercial custard was the lowest.

Because of their high WAC, composite flours are employed in dairy, meat, and pastry products. Amylose solubility rises with higher WAC, which leads to leaching and the breakdown of crystalline starch structure. Proteins interact with water in both hydrophilic and hydrophobic ways, which limits the development of the gluten network [63]. Water is absorbed by proteins, blocking the interaction of wheat proteins with the gluten network [64]. Variations in the crystalline and amorphous parts of starch may be linked to changes in swelling and solubility [65].

The swelling power of the custard samples ranged from 18.70 to 30.64%. Sample T8 exhibited the highest swelling power, whilst T1 had the lowest. Because of the amylose content, reduced swelling, resistance to digestion, and low melting temperatures, the swelling power increased with the cassava starch and broken chickpea flour ratios [66]. The swelling power of starch-based food indicates hydrogen bonding between the granules [67]. Protein amount, water interaction, and structural characteristics all affect the swelling and solubility of starch [8].

The control sample has the highest significant gelatinization temperature (81.5°C). Among the other samples, T1, T2, and T7 showed the closest values of the gelatinization temperature to the control sample.

Starch interactions are effective at high concentrations, and support the development of a bulk network structure. Gelatinized starch is the formation of a bulk network structure in the final product through interactions between starch particles and other polysaccharides, with non-linear effects at high starch concentrations [57]. Starch granules undergo gelatinization, a process influenced by temperature, botanical origins, and water content [68, 69]. The functional properties of flour vary due to the proportion of commodities and can be influenced by processing conditions [70].

Sensory Evaluation of Custard Made from the Blends: The sensory evaluation of different custard samples is illustrated in Table 7. The sensory evaluation proved that all the proposed samples are acceptable particularly those with high levels of cassava starch and low chickpea flour.

The sensory properties of the prepared custard samples showed significant differences in all sensory attributes. Regardless, Commercial control sample C scored the most acceptable sample, and overall acceptability scores of T1-T4 were insignificantly different from those of the control sample. However, T8 (70% broken chickpea flour and 20% cassava starch mixture received a minimum score of 5.70.

Our findings coincide with those of Kohajdová *et al.* [71], who found that increased pea flour levels significantly reduced the taste, odor, and overall acceptance of the finished products, due to increased intensity of leguminous taste and odor. According to Omoba and Omogbemile [72], a key consideration in product selection is consumer quality, which is primarily determined by the texture, taste, and surface color of food items. Along with flavor and shelf life, texture is a critical component in determining the quality of powdered products. To ensure a constant and alluring texture for powdered items, manufacturers need to ensure customer satisfaction [73].

Amino Acids Composition of the Best Acceptable Custard Samples: The amino acid contents of the most acceptable samples of custard (T1, T2, T3 and T4) obtained from cassava starch and broken chickpea flour blends were determined and the results are shown in Table 8.

It is evident from Table 8 that T4 has the highest total amino acid content (total, essential, and non-essential) and biological value (BV). This implies that the T4 blend

Table 7: Sensory evaluation of custard made from the blends.

Treatment*	Color (9)	Aroma (9)	Mouth feel (9)	Taste (9)	Consistency (9)	Overall acceptability (9)
C	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.00^{a}
T1	8.85±0.24^{ab}	8.90±0.21^{a}	8.65±0.24^{a}	8.70±0.35^{ab}	8.95±0.16^{a}	8.80±0.26^{a}
T2	8.70±0.42^{ab}	8.65±0.41^{a}	8.65±0.34^{a}	8.50±0.33^{ab}	8.85±0.34^{ab}	8.55±0.37^{a}
T3	8.65±0.41^{abc}	8.65±0.41^{a}	8.65±0.41^{a}	8.55±0.44^{ab}	8.70±0.35^{ab}	8.75±0.35^{a}
T4	8.50±0.41^{bcd}	8.25±0.26^{b}	8.70±0.42^{a}	8.35±0.63^{b}	8.35±0.41^{b}	8.60±0.39^{a}
T5	8.20±0.79^{cde}	8.05±0.72^{b}	7.70±0.75^{b}	7.75±0.79^{c}	7.80±0.59^{c}	7.85±0.58^{b}
T6	7.75±0.63^{de}	8.05±0.64^{b}	7.70±0.54^{b}	7.60±0.52^{c}	6.85±0.67^{d}	7.00±0.75^{c}
T7	8.05±0.55^{e}	7.25±0.26^{c}	7.60±0.52^{b}	7.75±0.92^{c}	5.85±0.63^{e}	6.40±0.61^{d}
T8	7.30±0.59^{f}	6.85±0.34^{d}	6.85±0.82^{c}	7.20±0.79^{c}	5.10±1.07^{f}	5.70±0.48^{e}

*See Table 3. Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$.

