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Utilization of Chickpea Split (*Cicer arietinum* L.) in Preparing Some Gluten-Free Casein-Free Food Products for Autism Children

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Abstract

This study aimed to prepare and evaluate some gluten-free and casein-free (GFCF) food products for autism children from rice and chickpea split. Like-milk beverages and snacks (bakery) were prepared by replacing rice with chickpea at a ratio of 25%, 50%, 75%, and 100%, and in a ratio of 25% and 50% with fried snacks. Chemical composition, antioxidant activity, the energy content of ingredients and final products, as well as the viscosity, texture profile analysis, and sensory evaluation of final products, were determined. The results showed that chickpea contains higher values of protein, fat, fiber, and ash compared with rice. Also, the antioxidant activity (total phenolic (TP), DPPH scavenging activity, and FRAP value) of chickpea was higher than rice. The addition of chickpea to rice caused a significant increase in protein (%), fat (%), minerals (Ca, Fe, K, Zn, and Mg) (%), and antioxidant activity of all products, and these values were increased with the increased of chickpea amount added, while the viscosity of rice-chickpea milk samples and the hardness of snacks (fried and bakery) were significantly decreased with the increase of chickpea amount added. According to the recommended daily allowances (RDA), it was found that 100 mL of chickpea milk (100%) could provide autism children with 99.5%, 32%, and 36% of the daily required iron, Ca, and Zn, respectively. Also, the daily intake of 100 g of snacks (sample BS5) could provide autism children with 75%, 7%, 42%, 125%, 1.7%, and 52% of the daily required of protein, fiber, Ca, iron, Mg, and Zn, respectively. On the other hand, 100 g fried snacks (sample FS3) could provide autism children with 59.9%, 42%, and 64% of the daily required protein, calcium, and iron, respectively. The best sensory evaluation scores were obtained with rice milk (100%), bakery snacks sample BS4 (25% rice: 75% chickpea), and fried snacks sample FS2 (75% rice: 25% chickpea).

Keywords

Autism, Chickpea Split, Rice, Gluten-Free Diet, Casein-Free Diet, Antioxidants

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder described by a lack of social communication and restricted/repetitive patterns of behavior [1], and known as one of the most common developmental disabilities in children, affecting approximately 1 in every 54 children [2]. The ASD starting showing occurs through at the first 3 years of life and has a genus prejudice with a ratio of 5 males to 1 female [3] [4]. In June 2021, the World Health Organization (WHO) revealed epidemiological statistics indicating that ASD affects one in every 160 children worldwide; further, the incidence ratio of ASD in many low- and middle-income countries remains unknown [5]. ASD children face challenges lifelong because of their unique needs, especially nutrition needs [6] [7]. This challenge including sensitivity and selectivity related to preferences of food and mealtime, including neophobia of food, selective and repetitive eating patterns, and oral-motor fixations and sensitivity, further complicated the pursuit of healthy lifestyle choices for children with autism [8] [9]. Additionally, strong aversions to the rigidity of dietary which attributed variations of food texture, flavor, and aroma, led to depend on a small repertoire of food choices [10] [11] [12]. Because of the lack of effective medical treatments for Autism spectrum disorder, most parents have turned to substitutional treatments that are mostly perceived as risk-free, among these, the most widely used is the gluten-free and casein-free (GFCF) diet [13] [14] [15]. The first observation of a possible correlation between gluten and ASD was reported in 1969 [16]. The studies on Gluten-free and casein-free diet interventions are aimed at preventing gluten or casein from entering the bloodstream and thereby reducing the autism symptoms [17]. The use of gluten-free and casein-free diets is dependent on the opioid theory that is related to neurotransmitters which concern the release of opioid peptides during the digestion of protein within the intestines. After food digestion, certain types of proteins namely peptides could cross the intestinal mucosa as intact if they were more permeable than normal as is the case when impaired by immunological factors or by lesions in the case of celiac disease. If these peptides transported by the bloodstream, were to cross the blood-brain barrier and reach the central nervous system in large quantities, brain function would be affected [18] [19]. The assumed theory is that some autism spectrum disorder children suffer from increased permeability of the gut and improper production of digestive enzymes related to casein and gluten. Inadequate levels of these enzymes result in failures in the transformation of casein and gluten into amino acids. Additionally, increased gut permeability enables leaking into the bloodstream, where they may pass the brain-blood barrier [20]. Moreover, reports exist suggesting a good and beneficial effect of the gluten-free diet (GFD) in decreased behavioral and intellectual problems associated with ASD [21]. Therefore, gluten-free legumes and grains (such as chickpeas and rice) are among the best sources used to produce foods suitable for ASD.

Rice (*Oryza sativa* L.) is one of the main cereal foods consumed by humans, especially in Ashia. It is a great main carbohydrate source and classified as whole grain and contains a range of important nutrients such as phosphorous, manganese, sodium, magnesium and potassium, and vitamin A and B [22] [23]. Rice contains about 64.3% carbohydrate, 7.3% protein, 2.2% fat, 0.8% fiber and 1.4% ash [24]. In milled rice (rice flour), starch is the major component of about 90% of the dry matter, proteins 6.7%, lipids 3.5%, and fibers ~0.4% which can be found in the rice endosperm [25]. Rice protein is a good alternative to whey because it does not show any allergenicity, and has a beneficial effect on muscle strength and thickness [26] [27] [28]. Rice is considered an ideal candidate for the development of extruded snacks due to its super puffing and expansion properties, bland taste, nice white color, hypoallergenicity, and digestion ease [29]. However, rice-based extruded products are low in protein content and rich in carbohydrates, besides having a high glycemic index (GI). Therefore, there is an increasing interest to enhance the protein content of rice snacks.

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop containing high dietary fiber, protein, vitamins, and essential minerals, and has a low glycemic index. It was reported that chickpea has beneficial effects on cancer, cardiovascular diseases, lowering of glucose level, cholesterol, and hypertension [30]. Chickpea was recommended for the development of nutrient-dense diets to promote general well-being and overall health [31]. Many studies showed that chickpea can be used either as a main component of new products or as a functional food ingredient in product formulations [32] [33] [34]. The digestibility of chickpea protein varies between 48% - 89.01% [35] [36]. Therefore, this study was carried out to prepare and evaluate some gluten-free and casein-free food products (such as like-milk beverages and snacks) from rice and chickpea split, suitable for children with autism disease.

2. Materials and Methods

2.1. Materials

Chickpea split, rice, sugar, butter, vanillin, ginger powder, onion powder, garlic powder and fine iodized salt were obtained from local market of Alexandria, Egypt. All chemicals and reagents used in this study were of analytical grade except Folin-Ciocalteu's phenol reagent of Sigma-Aldrich Company (St. Louis, Missouri, USA).

2.2. Methods

2.2.1. Preparation of Chickpea Split Flour

The chickpea was sorted to remove small stones, lumps of dirt and defective seeds then washed using tap water. Chickpea was soaked in water (1:10) for 12 h. Discard soaking water and the soaked chickpea seeds were cooked in boiling water for 30 minutes, and then dried in a hot air oven dryer for 12 hours at 50˚C. The dried chickpea seeds were milled using mill (Moulinex AR1044). After that, it was sieved to pass a 40 mesh sieve, then packed into polyethylene bags and kept at 4˚C until used [37].

2.2.2. Preparation of Rice Flour

Rice was sorted to remove small stones, lumps of dirt and defective seeds then washed using tap water, and then dried in a hot air oven dryer for 3 hours at 50˚C. The dried rice was milled using mill (Moulinex AR1044). After that, it was sieved to pass a 40 mesh sieve, then packed into polyethylene bags and kept at 4˚C until used [38].

2.2.3. Preparation of Chickpea Split: Rice Milks

1) **Preparation of Chickpea milk:** chickpea seeds were washed well and soaked in distilled water for 12 h at room temperature. After that, water was decanted, and chickpeas were boiled with distilled water in a 1:10 ratio for 30 min by using an electric pot. Chickpeas were wet-milled continuously for 5 min by using a homogenizer (Moulinex AR1044) and filtered through double-layered cheesecloth. Sugar (5%) and vanillin (0.5%) were added. The Chickpea milk was preheated to 90˚C/10 min, then cooled and stored until analysis [39].

2) **Preparation of rice milk:** Rice milk was prepared by soaking the rice with distilled water in a ratio 1:3 for 2 h at room temperature (about 25˚C). The soaked rice samples were drained and boiled with distilled water in a 1:9 ratio for 15 min, then ground for 5 min using a grinder until a smooth slurry was produced, then supernatants were filtered. 5 g sugar and 0.5 g vanillin were added to each 100 mL rice milk. The rice milk heated to 90˚C/10min, then cooled and stored until analysis [40].

3) **Preparation of chickpea: rice milks:** samples were prepared by replacing rice milk with chickpea milk at 0% (M1), 25% (M2), 50% (M3), 75% (M4), and 100% (M5).

2.2.4. Preparation of Bakery Snacks

Bakery snacks samples were prepared according to the method of Bhat *et al.* [41], by replacing rice flour with chickpea split flour at 0% (BS1), 25% (BS2), 50% (BS3), 75% (BS4), and 100% (BS5). For each 100 g of the previous mixtures, 5 g spice mix (consisting of 5 g sugar, 1 g ginger powder, 1 g onion powder and 0.75 g garlic powder) was added. The ingredients were mixed in a blender, adding water gradually until dough was produced. The dough was formed in a sheets, then cut into squire forms (4 × 4 cm), finally, baked for 30 min at 180˚C in preheated oven. The baked snacks were stored in a cool and dry place until analyses.

