Food Technology Research Journal, Vol. 4, issue 1, 49 –63, 2024

FTRJ

Evaluation of Vermicelli with High Nutritional Value

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Original Article

Article information
Received 09/04/2024
Revised 12/05/2024
Accepted 18/05/2024
Published 22/05/2024
Available online 01/06/2024

Keywords:
Chickpea – germination - pumpkin - vermicelli

ABSTRACT

This research aimed to utilize whole pumpkin (without seeds) and germinated chickpeas to create dry vermicelli with enhanced nutritional value. The study evaluated the chemical composition, minerals, antioxidants, total phenols, and total flavonoids in whole pumpkin powder, whole germinated chickpea flour, wheat flour (72% extraction), and the resulting vermicelli. Additionally, various aspects such as cooking quality, color, texture profile, and sensory evaluation of the vermicelli were investigated. Germinated chickpea flour had significantly higher protein, fat and fiber content (24.38, 7.6 and 5.4%, respectively) compared to other ingredients. Whole pumpkin powder was higher in ash (5.68%), radical scavenging activity (61.69%), total phenols (9.39 mg gallic acid/g sample), and total flavonoids (2.24 mg quercetin/g sample). Substituting 15% of the wheat flour with germinated chickpea flour increased the protein content of the vermicelli. Meanwhile, adding whole pumpkin powder led to an increase in fiber and ash content. Furthermore, a significant increase in mineral content was observed. Vermicelli containing 20% whole pumpkin powder displayed the highest beta-carotene content. Substituting wheat flour with germinated chickpea flour and whole pumpkin powder improved cooking quality and resulted in a darker yellow to brown color of the vermicelli. When served with milk, 100g of this vermicelli increased daily nutrient intake by up to 60.96% for protein, with iron and zinc content doubling, and beta-carotene reaching 30.1. The study successfully produced vermicelli by incorporating up to 15% whole pumpkin powder and 15% germinated chickpea flour.

1. Introduction

Vermicelli is a traditional product made from firm dough that is formed, extruded, and sun-dried using whole or refined wheat flour. The protein quality is still low in wheat flour because it lacks lysine, one of the necessary amino acids. Wheat refining further lowers the nutritional quality. Value addition of vermicelli is therefore crucial to improve its nutrient content while preserving its delicate texture. Utilizing additives like germinated chickpea flour, rich in protein and lysine, can achieve this goal (Mogra and Midha 2013). Furthermore, value-added, convenient and processed food can be a solution to address issues related to supplementary feeding and undernutrition. Functional foods, beyond simply providing essential nutrients, can also play a crucial role in protecting against various disorders while supporting a healthy gut microbiota and overall well-being. A balanced gut microbiota is essential for defending against gastrointestinal disorders like infections and inflammatory bowel syndromes (Shirsath and Zawar, 2024).

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Studies have also shown that substituting wheat with chickpea flour in pasta production delivers more nutrition at a lower environmental cost (Saget et al., 2020). Chickpea (*Cicer arietinum L.)* a legume commonly cultivated in temperate and subtropical regions, hold the title of the second most produced pulse crop globally (FAOSTAT, 2021). According to data from the Bulletin of Agricultural Statistics, Egypt produced 3176 tonnes of pumpkin and 3506 tonnes of chickpeas overall in 2019. Research has revealed significant benefits to germinating chickpeas, including the elimination of antinutrients, increased antioxidant activity, improved nutrient bioavailability, and an overall enhancement of the seeds' nutritional and medicinal values. Studies demonstrably shown significant improvements in the nutritional composition of germinated chickpeas. Pumpkin *(Cucurbita Moschata D.*), a type of cucurbita belong to Cucurbitaceae family, is a widely cultivated crop globally. They are valued for their rich nutrient profile, including carotenoids, water-soluble vitamins, phenolics, flavonoids, polysaccharides, mineral salts, and essential vitamins (Balaswamy et al., 2022). Research has revealed that pumpkin polysaccharides have antioxidant properties, helping to combat free radicals in the body (Chen and Huang, 2019). Furthermore, the peel, flesh, and seeds of pumpkins are rich sources of total phenolic, total flavonoid, total carotenoid, and mineral contents (Hussain et al., 2021). Pumpkins are highly valued for their abundance of essential vitamins and minerals, making them a popular choice for consumption as part of a healthy diet. They are recognized for their potential to help combat the underlying factors contributing to the COVID-19 pandemic (Perez-Alvarez et al., 2020).

This study aimed to enhance the nutritional value of vermicelli by incorporating whole pumpkin powder and germinated chickpea flour. Pumpkin powder is well-known for its richness in antioxidants and beta -carotene, while germinated chickpea flour boasts a higher protein and essential amino acid content. We investigated the effects of varying concentrations of whole pumpkin powder, in combination with a constant 15% germinated chickpea flour, on the quality characteristics of the resulting vermicelli.