Table 8: Amino acids composition of custard blends.

Amino acids	T1	T2	T3	T4
Threonine (THR)	0.16	0.34	0.38	0.44
Valine (VAL)	0.19	0.39	0.47	0.62
Isoleucine (Iso)	0.20	0.37	0.45	0.52
Leucine (LEU)	0.33	0.63	0.77	1.01
Phenylalanine (PHE)	0.28	0.49	0.60	0.74
Histidine (HIS)	0.09	0.20	0.24	0.33
Lysine (LYS)	0.24	0.51	0.62	0.77
Methionine	0.06	0.12	0.15	0.25
Total (EAA)	1.55	3.05	3.68	4.68
Glycine (GLY)	0.15	0.34	0.36	0.42
Alanine (ALA)	0.16	0.40	0.47	0.62
Tyrosine (TYR)	0.24	0.29	0.34	0.44
Arginine (ARG)	0.20	0.59	0.72	0.79
Proline (PRO)	0.19	0.35	0.46	0.65
Cystine (CYS)	0.04	0.12	0.16	0.21
Aspartic (ASP)	0.48	0.92	1.10	1.20
Serine (SER)	0.17	0.40	0.47	0.59
Glutamic (GLU)	0.66	1.28	1.42	1.69
Total (Non-EAA)	2.29	4.69	5.50	6.61
Total amino acids	3.84	7.74	9.18	11.29
C-PER	-0.54	-0.41	-0.35	-0.25
BV	44.19	45.55	46.20	47.23

C-PER = Computed protein efficiency ratio. BV = Biological value.
T1: 90% cassava starch. T2: 10% Broken chickpea flour and 80% cassava starch, T3: 20% Broken chickpea flour and 70% cassava starch, T4: 30% Broken chickpea flour and 60% cassava starch,

has a higher nutritional value than the other mixes. This blend may support physiological equilibrium, and improve metabolic processes. Among the essential amino acids, it includes phenylalanine, leucine, and lysine, which are required for protein synthesis.

Aspartic, glutamic, and non-essential amino acid contents in T4 may help in the synthesis of hormones and enzymes required for several body processes as well as improve mood and cognitive performance. The immune system, general health, and muscular growth may all benefit from the combination of essential and non-essential amino acids. and might also aid in the production of proteins and influence the activity of neurotransmitters.

Amino acids, the basic building blocks of proteins, have an impact on both the number and quality of proteins. They serve as neurotransmitters, facilitate the synthesis of essential biological components, and improve human muscle's anabolic properties [74]. In many underdeveloped nations, chickpea proteins are considered a potential source of dietary protein due to their perfectly balanced EAA composition [75].

This composite food product can complement essential nutrients, address malnutrition, promote local food availability, and create new markets for produce. Exploiting underutilized local ingredients can discover new flavors, textures, and nutritional benefits, contributing to sustainable food systems and supporting local farmers [76].

Chickpea seeds are nutritious plant-based protein for vegans and vegetarians, with a low glycemic index. They are versatile and can be added to various food items [77]. This reduces malnutrition and enhances health outcomes, particularly for those people with less access to a variety of nutrient-dense meals. Chickpea versatility for the creation of diverse and creative and varied meal options that cater to various dietary needs and preferences.

Chickpea proteins are one example of a plant-based protein source that may be added to a range of dishes to improve health and reduce malnutrition.

The Contribution of Custard Blends to the Recommended Daily Allowances for Children (4-8 Years): Table 9 presents the contents of protein, fat, fiber, carbohydrate, and calorie levels in 100 g of the various custard blends as the percentages of recommended daily allowances for children aged 4-8 years old.

Table 9 displays significant differences in custard blends that satisfy the needs of 4-8 years old. A 100g of T7 and T8 could provide the required daily protein intake and reasonable amounts of their needs for fat, fiber, carbohydrates, and calories. These findings suggest

Table 9: The percentages of protein, fat, fiber, carbohydrates, and energy contents of control and different blends covering children's needs at age (4-8 years old).