2.2.5. Preparation of Fried Salty Snacks

Fried salty snacks samples were prepared according to the method of Miranda *et* *al.* [42], by replacing rice flour with chickpea split flour at 0% (FS1), 25% (FS2), and 50% (FS3), while, the treatments containing 75% and 100% chickpea (FS4 and FS5) were canceled because its texture is crumbly. For each 100 g of each previous mixture, 5 g of salt, 70 mL of water, and 40 g of butter (82% fat) were added. The mixture was then kneaded to form smooth dough, then steam pre-cooked for 20 min. The dough was cooled to room temperature, and sheeting until reaching a final thickness of 1 mm. The dough sheets were cut into circles using a mold (4 cm diameter). Finally, they were fried in corn oil for 5 sec. at 170˚C. The fried snacks were stored in a cool and dry place until analyses.

2.2.6. Antinutritional Factors of Chickpea Split

Phytic acid was determined based on the method of Wheeler and Ferrel [43]. Total tannins were determined according to the method of AOAC [44]. Trypsin inhibitor activity was determined according to the method of Kakade *et al.* [45].

2.2.7. Gross Chemical Composition and Total Caloric Values

Chemical constituents of chickpea split and rice flours and final products (moisture, protein, fat, ash, crude fiber) were determined by AOAC [46]. Carbohydrates were calculated by difference. Total caloric values (K.cal) of ingredients (chickpea and rice flours) and final products were calculated using the method of AOAC [46]

$$\text{Energy}(\text{K.cal}) = [\text{Protein}(\text{g}) \times 4] + [\text{Carbohydrate}(\text{g}) \times 4] + [\text{Fat}(\text{g}) \times 9].$$

1) Amino Acid Composition of chickpea split and rice flours

Amino acid content was estimated as described by AOAC [47]. Amino acids were determined using High Performance Amino Acid Analyzer.

Chemical Score **(*CS*)** was calculated according to FAO/WHO [48].

$$\text{C.S} = \frac{\text{mg of essential amino acid in g test protein}}{\text{mg of essential amino acid in requirement pattern}}$$

2) Calculation of food protein (A)/total essential amino acids content (E) ratio

The relationship between the content of an individual essential amino acid in the food protein (A) and the total essential amino acids content (E) was calculated according to FAO, [49] as follows:

A/E ratio = mg of the individual essential amino acids/g of essential amino acids.

3) Calculation of protein efficiency ratio (PER)

Protein efficiency ratio was calculated using the equation mentioned by Alsmeyer *et al.* [50], as follows:

$$\text{PER} = -0.684 + 0.456(\text{Leucine}) - 0.047(\text{Proline})(\text{g}/100\text{ g protein})$$

4) Calculation of biological value (BV)

Biological value of protein was calculated according to the equation of Oser, [51] as follows:

$$BV = 49.09 + 10.53(PER).$$

5) Fatty Acid Composition of chickpea split and rice flour

Preparation of fatty acid methyl esters of oils extracts from chickpea and rice flours were performed according to the procedure of Radwan [52]. Using 1% sulphuric acid in absolute methanol, the fatty acid methyl esters obtained were separated by Shimodzu gas chromatograph (GC-4 CM-PFE) under the following conditions: column, 10% DEGS on 801,100 chromosorb Q III; Detector temperature 270˚C: flow, N2 and chart speed, 5 min. Standard fatty acid methyl esters were used for identification. The area under each peak was measured by the triangulation method as percentage of each fatty acid was regard to the total area.

6) Determination of minerals of chickpea split, rice and final products

Minerals including calcium (Ca), iron (Fe), potassium (K), sodium (Na), zinc (Zn), magnesium (Mg) and cooper (Cu) were measured in ash solution using ICP-OES Agilent 5100 VDV according to AOAC [46].

2.2.8. Antioxidant Activity of Chickpea Split, Rice and Final Products

1) Preparation of ethanolic extracts of chickpea, rice and final products

Five grams of each ingredient (chickpea and rice flours), and final products were mixed with 30 mL ethanol (75%), stirring for 2 hours at room temperature, and then, filtered using Whatman No.1 and the extracts were stored at −20˚C until analysis [53].

2) Determination of total phenolic contents of extracts

Total phenolic contents of extracts were determined using the method developed by Abirami *et al.* [54]. A 300 µl were added to 1.5 mL of Folin–Ciocalteu's reagent (diluted 10 times) and 1.2 mL of Na_2CO_3 (7.5% w/v). The mixtures were kept for 30 min, in dark at room temperature before measuring absorbance at 765 nm using a spectrophotometer (Pg T80+, England), tests were carried out in triplicate. Total phenol content (TPC) was expressed as Gallic acid equivalent in mg/g plant material or extract.

3) DPPH scavenging activity %

Scavenging activity of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical was determined according to the method of Brand-Williams *et al.* [55]. Two milliliters of 0.15 mM DPPH was added to 1 mL of each extract in different dilutions. A control was prepared by adding 2 ml of DPPH to 1 mL of ethanol. The mixtures were kept in dark for 30 min at room temperature, and absorbance was measured at 517 nm using a spectrophotometer (Pg T80+, England). The results were expressed as % radical scavenging activity. Triplicate tubes were prepared for each extract.

$$\text{Radical scavenging activity\%} = \frac{\text{A control} - \text{A sample}}{\text{A control}} \times 100$$

4) Ferric reducing antioxidant power (FRAP)

One and half milliliter of each extract was added to of phosphate buffer (2.5 mL, 0.1 M, pH 6.6) and potassium ferricyanide (2.5 mL, 1% w/v). Mix well, and the mixture was then incubated in a water bath (50˚C for 20 min) then cooling to room temperature. After that, 2.5 mL of trichloroacetic acid (10% w/v) was added. The mixtures of the tubes were centrifuged at 8000 ×g at 5˚C for 15 min, then, 2.5 mL of supernatant was removed from each tube, and mixed with 2.5 mL of distilled water and 0.5 mL of ferric chloride solution (0.1% w/v). These mixtures were allowed to stand for 30 min (in dark at room temp.). The absorbance was measured at 700 nm using UV/Visible spectrophotometer (Pg T80+, England). The assay was done in triplicate. The FRAP values, expressed in mg GAE/g of extract, were derived from a standard curve [56].

2.2.9. Color Measurement of Final Products

Color values like the L* (lightness), a* (red intensity), and b* (yellow intensity) of the samples were measured using a Hunter Lab Ultra Scan, VIS model, colorimeter (USA). The instrument was standardized during each sample measurement with a black and white tail (L* = 94.1, a* = 1.12, b* = 1.26). Mean of five readings of each color index of Hunter scale (L*, a*, b*) were recorded [57].

2.2.10. Determination of Viscosity of Chickpea and Rice Milk's

The viscosity of rice and chickpea milks were measured in triplicate at 10˚C ± 1˚C using oscillatory viscometer (VR 3000M YR Viscometers, Spain), using spindle 2 at speed of 60 rpm [58].

2.2.11. Texture Profile Analysis (TPA) of Snacks

Texture profile analysis of final products were performed using TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by Yuan and Chang [59]. Force time deformation curves were obtained during applying a 5 kg load cell, at a 1 mm/s cross head speed. The following texture attributes were calculated, Hardness (g), Adhesive Force (g), Resilience, and Springiness (mm).

2.2.12. Sensory Evaluation of Final Products

The final product (chickpea milk, bakery snacks, and fried snacks) were served to 20 staff members of Food Technology Research Institute Alexandria, Egypt. The panelists were asked to judge for color, taste, odor, texture, and overall acceptability of samples using standard hedonic rating scale from 9 (like extremely) to 1 (dislike extremely), according to Banach *et al.* [60].

2.2.13. Statistical Analysis

The statistical analysis was performed using one-way analysis of variance (ANOVA) using SAS statistical analysis software (2004). Means were compared by Duncan's test at the significance level of $P < 0.05$. Pearson's correlation coefficient was used to calculate the correlation [61].

3. Results and Discussion

3.1. Effect of Preparation Method on Anti-Nutritional Factors in Chickpea Split

Chickpeas have anti-nutritional factors, including tannins, protease inhibitors, phytic acid, alkaloids, and saponins [62]. Data illustrate in **Table 1** showed the effect of soaking, cooking and drying treatments on the anti-nutritional factors (tannic acid, trypsin inhibitor, and phytic acid) in chickpea. The soaking and cooking treatments caused a significant ($P < 0.05$) decrease in trypsin inhibitor (8.99%), phytic acid (59.76%), and tannic acid (31.53%). This results in agree with Alajaji and El-Adaway [63] who reported that the effect of anti-nutritional factors can be reduced by cooking. These anti-nutritional factors can reduce the digestibility of chickpeas and make chickpeas astringent. Phytates can also join with cations, including calcium, magnesium, zinc, and iron, limiting their absorption [62]. While, tannins which are phenolic compounds that bind proteins through non-covalent interactions, thereby reducing their nutritional availability [64]. Also, the other anti-nutritional factor found in chickpea seeds are the trypsin inhibitors which competitively inhibit trypsin activity in the digestive track of humans, and thus interfere with the digestion of proteins [63]. El-Adawy [65] Studied the effects of different cooking methods on nutritional and antinutritional components in chickpeas and they found that cooking resulted in significant decreases in antinutritional components and increases in dietary fibers and digestibility of protein. According to Sadigova *et al.* [66], the methods of chickpea seeds treatment allowed removal of the specific odor of legume and decreased the anti-nutritional substances content in chickpea flour.

