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ORIGINAL ARTICLE

Development of Low Glycemic Index cold pasta extrudates using buckwheat and chickpea

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ABSTRACT
This article targets development of low glycemic index extruded pasta using buckwheat and chickpea flour by cold extrusion technology. The extruded pasta was prepared with varied concentrations of buckwheat (50 – 100 %) and chickpea (0 – 50%). The amount of salt and water has been kept constant at 1.5 % and 40% respectively. A trial-and-error approach with six formulations for the varied buckwheat and chickpea flours has been adopted to characterize cooking time, water uptake ratio, solid gruel loss, volume expansion, swelling index, texture, colour and sensory parameters of the developed product. The results affirmed a significant enhancement in water uptake ratio, volume expansion and swelling index from 2.00 – 4.23, 0.90 – 1.11% and 18.48 -22.67 respectively. On the other hand, cooking time and solid gruel loss have been reduced from 4.28 -3.71 min and 8.55 -3.74% respectively. Based on such investigations, the optimum characteristics were achieved for T_5 (60:40 buckwheat to chickpea ratio). This investigation provides a guideline for the development of various value added products with low glycemic index and optimum characteristics.
Keywords: *buckwheat; chickpea;cooking parameters; extruded pasta; low glycemic index; overall acceptability*

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INTRODUCTION

Cold extrusion technology for the development of buckwheat and chickpea-based pasta extrudates sets a guideline to develop standardized pasta with low glycemic index. This is indeed beneficial for diabetic people. On the other hand, such product adds additional nutritional values to the consumers. Further, the research approach is useful to identify the optimum characteristics for various nutritious and healthy food products. Food is regarded as the most promising sector from the prospective of economy of the country. With the advancement of food science and technology, there has been a major shift towards development of various value-added products across the globe. Demand of such products is growing in the market due to various demographic factors such as nuclear family, enhanced income, health consciousness, busy schedule etc. Among various value-added products, snacks and pasta are the most accepted product especially among the children and adults. The Indian Pasta market reached a value of US$ 671.8 Million in 2021. On the other hand, the market is expected to reach US$ 1,754.5 Million by 2027, exhibiting a Compound Annual Growth Rate(CAGR) of 17.44% during 2022-2027 (IMARC). Pasta is basically manufactured by subjecting the kneading dough to cooking and forming processes and finally expanded product with desired quality characteristics is formed [1]. In the vast scenario of development of pasta product, there are two basic approaches being adopted for the development of pasta product. Firstly, manual approach involves providing the desired shapes to the kneaded dough in the form of elongated thread like structure and subjecting to cooking process to achieve the final product. Secondly, extrusion technique involves a series of processes in a single unit. Subsequently, unit operations such as kneading, mixing, cooking and forming are carried out by passing the mixture of ingredients through a hopper to the extruder. A desired shape is provided with a suitable die attached at the end section of the extruder. Further, this extrusion technique comprises of two separate approaches. One being maintained with a temperature less than 100°C known as cold extrusion and another refers to hot extrusion in which temperature goes above 100 °C. Among the approaches mentioned above, cold extrusion has got many advantages over other techniques such as manual and hot extrusion in terms of better retention of nutritional content of the product, ease in handling and better process control with achievement of desired product characteristics. On the other hand, manual process involves drudgery and much time. Further, there is no control over the process which leads to inferior quality characteristics of the final product. Therefore, a mature approach is highly necessary to target product such as pasta. Extrusion cooking is one of the novel approaches to transform various agricultural produces into a value added product. Among various food products, being manufactured industrially, the most common product refers to cereal baby food, confectionary breakfast cereals, snacks, bakery products, etc, pet food and pasta products. Therefore, such a technique has got immense potential to address and develop a nutritionally enriched extruded product into pasta. Generally, Pasta is a flour based noodles prepared using cereals in combination with other ingredients. Among various cereals, the most commonly used cereal refers to wheat. But pasta product with such an ingredient possesses a high glycemic index. On the other hand, other cereals also significantly enhance the glycemic index of the product. Therefore, an attempt has been made to identify and use an ingredient which contributes less towards glycemic index. Product with low glycemic index with better quality characteristics would be beneficial for the consumers to combat glycemic intolerance among the consumers. The glycemic index is defined as the incremental area under the blood glucose response curve after intake of standard amount of carbohydrates from a test food relative to a