Treatment*	Protein (%)	Fat (%)	Crude fiber (%)	Carbohydrates (%)	Total Calories (Kcal) 1600
RDA	19g	53g	25g	262g	%
C	10.18 ± 0.30^{h}	2.06 ± 0.21^{f}	0.00 ± 0.00^{g}	34.70 ± 0.21^{a}	23.82 ± 0.09^{de}
T1	17.96 ± 0.71^{g}	3.30 ± 0.18^{e}	$0.48\pm0.00f^{g}$	33.71 ± 0.13^{b}	23.91 ± 0.08^{d}
T2	46.40 ± 2.39^{f}	2.55 ± 0.62^{f}	1.24 ± 0.36^{ef}	31.74 ± 0.35^{c}	23.75 ± 0.07^{e}
T3	48.63 ± 2.47^{f}	4.03 ± 0.38^{cd}	1.80 ± 0.08^{e}	31.43 ± 0.20^{c}	24.10 ± 0.06^{c}
T4	59.77 ± 1.13^{e}	4.58 ± 0.11^{c}	2.76 ± 0.12^{d}	30.35 ± 0.09^{d}	24.08 ± 0.08^{c}
T5	75.02 ± 2.81^{d}	3.84 ± 0.01^{de}	3.81 ± 0.10^{c}	29.39 ± 0.29^{e}	23.96 ± 0.09^{cd}
T6	85.46 ± 1.42^{c}	8.34 ± 0.25^{b}	3.97 ± 0.14^{c}	27.61 ± 0.17^{f}	24.63 ± 0.11^{b}
T7	99.58 ± 0.82^{b}	8.25 ± 0.49^{b}	10.44 ± 0.10^{a}	26.59 ± 0.27^{g}	24.61 ± 0.14^{b}
T8	110.82 ± 2.45^{a}	10.28 ± 0.57^{a}	7.20 ± 1.04^{b}	25.45 ± 0.45^{h}	25.00 ± 0.07^{a}

*See Table 3. Values are means ± SD (n=3), mean numbers in the same column bearing different superscript letters are significantly different at $p < 0.05$.

Table 10: Production costs of custard blends (L.E. /100g).

	Price (L.E.)			
Blends*	100g of Ingredient	Electricity and water	Service	Collection of cost
C	21.55	4.50	7.00	33.05
T1	53.55	4.50	7.00	65.05
T2	45.30	4.50	7.00	56.80
T3	41.20	4.50	7.00	52.70
T4	37.05	4.50	7.00	48.55
T5	32.95	4.50	7.00	44.45
T6	28.80	4.50	7.00	40.30
T7	24.70	4.50	7.00	36.20
T8	20.55	4.50	7.00	32.05

*See Table 3.

that the formulated custard blends (T7 and T8) can be a valuable source of protein for them. These nutritious options, including chickpea proteins, are a convenient and nutritious way to meet their dietary needs and promote growth.

In addition, each sample's fat content is within the acceptable range for children in this age group, ensuring a balanced diet. Further research is needed to assess the nutritional benefits of the various custard blends, account for a child's unique dietary needs when incorporating them into a child's diet plan, and ascertain how this will impact the child's overall nutrient intake and long-term health outcomes.

Dairy products and milk are essential sources of nutrition for people all over the world, especially the elderly and young. Milk fat, lactose, casein, whey proteins, fat-soluble vitamins, minerals, and essential amino acids are among the important ingredients they contain. In addition, custard product support overall growth, muscle function, and bone formation. They also supply the amino acids needed to synthesize proteins [78]. Custard product can lower the risk of chronic diseases, help people maintain a healthy weight, and enhance brain health and cognitive function. They may help reduce the occurrence of certain malignancies and are an excellent source of calcium and vitamin D, both of which support bone health [21].

Production Costs of Custard Blends: Table 10 present a comparison of the production costs for the different blends.

Custard blends vary in price depending on the kind and quantity of ingredients used; higher costs are associated with higher levels of cassava starch. When choosing custard blend composition manufacturers need to consider employing less expensive ingredients, and the financial consequences of their decisions.

The cost of samples varies depending on the ingredients and quality as T8 is the least inexpensive at 32.05 L.E. /100g containing 70% broken chickpea flour and 20% cassava starch.

Broken chickpea flour and cassava starch can be used to enhance homemade custard. This is a more cost-effective and healthier alternative that doesn't contain any artificial flavors or preservatives. This method improves the dessert's texture, taste, and mouthfeel, making it more customizable and healthier. Enriched custard powder from indigenous local ingredients offers new choices over traditional custards and also contributes to the promotion of sustainable food systems and the decrease of food waste.

CONCLUSION

The study suggests that custard, a popular product, can be partially replaced with legume flour, providing protein and a solution for lactose intolerance or dairy allergies. According to a study, using broken chickpea flour can increase the protein content of custard, a popular product. Custard containing cassava starch and broken chickpea flour are nutritious, rich in essential amino acids, fiber, and protein, and good for children's health and promote healthy digestion and gut health through prebiotic properties. The study recommends that incorporating local ingredients into custard powder can improve taste, promote healthy consumption, boost community prices, support local farmers and producers, and promote sustainable practices.

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