3.2. Chemical Composition of Rice and Chickpea Split

The chemical composition of rice and chickpea presented in **Table 2** showed that the chickpea was higher in protein (23.5%), fat (5.5%), Ash (3.41%), and fiber (2.06%) in comparison with rice, while, the rice was the higher in moisture (8.26%) and carbohydrates (81.69%). The results of our study in agree with Gupta *et al.* [34] who noted that the types of chickpea had: protein (23.33% to 30.95%), lipid (4.25% to 6.98%), and carbohydrate (54.60% to 60.40%) contents. Similarly, Boye *et al.* [67] and Jukanti *et al.* [62] reported that the lipid (%) of chickpea seeds ranges from 4.5% to 6% g oil/100 g of bean, while, in rice was 0.6%.

Costa *et al.* [68] found that the seed of legume is relatively high in protein

Table 1. Effect of soaking, cooking and drying process on anti-nutritional factors in chickpea split.

Treatment	Trypsin inhibitor		Phytic acid		Tannins	
	U/mg sample	Reduction (%)	mg/g sample	Reduction (%)	mg/g sample	Reduction (%)
Raw	8.90 ± 0.11^{a}	0.00	1.014 ± 0.086^{a}	0.00	0.498 ± 0.114^{a}	0.00
Soaking, cooking and drying	8.1 ± 0.11^{b}	8.99	0.408 ± 0.038^{b}	59.76	0.341 ± 0.023^{b}	31.53

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same Column are significantly different ($P < 0.05$).

Table 2. Chemical composition and energy content of rice and chickpea split.

Parameters	Rice	Chickpea
Moisture (%)	8.26 ± 0.28^a	5.56 ± 0.32^b
Protein (%)	8.50 ± 0.30^b	23.50 ± 0.21^a
Fat (%)	0.635 ± 0.075^b	5.50 ± 0.22^a
Ash (%)	0.438 ± 0.011^b	3.41 ± 0.099^a
Carbohydrates (%)	81.69 ± 0.24^a	59.97 ± 0.58^b
Crud fiber (%)	0.470 ± 0.030^b	2.06 ± 0.14^a
Energy content (Kcal/100 g)	366.48 ± 1^b	383.38 ± 1.8^a
Minerals (mg/100 g)		
Ca	257.3 ± 0.20^b	807.04 ± 0.46^a
Fe	11.32 ± 0.68^b	14.08 ± 0.18^a
K	84.43 ± 0.57^b	879.8 ± 0.24^a
Zn	3.64 ± 0.17^b	5.42 ± 0.12^a
Mg	1.937 ± 0.18^b	3.85 ± 0.26^a

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same row are significantly different ($P < 0.05$).

which ranges from 18.5 ± 1.74 to 21.3 ± 0.73 depending on the species. Legumes contain 60% to 65% carbohydrate, which is slightly lower than cereals (70% - 80%). Carbohydrates of legumes are mostly composed of monosaccharides, disaccharides, oligosaccharides, and polysaccharides [69]. Carbohydrates were the major component in chickpeas flour (30% - 56%) with fiber and starch being the most relevant. The carbohydrates in chickpea, are absorbed and digested slowly, as in other pulses, and thus help control obesity and diabetes diseases [70]. Chickpea is an important source of Mg, Ca, Fe, K, Zn, Mn, and P levels which are higher than other legumes [71]. Our results showed that the nutritional value (K. calorie) and minerals (Ca, Zn, K, Fe, Mg %) of chickpea were higher than those of rice (**Table 2**). A ration of chickpea (100 g), can provide the recommended daily intake of zinc (4.2 mg and 3 mg), and Fe (1.05 - 1.46 mg for homes and women, respectively), while consumption of chickpeas by a percentage of 200 g, will provide the recommended daily intake of Mg (260 mg and 220 mg, respectively) [62]. Our results showed higher content in Ca (807.04 mg/100 g), while, the Mg content was lower (3.85 mg/100 g) in comparison with Costantini *et al.* [72] who found that the Ca and Mg contents in chickpea were 104 and 140.2 mg/100 g, respectively. Meanwhile, Wang and Daun [73] found that the values of Zn, Cu, Fe, and P in chickpeas were a range of 2.50 - 5.20, 0.40 - 0.90, 4.30 - 7.90, and 270.30 - 950.50 mg/100 g, respectively.

3.3. Amino Acids Composition of Rice and Chickpea Split

The content of amino acids is a very important indicator of the nutritional value of all foods [74], nine amino acids are essential and must be present in the diet [36]. **Table 3(a)** presents the amino acids composition of rice and chickpea

Table 3. (a) Amino acids content of rice and chickpea split. (b) Chemical score of rice and chickpea split compared with FAO/WHO [77]. (c) The values of A/E, PER and B.V. of rice and chickpea split.

(a)

Amino Acid (%)	Rice	Chickpea
Essential Amino Acids		
Therionine (THR)	0.21	0.77
Phenylalanine (PHE)	0.31	1.06
Methionine	0.11	0.15
Leucine (LEU)	0.48	1.56
Isoleucine (ILE)	0.25	0.93
Valine (VAL)	0.36	1.02
Lysine (LYS)	0.22	1.46
Hisitidine (HIS)	0.14	0.49
Total essential amino acids	2.08	7.44
Conditionally Essential Amino Acids		
Argnine (ARG)	0.53	1.52
Glycine (GLY)	0.28	0.86
Proline (PRO)	0.28	0.84
Tyrosine (TYR)	0.32	0.82
Total conditionally amino acids	1.41	4.04
Non-Essential Amino Acids		
Alanine (ALA)	0.33	0.94
Aspartic (ASP)	0.62	2.3
Glutamic (GLU)	1.09	3.43
Serine (SER)	0.26	0.88
Cystine (CYS)	0.11	0.21
Total non-essential amino acids	2.41	7.76
TAAA	0.63	1.88
TSAA	0.11	0.15
Leucine: Isoleucine ratio	1.92:1	1.68:1

Total Aromatic Amino Acids (TAAA) = Tyrosine + Phenylalanine, Total sulfur-containing Amino Acid (TSAA) = Cystein + Methionine.

(b)

Essential Amino Acids	Chemical score	
	Rice	Chickpea split
Therionine (THR)	61.77	81.92
Valine (VAL)	84.71	86.81
Isoleucine (ILE)	73.53	98.94
Leucine (LEU)	80.67	94.83
Lysine (LYS)	51.77	124.26
Total sulfur amino acids	73.95	43.77
Total aromatic amino acids	123.53	133.33
Total essential amino acid	85.29	105.91
Limiting amino acids		
First	Lysine	Total sulfur amino acids
Second	Threonine	Threonine

(c)

Essential Amino Acids	Rice	Chickpea
A/E ratio		
Therionine (THR)	80.46	85.94
Phenylalanine (PHE)	118.77	118.30
Methionine	42.15	16.74
Leucine (LEU)	183.91	174.11
Isoleucine (ILE)	95.79	103.80
Valine (VAL)	137.93	113.84
Lysine (LYS)	84.29	162.95
Hisitidine (HIS)	53.64	54.69
PER (g)	1.74	2.19
B.V. (%)	67.37	72.13

A/E ratio: essential amino acid in the food protein (A)/total essential amino acids content (E) ratio, PER: protein efficiency ratio and B.V.: biological value.

flour. Results found that the total of essential amino acids in chickpea (7.44%) was higher than in rice (2.08%). Also, the chickpea was higher in the content of leucine and lysine amino acids. While, the leucine: isoleucine ratio in rice was 1.92:1, while, and in chickpea was 1.68:1. Note that the proposed ratio is 1.8:1. In addition, non-essential amino acids in chickpea (7.76%) were higher than rice and (2.41%). Also, the total aromatic amino acids (TAAA) and total sulfur amino acids in chickpea were 1.88% and 0.15%, respectively, compared to 0.63 and 0.11%, respectively, in rice. The results cleared that lysine was the first limiting amino acid in rice, while threonine was the second limiting amino acids (**Table 3(b)**). Meanwhile, total sulfur amino acids were the first limiting amino acid in chickpea, while threonine was the second limiting amino acid. The data in **Table 3(c)** showed the A/E ratio of rice and chickpea. It was found that the methionine was the lower content in rice and chickpea (42.15 and 16.74, respectively) followed by the histidine (53.64 and 54.69, respectively), while, the leucine was the highest (183.91 and 174.11, respectively). The chickpea flour become to be the in the value of protein efficiency ratio (2.19 g) and biological value of protein (72.13%) in compared with rice flour (1.74 and 67.37, respectively).

In chickpea flour, the content of essential amino acids was 39.89 g/100 g protein, and the content of endogenous amino acids was 58.64 g/100 g protein, which is higher than in wheat flour (32.20 and 56.55 g/100 g protein, respectively) [75]. The chickpea flour was lowering in methionine and cysteine amino acids, while, in wheat flour, the limiting amino acids are lysine, methionine, cysteine, and leucine [75] [76]. Meanwhile, Boye *et al.* [67] reported that the limiting amino acids in the chickpea flour are also arginine and aspartic acids.