control food (glucose or white bread). The beneficial effects of low glycemic index diet would be greatly pronounced for the diabetic patients [2]. On the other hand, pasta developed using low glycemic index and gluten flour would provide a rigid and soft texture when dried and cooked respectively. In the context of alternate sources of glycemic and gluten ingredient, buckwheat provides a potential option for the development of pasta using cold extrusion technique. Buckwheat is a pseudocereal from the family Polygonacae as it resembles cereal. It is rich in proteins, minerals, vitamins and also good amount of dietary fibre, myo-inositol, d-chiro- inositol, fagopyritols, flavonoids and phytosterol. Proteins present in buckwheat possess a higher biological value due to greater value of amino acids compared to other cereals. With no gluten content, buckwheat is recommended for celiac patients. As buckwheat is rich in terms of nutritional value, nutraceutical properties, resistant starch and because of its low glycemic index offers a good opportunity to use it as a main ingredient in the preparation of pasta extrudates for celiac as well as diabetic people. It is also helpful in reducing high blood pressure, lowering the cholesterol levels and preventing risk of cancer [3]. Buckwheat is being used for the development of bread, cookies, pies, pancakes and macaroni products. On the other hand, raw buckwheat groats have been reported to contain 33.5% resistant starch [4], because of which it is considered to be a good source to develop a value added food product with low glycemic index. About 30% buckwheat flour in combination with other flours offers best results for the preparation of biscuits, girdle cakes, cracknuts, pancakes and noodles with low glycemic index [5]. On the other hand, chickpea (*Cicer arietinum*. L) is a legume with high content of protein (19.0 %), carbohydrate (61.0 %), and fibre (17.0 %) [6]. With hydrolysate proteins being potential bioactive ingredients, the protein quality of chickpea is considered to be best as compared to other pulses. Further, it is a good source of minerals especially potassium and also vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor, β-carotene [6]. The available carbohydrate content of chickpea has been reported to have low glycemic response in nutrition. Similarly, chickpea also rich in various minerals such as potassium, sodium, calcium, magnesium, copper, iron and zinc. Chickpea flour possesses low glycemic index and higher dietary fiber content compared to than wheat and rice [7]. Therefore, with low glycemic index, buckwheat and chickpea provides an alternate solution for the development of a low glycemic index pasta product using cold extrusion technology. Available literature indicates few investigations towards development and characterization of low glycemic index pasta products. [8] studied formulation of a low glycemic index pasta product with varied chickpea flour and affirmed that about 25 % chickpea flour possessed a significantly lower glycemic index and higher mineral content compared to pasta prepared using durum wheat. Also, [9] reported the positive effect of chickpea flour inclusion in pasta product developed with durum wheat lasagne and chickpea. On the other hand, incorporation of about 5-30 % of various pulse flours into durum wheat flour based spaghetti enhanced firmness and colour intensity of product. Similarly,[10] developed a nutritionally enhanced spaghetti with 35% legumes (split pea or faba bean) and durum wheat semolina. [11] conducted physiochemical evaluation of extrudates developed with corn grits and 10-30 % buckwheat flours using extrusion process. Based on such investigation, optimum pasta was reported for corn grits containing 20 % buckwheat flour. On the other hand, available literature affirmed few other products using buckwheat and chickpea. Evaluation of the functional properties for the biscuit developed using 20-30% buckwheat flour. Incorporation of 30 % chickpea flour showed acceptable processed chickpea-based food products like biscuits, cookies, bar, tart, buns, butter cake and waffles [5]. A critical analysis of the available state of art affirmed limited investigations towards development of low glycemic index pasta formulation. Further, pasta formulation using buckwheat and chickpea has not been targeted till date. On the other hand, available literature does not fix the guideline for choosing the concentration levels of buckwheat flour and chickpea flour in the preparation of low glycemic pasta extrudates using cold extrusion technology. Lastly, systematic and complete characterizations for the pasta product with low glycemic index such as cooking time, glycemic index, swelling index, textural and colour properties have not been addressed so far. Considering the lacunae in the available literature, this study targets optimization and characterization of low glycemic index pasta product with buckwheat and chickpea flours using cold extrusion technology. With varied concentrations of buckwheat (50-50%) and chickpea (0-50%) flours, a trial and error based approach with six formulations has been adopted to characterize cooking time, water uptake ratio, solid gruel loss, volume expansion, swelling index, textural and colour sensory parameters of the developed pasta product. Such investigation provides a guideline for the development of cold extruded pasta product. Further, this addresses a low glycemic index pasta product with optimum characteristics which is promising for the consumers specifically for glycemic intolerance individuals.