3.4. Fatty Acids Composition of Rice and Chickpea Split

The Fatty acids composition of rice and chickpea were shown in **Table 4**. The

Table 4. Fatty acids content of rice and chickpea split.

Fatty acid (%)	Rice	Chickpea split
Saturated fatty acids (SFA)		
Myristic (C14:0)	0.615	0.061
Palmitic (C16:0)	21.45	3.304
Stearic (C18:0)	2.491	0.899
Mono-unsaturated fatty acids (MUFA)		
Oleic (C18:1, $\omega 9$)	29.57	12.80
Poly-unsaturated fatty acids (PUFA)		
Linoleic (C18:2, $\omega 6$)	45.88	80.91
α-Linolenic (C18:3, $\omega 3$)	ND	2.021

results showed that contents of saturated fatty acids (Meristic, stearic, palmetic) were higher in rice compared to chickpea. Also, the Mono-unsaturated fatty acids (oleic acid) were higher in rice than in chickpea. On the other hand, chickpea showed higher content of Linoleic acid (80.91%) compared with rice (45. 88%). While, α-Linolenic acid was found in chickpea (2.021%), and not detected in rice. The fat content in chickpea (6.04%) is higher than that in other pulses such as red kidney bean (1.06%), mung bean (1.15%), lentils (1.06%), and pigeon pea (1.64%), and also in some types of cereals such as rice (0.60%) and wheat (1.70%) [78]. Chickpea is composed of about 66% polyunsaturated fatty acids, about 19% mono unsaturated fatty acids and about 15% saturated fatty acids [73]. Rachwarosiak *et al.* [36] reported that the lipids of chickpea seeds containing a high level of essential unsaturated fatty acids such as oleic acid (21.6% - 22.2% in oil), linoleic acid (54.7% - 56.2% in oil), and linolenic acid (0.5% - 2.35% in oil), in addition to saturated fatty acids such as Palmitic acid (18.9% - 20.4% in oil) and stearic acid (1.3% - 1.7% in oil). Linoleic acid has a higher nutritional value, which is very vital due to its metabolism in the tissues of the body where production of prostaglandins takes place, which reduces blood pressure and regulates the contraction of smooth muscle [79]. Meanwhile, rice was higher in oleic monounsaturated fatty acid (C18:1, W9) than chickpea, while, the chickpea was the higher in linoleic fatty acid (C18:2, W6). As for α-linolenic fatty acid (C18:3, W3) it was found only in chickpea (2.21%) and absent in rice [36]. The palmitic acid in chickpea flours (about 12%) is lower than in wheat flour (21.96%) [80].

3.5. Antioxidant Activity of Rice and Chickpea Split Flour

Antioxidant activity namely, total phenolic content, DPPH radical scavenging activity (%) and Ferric reducing antioxidant power (FRAP) of rice and chickpea flour were studied Figure 1. The results showed that the total phenolic content (TP) in chickpea was 2.36 mg GA/g, while, it was not detected in rice. The DPPH radical scavenging activity (%) was significantly higher in chickpea

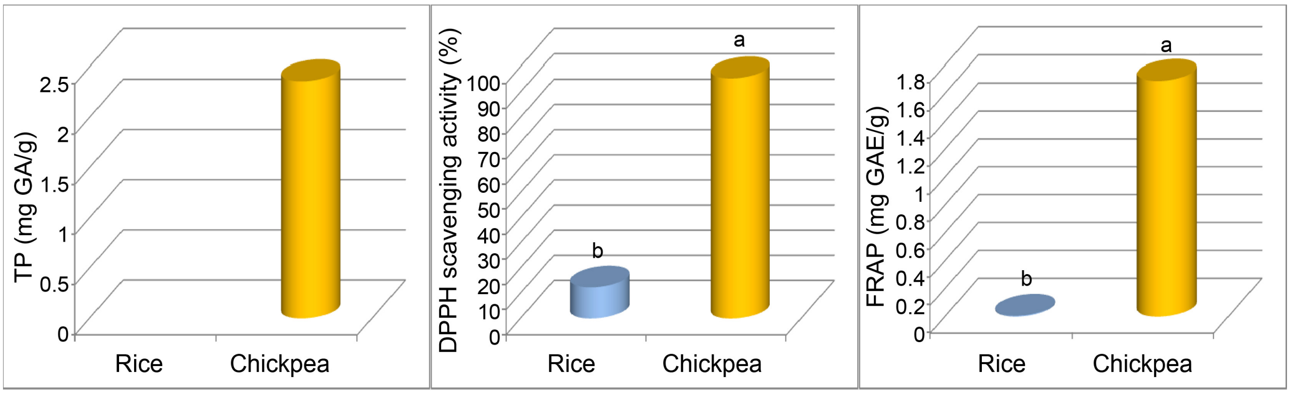

Figure 1. Antioxidant activities (Total phenolic (TP), DPPH scavenging (%) and FRAP) of rice and chickpea split.

(95.46%) than in rice (12.38%). Also, the FRAP value in chickpea (1.69 mg GAE/g) was higher than that in rice (0.006 mg GAE/g). The obtained mean value of total phenolic (2.36 ± 0.133 mgGA/g) was higher than the mean value found by Zia-Ul-Haq *et al.* [81], who noted that the total phenolic compounds found in the cultivar Climax were 0.99 mg/g. Also, it was noted that the different phenolic compounds are responsible for quenching the different types of free radicals [82]. The effect of antioxidative components on inhibition of DPPH radical is considered to be due to their ability of hydrogen-donating [83]. According to Chaiklahan *et al.* [84], the DPPH radical scavenging activity of chickpea depended on its content from phenolic. The previous studies found a positive correlation between DPPH• scavenging activity of several legumes (such as chickpeas, lentils, peas, lupines, and grass peas) and lipid contents especially unsaturated fatty acid contents [85] [86], because when the number of unsaturated bonds increases induces an increase in the susceptibility to oxidation [72].

3.6. Chemical Composition of Final Products

Data in **Table 5(a)** and **Table 5(b)** showed the chemical composition of rice and chickpea milks and their mixtures. The sample containing of 100% chickpea milk (M5) showed the highest contents of protein (%), fat (%), ash (%) moisture (%) and minerals (Ca, Fe, K and Zn) compared to other treatments. On the other side, the sample containing 100% rice (M1) was significantly highest in carbohydrates (%) and energy content. The mixtures of rice-chickpea milk showed a significant increase in contents of protein, fat, ash, mineral (Ca, Fe, K and Zn) and moisture with the increase of chickpea percentage in mixture and the highest values were found with treatment M4 (25% rice: 75% chickpea).

The comparison between snacks prepared from rice or chickpea flour showed that the bakery snacks made from chickpea flour only (BS5) were the heights in protein (%), fat (%), ash (%), minerals (Ca, Fe, K, Mg, and Zn) and moisture (%) compared to that made from rice flour (**Table 5(a)** and **Table 5(b)**). On the other hand, bakery and fried snacks made from rice flour (BS1 and FS1) were the highest in carbohydrate and energy contents. Moreover, the corporation

Table 5. (a). Effect of different concentrations of rice and chickpea split on chemical composition of rice and chickpea milk's, bakery snacks, and fried snacks. (b). Effect of different concentrations of rice and chickpea split on mineral content.

(a)

Products	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crud fiber (%)	Carbohydrates (%)	Energy C. (Kcal/100 g)
Rice and chickpea milks							
M1 (100%R)	83.76 ± 0.18^{e}	0.701 ± 0.21^{d}	0.556 ± 0.045^{d}	0.219 ± 0.010^{e}	-	14.76 ± 0.15^{a}	66.85 ± 1.46^{a}
M2 (75%R:25%Ch)	84.38 ± 0.23^{d}	0.903 ± 0.35^{c}	0.769 ± 0.031^{cd}	0.350 ± 0.010^{d}	-	13.60 ± 0.22^{b}	64.93 ± 2.01^{b}
M3 (50%R:50%Ch)	86.05 ± 0.01^{c}	1.063 ± 0.23^{b}	1.01 ± 0.11^{bc}	0.421 ± 0.010^{c}	-	11.45 ± 0.13^{c}	59.14 ± 1.36^{c}
M4 (25%R:75%Ch)	86.66 ± 0.06^{b}	1.09 ± 0.2^{ab}	1.07 ± 0.10^{b}	0.587 ± 0.006^{b}	-	10.60 ± 0.12^{d}	56.39 ± 0.39^{d}
M5 (100%Ch)	87.90 ± 0.44^{a}	1.125 ± 0.25^{a}	1.75 ± 0.31^{a}	0.626 ± 0.004^{a}	-	8.60 ± 0.64^{e}	54.65 ± 1.57^{e}
Bakery Snacks							
BS1 (100%R)	9.59 ± 0.13^{b}	6.90 ± 0.66^{e}	2.11 ± 0.36^{e}	0.442 ± 0.011^{e}	0.345 ± 0.015^{e}	80.62 ± 0.48^{a}	369.07 ± 2.16^{d}
BS2 (75%R:25%Ch)	9.53 ± 0.66^{b}	8.80 ± 0.31^{d}	3.12 ± 0.18^{d}	1.150 ± 0.057^{d}	0.743 ± 0.021^{d}	76.65 ± 0.68^{b}	369.89 ± 3.0^{cd}
BS3 (50%R:50%Ch)	9.66 ± 0.43^{b}	13.13 ± 0.48^{c}	6.01 ± 0.19^{c}	1.877 ± 0.029^{c}	1.14 ± 0.06^{c}	68.19 ± 0.98^{c}	379.37 ± 1.39^{a}
BS4 (25%R:75%Ch)	9.85 ± 0.02^{b}	16.07 ± 0.40^{b}	6.53 ± 0.23^{b}	2.61 ± 0.041^{b}	1.77 ± 0.102^{b}	63.17 ± 0.77^{d}	375.73 ± 0.64^{b}
BS5 (100%Ch)	10.83 ± 0.05^{a}	18.06 ± 0.32^{a}	7.31 ± 0.28^{a}	3.20 ± 0.092^{a}	1.94 ± 0.046^{a}	58.68 ± 0.73^{e}	372.75 ± 0.9^{bc}
Fried snacks							
FS1 (100%R)	9.11 ± 0.52^{c}	6.00 ± 0.21^{c}	0.941 ± 0.16^{a}	0.413 ± 0.016^{c}	1.50 ± 0.105^{c}	82.03 ± 0.84^{a}	360.59 ± 1.87^{a}
FS2 (75%R:25%Ch)	17.83 ± 0.43^{b}	9.01 ± 0.31^{b}	1.04 ± 0.06^{a}	1.193 ± 0.037^{b}	1.89 ± 0.108^{b}	69.04 ± 0.43^{b}	321.56 ± 1.62^{b}
FS3 (50%R:50%Ch)	21.63 ± 0.68^{a}	14.38 ± 0.32^{a}	1.22 ± 0.18^{a}	1.76 ± 0.144^{a}	2.29 ± 0.011^{a}	58.73 ± 0.48^{c}	303.42 ± 2.76^{c}

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same Column are significantly different ($P < 0.05$). R: Rice and Ch: Chickpea split.

(b)

Products	Ca (mg/100 g)	Fe (mg/100 g)	K (mg/100 g)	Zn (mg/100 g)	Mg (mg/100 g)
Rice and chickpea milks					
M1 (100%R)	83.1 ± 0.60^{e}	7.98 ± 0.48^{d}	24.28 ± 0.30^{e}	2.43 ± 0.11^{d}	ND
M2 (75%R:25%Ch)	129.7 ± 0.58^{d}	8.53 ± 0.25^{cd}	81.33 ± 0.25^{d}	2.76 ± 0.25^{cd}	ND
M3 (50%R:50%Ch)	171.9 ± 0.39^{c}	8.96 ± 0.49^{bc}	138.35 ± 0.35^{c}	3.07 ± 0.17b^{c}	ND
M4 (25%R:75%Ch)	215.9 ± 0.90^{b}	9.41 ± 0.41^{ab}	195.01 ± 0.95^{b}	3.36 ± 0.35^{ab}	ND
M5 (100%Ch)	260.6 ± 0.51^{a}	9.95 ± 0.45^{a}	252.46 ± 0.55^{a}	3.66 ± 0.35^{a}	ND
Bakery Snacks					
BS1 (100%R)	108.1 ± 0.51^{e}	8.5 ± 0.39^{e}	34.8 ± 0.32^{e}	3.52 ± 0.21^{d}	1.11 ± 0.11^{c}
BS2 (75%R:25%Ch)	165.8 ± 0.68^{d}	9.5 ± 0.25^{d}	117.0 ± 0.52^{d}	3.97 ± 0.38^{cd}	1.36 ± 0.35^{bc}
BS3 (50%R:50%Ch)	223.8 ± 0.39^{c}	10.5 ± 0.22^{c}	199.1 ± 0.58^{c}	4.40 ± 0.39^{bc}	1.66 ± 0.36^{abc}
BS4 (25%R:75%Ch)	281.6 ± 0.55^{b}	11.5 ± 0.48^{b}	281.3 ± 0.25^{b}	4.85 ± 0.36^{ab}	1.93 ± 0.43^{ab}
BS5 (100%Ch)	339.3 ± 0.31^{a}	12.5 ± 0.50^{a}	363.4 ± 0.35^{a}	5.26 ± 0.26^{a}	2.21 ± 0.20^{a}
Fried snacks					
FS1 (100%R)	164.6 ± 0.22^{c}	5.73 ± 0.33^{b}	5.81 ± 0.31^{c}	2.12 ± 0.22^{a}	1.48 ± 0.22^{b}
FS2 (75%R:25%Ch)	252.5 ± 0.31^{b}	6.09 ± 0.22^{ab}	19.5 ± 0.40^{b}	2.38 ± 0.32^{a}	1.85 ± 0.25^{ab}
FS3 (50%R:50%Ch)	340.6 ± 0.52^{a}	6.44 ± 0.34^{a}	33.16 ± 0.64^{a}	2.64 ± 0.43^{a}	2.22 ± 0.22^{a}

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same Column are significantly different ($P < 0.05$). R: Rice and Ch: Chickpea.

between chickpea flour and rice flour significantly increased the values of protein, fat, ash, minerals (Ca, Fe, K, Mg, and Zn) and fiber in a rice-chickpea bakery or fried snacks, and the bakery snacks samples containing 75% chickpea and 25% rice (BS4) was significantly higher other treatments (BS2 and BS3), but it was the lowest in carbohydrate and energy contents (**Table 5(a)** and **Table 5(b)**). While, in fried snacks, the sample containing chickpea flour and rice flour by ratio 50:50 (FS3) was the highest in protein (%), ash (%), minerals (Ca, Fe, K, and Mg), and moisture (%), but it was the lowest in carbohydrate and energy contents compared to FS1 and FS2 samples.

These results agreed with Gupta and Bansal, [87] who found that the moisture content of chickpea products ranged from 6.63% to 9.15%, in spite of having gluten-free properties. Gram flour and chickpea flour acted as a good binding factor and rendered smooth light yellow-texture to the dough on kneading with water. The chickpea proteins are mainly globulins (salt soluble proteins) and albumins (water-soluble proteins). The fractional composition data of these proteins confirmed that the products of chickpea can be used in the technology of cooking foods with low gluten content [88]. Xu *et al.* [37] stated that hydration and swelling properties as well as water absorption and holding capacities of cooked chickpeas were higher than raw chickpeas, with the largest increases in the pressure-cooked seeds. Therefore, kneading the dough from chickpea flour resulted in fundamental changes in dough rheology and led to an increase in chickpea water-soluble proteins.

A study carried out by Hall *et al.* [89] showed that the carbohydrate (%) in chickpea snacks was 40.4% - 42.6%. Also, Xu *et al.* [37] found that the protein (%) of chickpea snacks samples was 23.33% to 30.95%. The reason for differences between these studies results and our results due to the composition of snacks formula used. Gonzales *et al.* [90] reported that the chickpea-based baked food products are considered as a good sources of nutrients particularly energy and contained around 105 - 526 Kcal. While, Gupta and Bansal [87] found that the chickpea based snacks had 500 - 541 Kcal owing to deep frying cooking methods of the products.

3.7. Recommended Daily Allowances (RDA)

In the present study, the final products made from rice, chickpea, or both together, were compared with the mean dietary intake for each nutrient to the published RDA norms [91], of calories, carbohydrates, fats, protein, and minerals for autism children (**Table 6**). The results showed that daily intake of 100 mL of chickpea milk (100%) could provide autism children with 99.5%, 32%, and 36% of the daily required iron, Ca, and Zn, respectively. Also, the daily intake of 100 g of snacks (sample BS5) could provide autism children with 75%, 7%, 42%, 125%, 1.7%, and 52% of the daily required of protein, fiber, Ca, iron, Mg, and Zn, respectively. on the other hand, 59.9%, 42%, and 64% of the daily required of protein, calcium, and iron could be obtained from 100 g fried snacks (sample

Table 6. Effect of different concentrations of rice and chickpea split on recommended daily allowances (RDA).