MATERIAL AND METHODS

Raw materials and sample preparation

Buckwheat was procured from KVK, Gurez of SKUAST-Kashmir (34.08 °N and 74.79 °E)and Chickpea was procured from KVK Samba of SKUAST-Jammu. (32.72 °N and 74.85°E) The samples were carried to the laboratory in airtight polyethylene bags to avoid any external contamination. Buckwheat and chickpea grains were initially washed and dried using sun drying for 5 days with an exposure time of 7-8 hours per day in the month of May. These were then sorted to remove the foreign particles. The dried and cleaned samples were then ground into flour in a mill that passes through 200 µ sieve. The flour obtained was kept in an airtight container until further use.

Pasta Preparation

The pasta was prepared with varied buckwheat and chickpea(G-1581) flours using a cold extruder(Pasta and Noodle Maker, Model 16009 Make, Kent). Trial and error approach has been adopted with six (06) formulations including a control formulation with buckwheat and chickpea varied from 100-50% and 0-50% respectively to optimize and characterize the pasta formulations. On the other hand, water and salt concentration were kept constant at 40% and 1.5%, respectively for all the combinations.

Formulation of different blends for the development of cold pasta extrudates.

Different types of pasta with varied levels of buckwheat (50-100%) and chickpea (0-50%) were prepared using a cold extruder (Pasta and Noodle Maker, Model 16009 Make, Kent). Lukewarm water was added gradually and continuous scrapping was done to avoid surface fouling. It was allowed to mix well and the dough was formed which took 10 minutes automatically in the extruder. After this, the extruder was switched on to prepare pasta with desired shape provided by the die attached to it. The collected pasta was then dried using a tray drier at 40°C until its moisture reached about 5-6%. After this, the extrudates were allowed to cool at room temperature followed by packaging and storage in ziplock bags for further use. The above-mentioned combinations of samples were evaluated for cooking quality parameters such as cooking time, water uptake ratio, gruel solid loss, volume expansion and swelling index, texture profile analysis, and sensory quality attributes. Further, the formulation was optimized to minimize cooking time and gruel solid loss and maximize volume expansion, water uptake ratio, and swelling index.

Analysis

Cooking time

Cooking time was determined usingprocedure mentioned in American Association of Cereal Chemists [12]. Cooking time was measured based on disappearance of the opaque centreof samples during cooking in water.Briefly, 5 g pasta sample was cooked in a beaker containing 75 ml of distilled water. Pasta extrudates were pressed between two plates after every 30 seconds. The maximum cooking time of pasta extrudates was recorded when the white bubble reaction of cooked pasta disappeared.

Water uptake ratio

The water uptake ratio (WUR) was determined as the ratio of the weight of cooked pasta to the weight of pasta before cooking using the equation as follows [12] :

$$\text{Water uptake ratio (\%)} = \frac{\text{weight of cooked pasta} - \text{weight of raw pasta}}{\text{weight of raw pasta}} x\ 100$$ (1)

Gruel solid loss (%)

Gruel solid loss of cooked pasta extrudates was determined by measuring the amount of solid substance lost to the cooking water [12]. Approximately, 10 g sample of pasta extrudates was added with 300 ml boiling water. After cooking, cooking water was collected in an aluminium dish and placed in an oven at 105°C for complete removal of water. The residue was weighed and percentage gruel solid loss was calculated using the following equation:

$$\text{Solid Gruel loss (\%)} = \frac{\text{Dried residue in cooking water}}{\text{weight of pasta before coking}} x\ 100$$ (2)

Swelling index

The swelling index (SI) was expressed as the weight of cooked pasta and calculated using the equation as follows (Cleary and Brennan, 2006):

$$\text{Swelling Index} = \frac{\text{weight of cooked pasta} - \text{weight of pasta after drying}}{\text{weight of pasta}} x\ 100$$ (3)

Volume Expansion Ratio:

The volume expansion ratio was calculated using the methodology mentioned in previous literature(Fan et., 1996). Therefore, volume expansion ration has been determined using the following expression:

$$\text{Expansion ratio} = \frac{D}{d}$$ (4)

where *D* and *d*refers to the diameter of extrudate and die in mm respectively.