Products	Age years	Energy content (Kcal/100 g)	Protein	Fat	Carbohydrates	Fiber	Ca (mg)	Fe (mg)	Mg (mg)	Zn (mg)
	3 - 5	1800	24 g (10% - 30%)	39 - 62 g (25% - 35%)	45% - 65%	23 - 28 g	800	10	130	10
	6 - 9	2000	28 g (10% - 30%)	62 - 85 g (25% - 35%)	45% - 65%	23 - 28 g	1300	10	240	10
Rice and chickpea milks										
M1 (100%R)	3 - 5	3.71	2.92	1.10	1.49	-	10.39	79.80	-	24.30
	6 - 9	3.34	2.50	0.76	1.34	-	6.39	79.80	-	24.30
M2 (75%R:25%Ch)	3 - 5	3.61	3.76	1.52	1.37	-	16.21	85.30	-	27.60
	6 - 9	3.25	3.23	1.05	1.24	-	9.98	85.30	-	27.60
M3 (50%R:50%Ch)	3 - 5	3.29	4.43	2.00	1.16	-	21.49	89.60	-	30.70
	6 - 9	2.96	3.80	1.37	1.04	-	13.22	89.60	-	30.70
M4 (25%R:75%Ch)	3 - 5	3.13	4.54	2.12	1.07	-	26.99	94.10	-	33.60
	6 - 9	2.82	3.89	1.46	0.96	-	16.61	94.10	-	33.60
M5 (100%Ch)	3 - 5	3.04	4.69	3.47	0.87	-	32.58	99.50	-	36.60
	6 - 9	2.73	4.02	2.38	0.78	-	20.05	99.50	-	36.60
Bakery Snacks										
BS1 (100%R)	3 - 5	20.50	28.75	4.18	8.14	1.35	13.51	85.00	0.85	35.20
	6 - 9	18.45	24.64	2.87	7.33	1.35	8.32	85.00	0.46	35.20
BS2 (75%R:25%Ch)	3 - 5	20.55	36.67	6.18	7.74	2.91	20.73	95.00	1.05	39.70
	6 - 9	18.49	31.43	4.24	6.97	2.91	12.75	95.00	0.57	39.70
BS3 (50%R:50%Ch)	3 - 5	21.08	54.71	11.90	6.89	4.47	27.98	105.00	1.28	44.00
	6 - 9	18.97	46.89	8.18	6.20	4.47	17.22	105.00	0.69	44.00
BS4 (25%R:75%Ch)	3 - 5	20.87	66.96	12.93	6.38	6.94	35.20	115.00	1.48	48.50
	6 - 9	18.79	57.39	8.88	5.74	6.94	21.66	115.00	0.80	48.50
BS5 (100%Ch)	3 - 5	20.71	75.25	14.48	5.93	7.61	42.41	125.00	1.70	52.60
	6 - 9	18.64	64.50	9.95	5.33	7.61	26.10	125.00	0.92	52.60
Fried snacks										
FS1 (100%R)	3 - 5	20.03	25.00	1.86	8.29	5.88	20.58	57.30	1.14	21.20
	6 - 9	18.03	21.43	1.28	7.46	5.88	12.66	57.30	0.62	21.20
FS2 (75%R:25%Ch)	3 - 5	17.86	37.54	2.06	6.97	7.41	31.56	60.90	1.42	23.80
	6 - 9	16.08	32.18	1.41	6.28	7.41	19.42	60.90	0.77	23.80
FS3 (50%R:50%Ch)	3 - 5	16.86	59.92	2.42	5.93	8.98	42.58	64.40	1.71	26.40
	6 - 9	15.17	51.36	1.66	5.34	8.98	26.20	64.40	0.93	26.40

R: Rice and Ch: Chickpea split.

FS3). According to Herndon *et al.* [92] the children with ASD had a lower consumption average of calcium (747 mg/day), a higher consumption average of vitamin B6 (1.5 g/day), and a higher consumption average of vitamin E (8 mg/day) as compared to 894 mg/day, 1.2 g/day, and 4 mg/day of calcium, V.B6, and V.E respectively with their counterparts. Zimmer *et al.* [93] found that children with ASD had lower consumption of protein (72.77 g/day), calcium (945.18 mg/day), magnesium (314.89 mg/day), vitamin B12 (4.69 µg/day), and vitamin D (198.62 IU/day), as compared with 92.64 g/day, 1221.98 mg/day, 265.93 mg/day, 6.66 µg/day, and 319.86 IU/day, of protein, calcium, magnesium, vitamin B12, and vitamin D, respectively, in their counterparts (normal children). Also, Emond *et al.* [94] found that the children with ASD consumed less vitamin C and vitamin D and more iodine with their counterparts. Previous studies have noted a significant decrease in the vitamins and minerals levels in the blood of autism children within comparison to controls, thus implying a role of these nutrients in autism pathophysiology [95].

3.8. Antioxidant Activity of Final Products

The antioxidant activity of rice and chickpea milk, and snacks is illustrated in **Figure 2**. The higher total phenolic (TP) content was found with chickpea milk (M5), while, in rice milk, TP was not detected. In the mixtures of chickpea-rice milk, the TP was significantly ($P < 0.05$) increased by the increases of chickpea milk amount in the mixture (M3 and M4). The same behavior was observed in fried and bakery snacks, whereas, TP was increased by increases of chickpea flour in the formula of snacks. Also, the results of DPPH scavenging activity (%) and FRAP assays showed that the higher antioxidative activity was found with the milk and snacks samples containing 100% chickpea (M5 and BS5). Furthermore, the values of the DPPH inhibition activity and FRAP of products containing a mix of rice and chickpea (milk, fried snacks, and bakery snacks) were significantly ($P < 0.05$) increased with the increase of chickpea amount in the product. The bioactive components such as phenolic, carotenoids, and anthocyanins, are recognized as antioxidants. So, they can prevent or reduce the peroxidation of lipid and scavenge free oxygen radicals [96]. Many studies found a positive correlation between ABTS•+ scavenging capacity and TP contents, as well as with the total flavonoids contents [82] [97]. Thanuja and Parimalavalli [98] found that the heat treatment generally causes a significant decreased in the total phenolic content and antioxidant activity of rice flour. It was suggested that when rice exposure to heat, the phenolic compounds have a tendency of breaking down into smaller stable forms which may or may not show antioxidant activity. On cooking, the cellular breakdown enhances the release of the bound phenolics [98]. There is a potentiality that these phenolics compounds could replace the free phenolics, the maximum of which got destroyed during the cooking process [99]. Meanwhile, some studies suggested that an imbalance of minerals would change the content of flavonoids and polyphenols [86]. Also, Sulaiman *et al.* [100] noted a significant correlation between Mn content and DPPH•

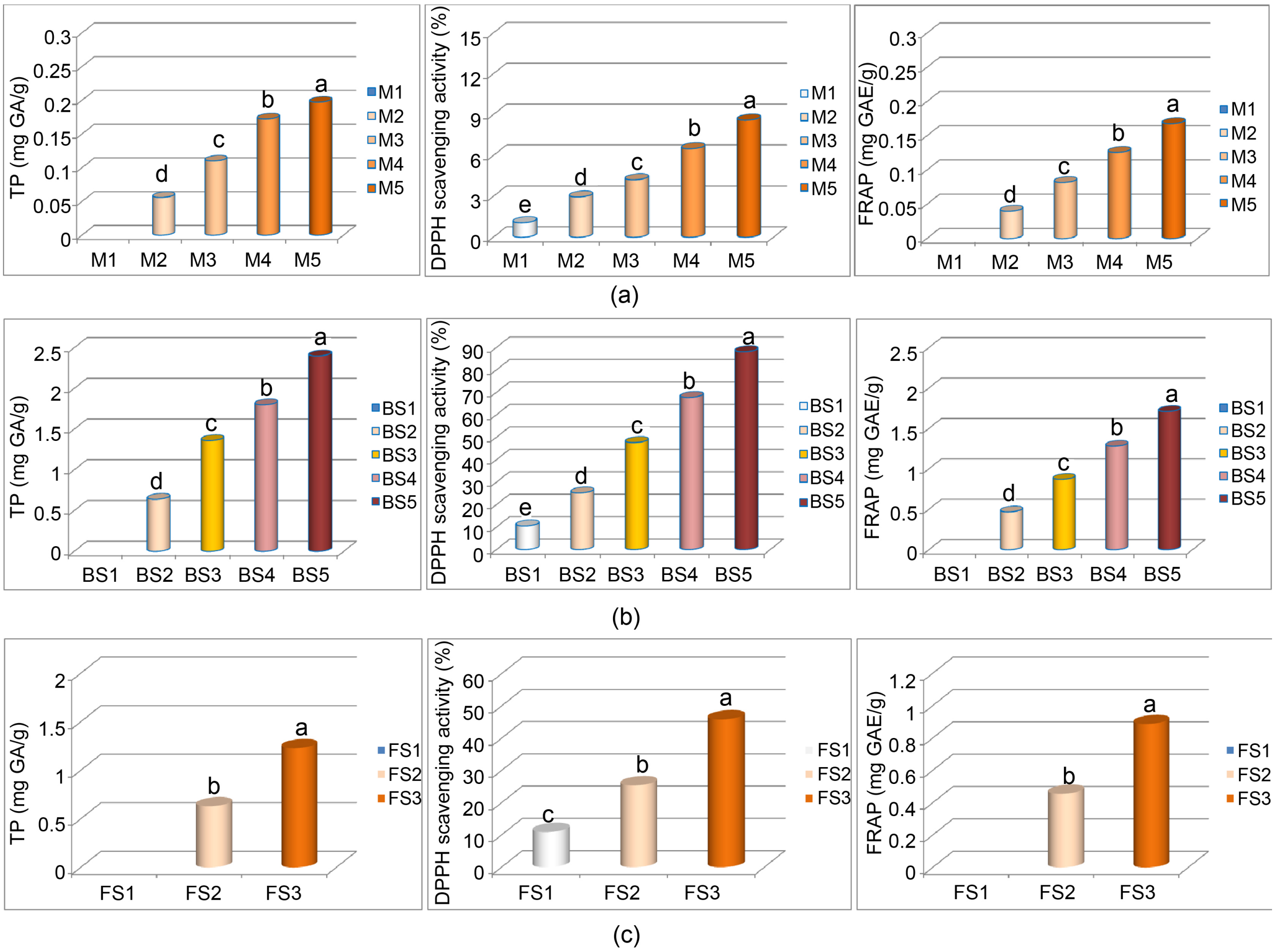

Figure 2. Effect of different concentrations of rice and chickpea split on antioxidant activity (Total phenolic (TP), DPPH scavenging (%) and FRAP) of (a): rice and chickpea milk's, (b): bakery snacks and (c): fried snacks. M1: 100% rice, M2: 75% rice: 25% chickpea, M3: 50% rice: 50% chickpea, M4: 25% rice: 75% chickpea, M5: 100% chickpea, BS1: 100% rice, BS2: 75% rice: 25% chickpea, BS3: 50% rice: 50% chickpea, BS4: 25% rice: 75% chickpea, BS5: 100% chickpea, FS1: 100% rice, FS2: 75% rice : 25% chickpea and FS3: 50% rice: 50% chickpea.

inhibition activity. From the results of this study as well as previous studies, it could be concluded that there is a significant correlation between the total phenolic content and minerals, and the antioxidant capacity of chickpea. On the other hand, Saxena *et al.* [101] reported that the soaking (overnight) seed of chickpea caused improvement in starch digestibility and reduces the content of phenols, proteins, and protease inhibitors.

3.9. Determination of Viscosity of Rice and Chickpea Split Milks

The sample containing 100% of rice milk has a higher viscosity value (24 ± 2.52 mpa.s) compared with all other treatments (**Figure 3**). On the other hand, the viscosity was significantly decreased with the increase of chickpea milk percentage in rice-chickpea milk treatments. Rohman *et al.* [102] reported that the milled rice has higher starch and lower protein and lipid content compared to brown rice within the same variety. Furthermore, it was found that the rice milk

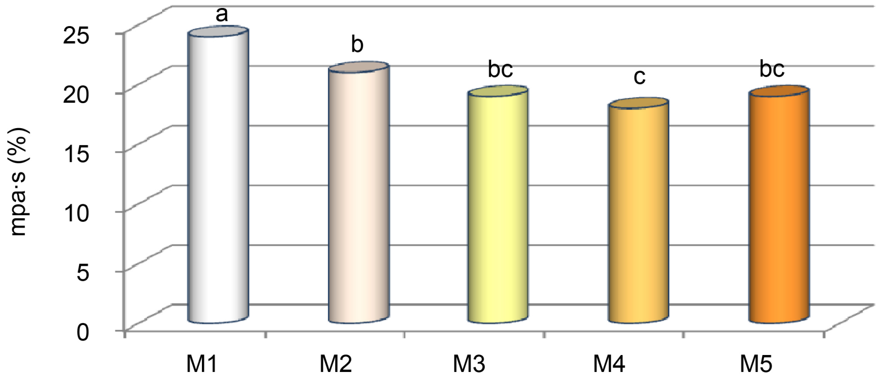

Figure 3. Effect of different concentrations of rice and chickpea split on the viscosity of rice and chickpea milks. M1: 100% rice, M2: 75% rice: 25% chickpea, M3: 50% rice: 50% chickpea, M4: 25% rice: 75% chickpea and M5: 100% chickpea.

made from Bengal milled rice has a higher viscosity compared to the other rice milk samples [40] [102]. The rate of viscosity was increased with the degree of milling being higher for medium grain than for long-grain cultivars. The swelling of starch granules determined the pasting behavior and rheological properties of a starch solution [103]. The swelling was a property of amylopectin, while lipid and amylose inhibited the swelling properties. Where, during the gelatinization process, amylose leaches from starch granules affecting the viscosity of the continuous phase [104]. Lopes *et al.* [105] reported that heat treatment (such as cooking and pasteurization), is able to remove off-flavors of legumes, which are the most challenging barrier to consumer acceptance, but high temperatures may cause immoderate denaturation of protein, decreased protein solubility, and may increase legume beverage viscosity, affecting its physical stability. So, Colloidal milling is known as a technological intervention capable to elevate the physical stability of beverages by reducing the size of the dispersed particles.

3.10. Color Measurements of Final Products

Color is an important characteristic attribute that governs the acceptability of food products [106]. The color values (lightness "L", redness "a", and yellowness "b") of the rice and chickpea milk, and snacks are shown in **Table 7**. By increasing, the added amount of chickpea milk to rice milk the lightness "L" value was significantly ($P < 0.05$) decreased, while, redness "a", and yellowness "b" values were significant ($P < 0.05$) increased. The same results were observed with bakery snacks, whereas the increase in chickpea flour addition caused a significant decrease in "L" value, while, "a", and "b" values were significant ($P < 0.05$) increased. The opposite was found with fried snacks, whereas the chickpea flour caused a significant ($P < 0.05$) decrease in "L", and "b" values, while the "a" value was not affected. Our results agree with Aguilar *et al.* [107], Xiao *et al.* [108] and Olojede *et al.* [109] who found that the addition of chickpea into various bread flours induced darkness of the bread, where lysine and sugars provided by the chickpea enhance the Maillard reaction. Whil, Sharima-Abdullah *et al.* [110]

Table 7. Effect of different concentrations of rice and chickpea split flour on color measurements.

Products	Lightness (L*)	Redness (a*)	Yellowness (b*)
Rice and chickpea milks			
M1 (100%R)	44.11 ± 0.89[a]	−1.08 ± 0.08[c]	−0.87 ± 0.05[e]
M2 (75%R:25%Ch)	41.20 ± 0.80[b]	−1.25 ± 0.05[d]	−0.25 ± 0.07[d]
M3 (50%R:50%Ch)	35.29 ± 0.79[c]	−1.00 ± 0.03[c]	0.57 ± 0.08[c]
M4 (25%R:75%Ch)	33.83 ± 0.93[c]	−0.83 ± 0.05[b]	1.00 ± 0.010[b]
M5 (100%Ch)	32.05 ± 0.95[d]	−0.55 ±0.05[a]	1.72 ± 0.08[a]
Bakery Snacks			
BS1 (100%R)	57.53 ± 0.53[a]	3.64 ± 0.25[d]	10.55 ± 0.46[e]
BS2 (75%R:25%Ch)	49.30 ± 0.30[b]	6.32 ± 0.19[c]	17.83 ± 0.33[d]
BS3 (50%R:50%Ch)	48.51 ± 0.50[b]	14.38 ± 0.62[b]	24.81 ± 0.21[c]
BS4 (25%R:75%Ch)	44.57 ± 0.68[c]	15.95 ± 0.45[a]	33.41 ± 0.20[b]
BS5 (100%Ch)	36.48 ± 0.53[d]	16.33 ± 0.34[a]	35.40 ± 0.29[a]
Fried snacks			
FS1 (100%R)	41.29 ± 1.29[a]	10.30 ± 0.71[a]	21.98 ± 0.4[a]
FS2 (75%R:25%Ch)	33.28 ± 2.28[b]	10.76 ± 0.47[a]	16.87 ± 0.38[b]
FS3 (50%R:50%Ch)	32.63 ± 2.75[b]	10.86 ± 0.32[a]	16.86 ± 0.63[b]

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same Column are significantly different ($P < 0.05$). R: Rice and Ch: Chickpea split.

reported that the addition of vegetable protein, chickpea flour's improved the color and visual appearance of the product and the optimized amounts are needed to improve consumer overall acceptance.

3.11. Texture Profile Analysis of Snacks

The use of chickpea as a food ingredient in different food categories increased due to its nutritional value and improved offer of options of gluten-free food, in addition, the options baked of gluten-free products had several obstacles that include decreased acceptability due to a compact structure, crumb with a hard and crumbly texture lack of cellular structure, and cracked crust [111]. The results in Table 8 clearly show that the addition of chickpea flour to rice flour caused a significant ($P < 0.05$) decrease in hardness, while the springiness and resilience were significantly ($P < 0.05$) increased. The higher hardness value (641 ± 6.05) was found with the sample containing 100% rice (BS1) followed by sample BS2 (containing 25% chickpea flour). While, the higher springiness (0.721 ± 0.021) and resilience (0.070 ± 0.003) values were observed with sample BS5 (100% chickpea flour). Concerning fried snacks, it was found that the sample containing 75% rice flour: 25% chickpea flour (FS2) has hardness and springiness values compared to other treatments (FS1 and FS3). Meanwhile, the higher scores of springiness (7.01 ± 0.52) and resilience (0.43 ± 0.08) were obtained with the

Table 8. Effect of different concentrations of rice and chickpea split flour on texture profile analysis of bakery and fried snacks.

Products	Hardness (g)	Adhesive Force (g)	Resilience	Springiness (mm)
Bakery Snacks				
BS1 (100%R)	641 ± 6.05[a]	0.00 ± 0.00[b]	0.010 ± 0.001[e]	0.250 ± 0.031[d]
BS2 (75%R:25%Ch)	430 ± 5.05[b]	0.00 ± 0.00[b]	0.020 ± 0.001[d]	0.310 ± 0.021[c]
BS3 (50%R:50%Ch)	319 ± 4.05[c]	3.00 ± 0.21[a]	0.030 ± 0.0[c]	0.450 ± 0.021[b]
BS4 (25%R:75%Ch)	289 ± 3.05[d]	0.00 ± 0.00[b]	0.060 ± 0.002[b]	0.710 ± 0.021[a]
BS5 (100%Ch)	233 ± 3.05[e]	0.00 ± 0.00[b]	0.070 ± 0.003[a]	0.721 ± 0.021[a]
Fried snacks				
FS1 (100%R)	462 ± 5.95[b]	4.00 ± 0.25[a]	0.14 ± 0.01[c]	0.22 ± 0.021[c]
FS2 (75%R:25%Ch)	666 ± 5.99[a]	0.00 ± 0.00[b]	0.28 ± 0.02[b]	7.01 ± 0.52[a]
FS3 (50%R:50%Ch)	249 ± 4.05[c]	0.00 ± 0.00[b]	0.43 ± 0.08[a]	1.72 ± 0.045[b]

Results are reported as mean ± SD, Mean values (±SD) with different small letters within the same Column are significantly different ($P < 0.05$). R: Rice and Ch: Chickpea split.

samples containing 25% and 50% chickpea flour, respectively (FS2 and FS3). In some previous studies, various percentages of chickpea flour were tested to examine their effects on baking performance [112] [113] [114] [115]. It was found that the addition of chickpea flour at a level of 5% resulted in higher dough stability. However, a level of 10% - 24% caused a weakened gluten network, which would result in decreased dough stability. While Boukid *et al.* [113] found that the supplementation with10% chickpea flour increased dough stability as well as had a similar color to an all wheat flour. Rachwa-Rosiak *et al.* [116] detected that the supplementation of dough with chickpea flour resulted in lower volume and higher hardness, which may agree with the lower viscosity of chickpea flour during processing. Also, incorporating chickpea flour in the production of flatbread significantly decreased the volume of the product and this is due to the decreased dough elasticity comparing the whole wheat sample [117].