Texture measurement:

By break-down method using a texture analyzer (TA-XT2, Stable Micro System Ltd., Surrey, UK). Equipped with a 500 Kg load cell has been used to assess the mechanical property of pasta extrudates. 1 mm/sec Pre-testvelocity, 3.00 millimetre per second test velocity and 10.00 millimetre per second post test were maintained. The compression produced a curve with distance force. Initial maximum value was recorded as this value indicated the first extrudate rupture at one time and this force value was calculated as a hardness measurement in terms of hardness, adhesiveness, springiness and chewiness has been investigated using Texture profile analyzers. The results of texture analysis varies with the temperature, so every pasta formulation was cooked afresh prior to each test and then stored in a Ziploc bag for analysis.

Colour measurement:

The colour was measured using Hunter's lab colour analyser (Hunter Lab Color Flex Reston VA, USA). Standard white and black ceramic tiles were used to calibrate the equipment. Thereby, the associated colour parameters such as L^*, a^*, and b^*have been evaluated for all the pasta formulations.

Sensory evaluation

A sample of cooked pasta extrudates prepared using various formulations was evaluated with an experienced and pretrained panel of 10 judges of age group between 21-55 years including faculty members, research scholars and students. The panel has been asked to evaluate the pasta extrudates for the parameters such as appearance, color, texture, taste, and overall acceptability). For such case, 9-point hedonic scale with extreme values i.e., 1 and 9 indicating dislike and like extremely respectively.

RESULTS AND DISCUSSION

Cooking time

Table 1depicts the variation of cooking time for various pasta formulations. The cooking time marginally variedfor various pasta formulations with varied concentrations of buckwheat and chickpea flour. The cooking time varied from 3.19- 4.28 min for the variation of buckwheat and chickpea flour from 50-100 % and 0-50 % respectively. The minimum cooking time value was obtained forT_6(buckwheat: chickpea, 50: 50). On the other hand,the maximum cooking time value was found in case of control formulation (100:0buckwheat: chickpea). Similar results have been reported for chickpea flour and protein isolate enriched pasta [13]. The higher cooking time for formulation T_6 is due to enhancement of protein content which resulted from increased chickpea flour content of the formulation. This trend is also in agreement with available literature [14] .On the other hand, for the control and intermediate formulations, cooking time has been found to be lower compared to T_6. This is due to higher water diffusivity through the pasta matrix in the absence or lesser extend of protein-starch interaction [14].

Table 1: Cooking Time

Sample	Cooking time (mts)
T_1	4.28 ±0.018[f]
T_2	4.10 ±0.015[e]
T_3	4.0 ± 0.03[d]
T_4	3.85 ± 0.01[c]
T_5	3.71 ± 0.03[b]
T_6	3.19 ± 0.09[a]
C.D (P≤0.05)	0.04

Water Uptake Ratio

Water uptake ratio is the weight gained by the product when cooked which depends on the nature of all the ingredients of the product. **Table 2**reveals variation of water uptake ratio (WUR) for various pasta formulations. The variable enhanced from 2.00 to 2.80 %. The enhancement of the value is due to higher protein content contributed by chickpea powder. Also, similar results have been reported for soy bean incorporated noodles .Higher protein content resulted in higher water diffusivity of the pasta sample. The increase in water uptake ratio is a good sign in terms of better quality of pasta products and such samples were found to absorb at least twice their weight during cooking [15]. The minimum and maximum values i.e. 2.00 and 4.23 were achieved forT_1 (control)and T_5 (buckwheat: chickpea60:40) formulations respectively.

Table 2 : Water uptake ratio

Sample	Water uptake ratio
T_1	2.00 ± 0.015[a]
T_2	2.80±0.057[b]
T_3	3.23±0.092[c]
T_4	4.03±0.04[d]
T_5	4.23±0.14[e]
T_6	4.21±0.10[e]
C.D (P≤0.05)	0.01

Gruel Solid Loss

Gruel solid loss measures the total amount of solids lost in water during the cooking of pasta product. Good quality pasta should have clear water after cooking.

Table 3 presents the variation of gruel solid loss for the formulations with varied buckwheat and chickpea. The gruel solid loss was found to be highest in case of control formulation with 0% chickpea flour. However, it gets reduced significantly with the enhancement of chickpea flour from 0 to 50 %. Alternatively, the variable possessed a reducing trend with the reduction of buckwheat flour from 80-70%. The corresponding reduction of the variable was8.55-7.38%. This is within the recommended value (≤ 9%) of gruel solid loss [12]. The minimum and maximum values of gruel solid loss were 3.73 and 8.55 %respectively. The corresponding formulations referred to T_1 and T_6 respectively.[16] reported that less values of solid gruel loss reflects the improved quality of cooked pasta which should always exist within 9%.Enhancement of gruel solid loss is attributed to the formation of a physical network due to higher protein content contributed by chickpea flour and thus, minimizes the gruel solid loss. The reason fits well with our results of decreasing the solid gruel loss with an increase in chickpea flour levels.