3.12. Sensory Evaluation of Rice and Chickpea Split Milks and Snacks

Sensory characteristics such as color, taste, odor, texture, and overall acceptability of rice and chickpea milks and snacks are presented in **Figure 4**. Rice milk (M1) sample has the highest scores in color, taste, odor, texture, and overall acceptability compared to all other treatments, but by addition of chickpea milk to rice milk all sensory properties was significantly ($P < 0.05$) decreased except the taste. Concerning of bakery snacks, the sample containing 75% chickpea flour: 25% rice flour (BS4) has the higher evaluation scores in taste, odor, texture, and overall acceptability compared to other treatments. While, the higher score in color was found with sample BS2 (75% rice flour: 25% chickpea flour) compared to other treatments. As for the fried snacks, it was found that the addition of chickpea flour by ration 25% or 50% to rice flour not affected on all sensory

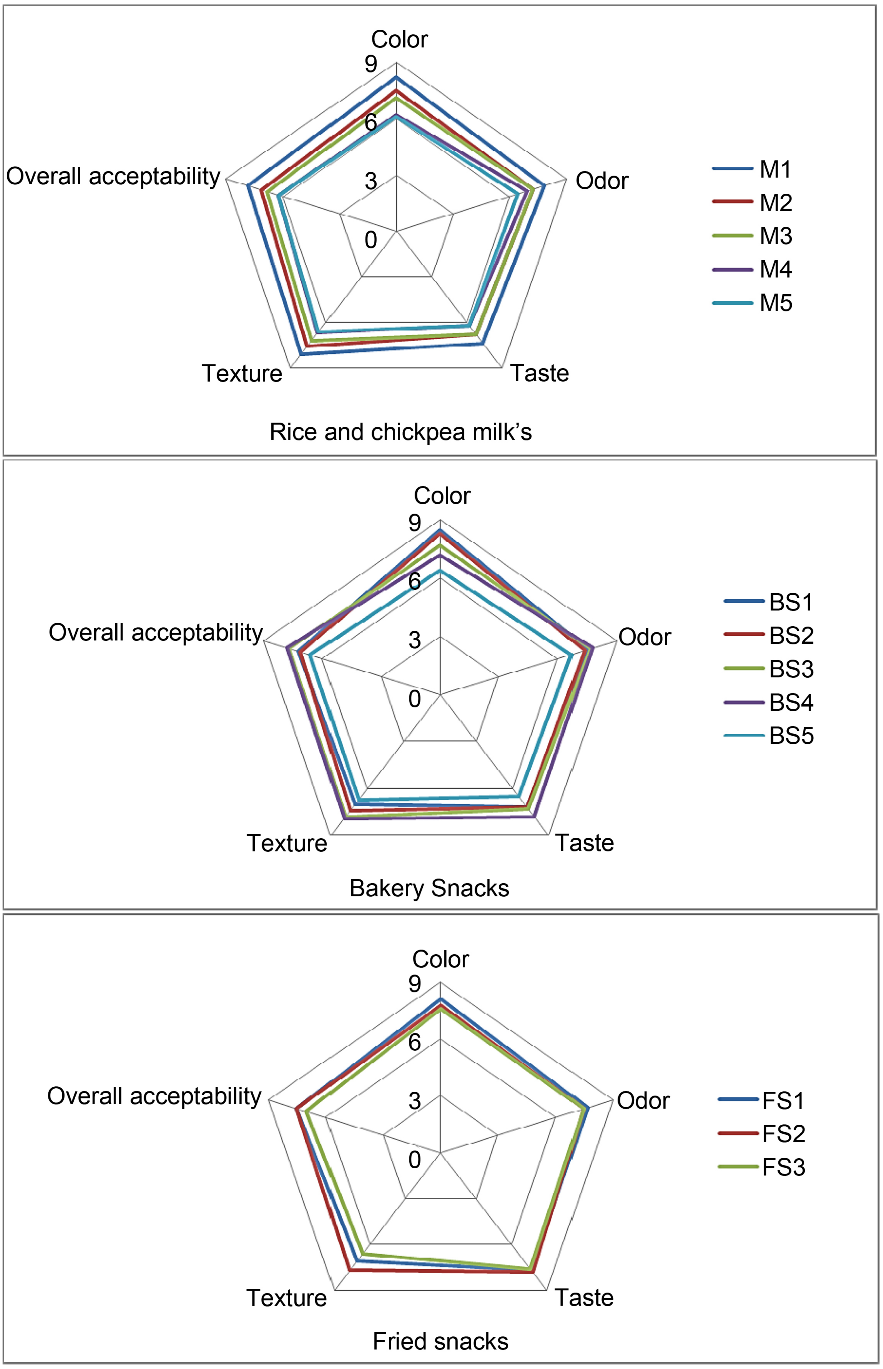

Figure 4. Effect of different concentrations of rice and chickpea split on the sensory properties of rice and chickpea milk's, bakery snacks, and fried snacks. M1: 100% rice, M2: 75% rice: 25% chickpea, M3: 50% rice: 50% chickpea, M4: 25% rice: 75% chickpea, M5: 100% chickpea, BS1: 100% rice, BS2: 75% rice: 25% chickpea, BS3: 50% rice: 50% chickpea, BS4: 25% rice: 75% chickpea, BS5: 100% chickpea, FS1: 100% rice, FS2: 75% rice: 25% chickpea and FS3: 50% rice: 50% chickpea.

properties of snacks. On the contrary to our findings, Han *et al.* [118] found that the fortification of noodles with chickpea flour (up to 20%) resulted in a weak dough with poor sensory quality, due to the technological effect of chickpea flour on the gluten-forming proteins and starch being diluted. While using germinated chickpea instead of chickpea flour in the formulation produced a good product with high nutritional value and without adverse effects on texture, color, and undesirable mouthfeel [118] [119]. on the other side, Rababah *et al.* [120] did not find any differences in the overall impression of maize-based snack products fortified with different levels of chickpea flour (up to 9%). Other researchers found that the gluten-free cookies made with buckwheat and amaranth, with the addition of chickpea flour (up to 60%) were better perceived than a less than 40% addition of chickpea flour on wheat cookies, whereas, this addition (40%) showed a texture change, causing a drop in sensory score from 6.14 to 3.44 and appearance of beany flavor and an aftertaste [121]. Armaforte *et al.* [122] found that the use of chickpea protein isolate (CPI) as an alternative emulsifier demonstrated similar behavior in acceptability in terms of texture, aroma, flavor, appearance, and overall acceptability compared with a control mayonnaise (egg-based). Lopes *et al.* [105] used chickpea to developing a new beverage with good texture, similar to the current non-dairy alternative beverages with good acceptability scores (3 on a scale of 5). Abou-Dobara *et al.* [123] studied the effect of mixing various concentrations of rice milk with cow milk on sensory evaluation scores. He found that the rice milk with its intense white gained the highest scores of appearance and color compared to the yellow color of cow milk.

4. Conclusion

In this study, we investigated the preparation and characterization of gluten-free and casein-free (GFCF) food products (Like-milk beverages and snacks) for autism patients from rice and chickpea split by replacing rice with chickpea at a ratio of 25%, 50%, 75%, and 100%, and in a ratio of 25% and 50% with fried snacks. The results showed that the addition of chickpea to rice significantly increased protein (%), fat (%), minerals (Ca, Fe, K, Zn, and Mg) (%), and antioxidant capacity of final products. On the other hand, the viscosity of rice milk and the hardness of snacks significantly decreased with the increase in the amount of chickpea split flour added. The recommended daily allowances (RDA) observed that the intake of 100 mL chickpea milk (100%) could provide autism children with 99.5%, 32%, and 36% of the daily required iron, Ca, and Zn, respectively. Also, the daily intake of 100 g of snacks (sample BS5) could provide autism children with 75%, 7%, 42%, 125%, 1.7%, and 52% of the daily required of protein, fiber, Ca, iron, Mg, and Zn, respectively. On the other hand, 100 g fried snacks (sample FS3) could provide autism children with 59.9%, 42%, and 64% of the daily required protein, calcium, and iron, respectively. The best sensory evaluation scores were obtained with rice milk (100%), bakery snacks sample BS4 (25% rice: 75% chickpea), and fried snacks sample FS3 (50% rice: 50% chickpea). This study recommends the addition of chickpea to rice by a ratio of 50:50 in the preparation of milk beverages and snacks for autism patients.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

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