Table 3: Gruel solid loss

Sample	Gruel solid loss (%)
T_1	8.55±0.15[e]
T_2	7.38±0.19[d]
T_3	5.98±0.16[c]
T_4	5.20±0.21[b]
T_5	3.74±0.09[a]
T_6	3.73±0.08[a]
C.D (P≤0.05)	0.09

Volume Expansion

Table 4 presents the variation of volume expansion for various formulations of pasta product with varied buckwheat and chickpea flours. The variable enhanced with increase in chickpea flour in the formulation. Contrary, the value enhanced with reduction of buckwheat flour in the pasta formulation. The volume expansion of pasta formulation enhanced marginally from 0.90-1.11% for the variation of chickpea and buckwheat flours from 0-50% and 100-50% respectively. Highest and lowest values were achieved for T_5 (1.11%) and T_1 (0.90%) formulations respectively. Similar results have been reported for plant protein-incorporated pasta [17]. The enhancement of volume expansion with chickpea concentration is due to higher protein content with higher hydration capacity leading to expansion of the sample during cooking [18].

Table 4 Volume expansion

Sample	**Volume expansion**
T_1	0.90 ± 0.05^a
T_2	0.96 ± 0.03^b
T_3	1.06 ± 0.06^c
T_4	1.07 ± 0.07^c
T_5	1.11 ± 0.01^c
T_6	1.06 ± 0.05^c
C.D (P≤0.05)	0.03

Swelling Index

Swelling index determines the quantity of water absorbed during cooking process for the gelatinization and hydration of starch and proteins present in the pasta product. Also, it defines the cooking qualities of pasta. Table 4 affirmed increasing trend of swelling index with enhancement and reduction of chickpea and buckwheat flours. The trend was T1 < T2 < T3 < T4 < T5 < T6. The minimum and maximum values obtained were18.48 and 22.67 respectively. Corresponding formulations refers to T_1 and T_5 respectively. Similar relationship between swelling index with chickpea flour level was reported for chickpea flour and protein isolate incorporated pasta [13].This is attributed to enhanced water absorption capacity of chickpea flour[13].

Table 5: Swelling index

Sample	**Swelling index**
T_1	18.48 ± 0.13^a
T_2	20.16 ± 0.04^b
T_3	21.60 ± 0.25^c
T_4	22.54 ± 0.06^d
T_5	22.67 ± 0.07^e
T_6	22.70 ± 0.22^e
C.D (P≤0.05)	0.15

Texture profile analysis:

Table 6,7,8 and 9 summarizes the texture profile analysis (TPA)of buckwheat and chickpea flour-based cold extrudates in terms of hardness, adhesiveness, springiness, and chewiness. All TPA parameters enhanced significantly with enhancement of chickpea flour in the pasta formulation. Such enhancement of textural parameters can be attributed to strengthening of gluten-gluten network due to higher protein content of the sample[19].

Among various parameters, hardness enhanced from 6.22 to 14.56 with corresponding lowest and highest values referred to T_1 and T_6 formulations respectively. Also, similar trend has been presented for buckwheat based unroasted extrudates[11]. Similarly, adhesiveness varied from 0.71 to 0.79mm for a variation of chickpea from 0-50%. Corresponding highest 0.79 and lowest 0.71values were achieved for T_6 and T_1 respectively. On the other hand, variation of springiness and chewiness were 0.84-10.40 and14.60 -17.44respectively for chickpea and buckwheat varied from 0-50% and 100-50% respectively. This affirmed better bonding of the pasta constituents holding them together during cooking with enhanced chickpea flour in the formulation. The minimum 0.84and maximum 10.40 values of springiness have been obtained for T_1 and T_6respectively. On the other hand, the corresponding formulations were T_1 and $T_6$for chewiness. Such increasing trends with enhancement of chickpea concentration can be related higher cooking loss of the pasta sample [20].

Table 6: Hardness

Sample	Hardness
T_1	6.22±0.09^a
T_2	7.21±0.18^b
T_3	7.48±0.24^c
T_4	9.38±0.22^d
T_5	12.18±0.10^e
T_6	14.56±0.13^f
C.D (P≤0.05)	0.538

Table 7: Adhesiveness

Sample	Adhesiveness
T_1	0.71±0.04^a
T_2	0.72±0.03^a
T_3	0.73±0.03^a
T_4	0.75±0.03^b
T_5	0.78±0.05^c
T_6	0.79±0.06^c
C.D (P≤0.05)	N/A

Table 8: Springiness

Sample	Springiness
T_1	0.84±0.10^a
T_2	0.87±0.08^a
T_3	0.95±0.09^b
T_4	0.98±0.03^b
T_5	1.01±0.05^c
T_6	1.04±0.01^c
C.D (P≤0.05)	N/A

Table 9 : Chewiness

Sample	Chewiness
T_1	14.60±0.19^a
T_2	15.06±0.20^b
T_3	15.85±0.04^c
T_4	15.95±0.16^d
T_5	16.15±0.13^e
T_6	17.44±0.22^f
C.D (P≤0.05)	0.537

Colour profile

Table 10 depicts the colour values in terms of lightness (L^*), redness (a^*), and yellowness (b^*) obtained for various pasta formulations. L^* values reduced with enhancement of chickpea flour. The value varied from 70.06-64.41forT_1 and T_6. The reduction of the variable is in agreement with legume incorporated pasta products [21]. Such reduction is due to higher ash content of legume flour present in the pasta products .

Further, the results indicated a significant enhancement of a^*value (5.13-7.28) with chickpea flour for pasta formulation. Pasta (T_5) with buckwheat: chickpea ratio of 50:50 was found to possess highest value of a^*. Similar results have been reported for faba bean flour incorporated pasta wherein a significant increase in redness(a^*) value was observed. On the other hand, b^*value reduced from 35.20-30.35 for chickpea and buckwheat flours varied from 0-50% and 100-50% respectively. Control pasta was found to be more yellow than T_5 (buckwheat: 60% and chickpea: 40%). The results corroborate well with findings reported for legume flour incorporated pasta product. Reduction of b^*value is attributed to the leaching out of colour pigments such as carotene and xanthophylls during cooking [21].

Table 10: Color

Sample	(L*)	(a*)	(b*)
T_1	70.060±0.12[f]	5.133±0.11[a]	35.203±0.18[d]
T_2	68.230±0.17[e]	5.620±0.07[b]	34.937±0.30[d]
T_3	64.110±0.26[b]	6.253±0.20[c]	34.850±0.08[d]
T_4	64.967±0.32[d]	6.940±0.04[d]	33.633±0.07[c]
T_5	63.320±0.23[a]	7.283±0.20[e]	31.270±0.95[b]
T_6	64.413±0.28[c]	7.280±0.18[e]	30.353±0.03[a]
C.D ($P\leq0.05$)	0.538	0.469	**1.305**

Sensory Evaluation

Table 11 summarizes the variation of overall acceptability for various pasta formulations with varied buckwheat and chickpea flours. Overall acceptability value enhanced significantly ($p<0.05$) from 3.10 - 7.86for T_1-T_5followed a marginal reduction of value from 7.86 to 6.49 for T_5-T_6. The maximum overall acceptability (7.86) has been achieved for $T_5$with buckwheat to chickpea ratio of 60:40. This is comparable with optimum foxtail millet extruded snackswith 70 % millet and 30% pulse flours [22].

Table 11: Overall acceptability

Sample	Overall acceptability
T_1	3.10 ± 0.119[a]
T_2	2.840± 1.236[a]
T_3	4.640 ±0.436[b]
T_4	5.467 ± 0.094[c]
T_5	7.860 ± 0.111[e]
T_6	6.493 ±0.208[d]
C.D ($P\leq0.05$)	1.705

Values are shown as mean ± standard deviation and values with different superscripts (within column) differ significantly ($p\leq0.05$)

CONCLUSION

With high demand towards value added products across the world, this investigation targeted a low glycemic index pasta formulation using novel sources such as buckwheat and chickpea. This investigation draws few important conclusions as follows: Firstly, incorporation of chickpea flour facilitated to reduce cooking time and gruel solid loss. On the other hand, water uptake ratio, volume expansion, and swelling index of pasta extrudates have been enhanced with enhancement and reduction of chickpea and buckwheat concentrations respectively.Secondly, with low glycemic index, the developed pasta product would enhance the demand among consumers specifically individuals with diabetes. Further, this would be beneficial for human consumption as it contains high nutritional values. Therefore, this would provide a guideline for the food processing sector to target such value-added products having great potential towards commercialization.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors.

AUTHORS' CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Puja Nayyar. The first draft of the manuscript was written by Puja Nayyar and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript**.**

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