2. Materials and Methods

Materials

Chickpea seeds (*Cicer arietinum L.*) and whole pumpkin (*Cucurbita Moschata D.*) were purchased from the local market. The wheat flour (72% extraction), was obtained from South Cairo Mills Company, Giza, Egypt. All chemicals used in the study were procured from El-Gomhoria Company, Egypt.pen_spark

Preparation of raw materials

The whole pumpkins were cleaned (seeds were excluded), and cut into small 2 mm thick pieces. To prevent browning and maintain a bright color in the final flour, the pumpkin pieces were soaked in a 0.25% sodium metabisulfite ($Na_2S_2O_5$) solution for 20 minutes. After soaking slices were dried in the oven at 50°C for 12 hours (Prabasini et al., 2013). Germination of whole chickpea seeds was carried out according to the method of (Marero et al., 1988). Once dried, both the pumpkin and germinated chickpeas were milled into a fine powder using a 60-mesh sieve (Aziah and Komathi, 2009). This resulted in a fine yellow pumpkin powder and chickpea flour.

Initial Experiment Design

Vermicelli formulations were prepared by substituting wheat flour with germinated chickpea flour at various levels: 5%, 10%, 15%, and 20%.

Based on the evaluation of natural characteristics (not mentioned what these were), the 15% chickpea flour substitution level was chosen for further experimentation. To enhance protein and amino acid content, this 15% germinated chickpea flour level was kept constant in subsequent formulations. In these following formulations, wheat flour was replaced with varying levels of whole pumpkin powder: 5%, 10%, 15%, and 20%.

Vermicelli Preparation

Different vermicelli formulations were created by mixing commercial wheat flour with 15% wholegerminated chickpea flour and varying proportions (5%, 10%, 15%, and 20% w/w) of whole pumpkin powder. The mixture was processed into vermicelli using a pasta-fast machine (Imperia Trading S.r.I. 10098 RIVOLI (TO)-C.so Susa, 242). All vermicelli samples, including a control group made with only wheat flour (no additives), were dried at 50°C for 24 hours.

Proximate Composition

Protein, fat, fiber and ash were determined following the (AOAC, 2019) methods**.** Total carbohydrates content was calculated by difference.

Determination of Mineral Contents

Mineral contents including calcium (Ca), iron (Fe), zinc (Zn) and potassium (K) were analysed using an atomic absorption spectrophotometer (Agilent Technologies [PerkinElmer], Model 4210 MP-AES) according to the (AOAC 2019) method.

Determination of beta –carotene

Beta-carotene content in both the raw materials and produced vermicelli was determined following the method described by (Okonkwo 2009). Carotene and measuring its absorbance at 450 nm using a spectrophotometer. The beta-carotene concentration (mg/g) in the sample is then calculated using the following formula:

$$\beta - carotene \left(\frac{mg}{g}\right) = \frac{A\ volume\ (ml) \times 10^4}{A^{10}\ \%\ (1cm) \times sample\ weight\ (g)}$$

Where: A = Absorbance, A^{10} % 1cm = 2592 to beta-carotene 10 Volume = 25 ml

Determination of Radical Scavenging Activity

Based on the scavenging effect on the stable DPPH radical activity, the radical scavenging activity (RSA) of the examined samples were evaluated. This method following (Braca et al., 2002), monitors the reduction of DPPH solution in alcohol caused by hydrogen-donating antioxidants. These antioxidants exhibit a strong absorption band at 517 nm, resulting in a deep violet color. The percentage inhibition of DPPH free radical is calculated using a specific equation.

$$\text{Inhibition\%} = (Ac - As / Ac \times 100)$$

Where, Ac: is the absorbance of the control and As: is the absorbance of the sample

Determination of Total Phenolic

Total phenolic content was determined according to the method described by (Cosmulescu and Trandafir 2012). The absorbance of the sample was measured at 765 nm using a spectrophotometer. The results were then compared to gallic acid Standard curve and expressed as milligrams of gallic acid equivalents per gram of sample (mg GAE/g).

Determination of Total Flavonoids

The total flavonoids content was assessed using the aluminum nitrate colorimetric method described by (Cosmulescu et al., 2015). Absorbance readings were measured at 510 nm using a blank for reference, he results were then expressed as milligrams of quercetin equivalents per gram of sample (mg QE/g) based on a quercetin standard curve.

Cooking Quality of Vermicelli

The cooking quality was analyzed by measuring volume increase (%), cooking loss (%) and weight gain were performed in triplicates by the following methods: Samples of vermicelli (10g) were cooked in 250 ml of boiling water for ten minutes, the cooked vermicelli were then drained and weighed immediately. The cooking water was retained and boiled to evaporate most of the water and then dried in an oven at 105˚C until constant weight. The volume increase (%), weight gain and cooking loss of vermicelli were calculated according to the method described by (Gelencsér et al., 2008).

$$Volume\ increasing\ \% = \left[\frac{Volume\ of\ cooked\ vermicelli - \text{Volume of uncooked vermicelli}}{Volume\ of\ uncooked\ vericelli}\right] \times 100$$

$$Weight\ gain\ \% = \left[\frac{weight\ of\ cooked\ vermicelli - 10}{10}\right] \times 100$$

$$Cooking\ loss\ \% = \left[\frac{weight\ of\ dried\ residue\ in\ cooking\ water}{10}\right] \times 100$$

Color Measurement

The color of vermicelli samples was measured using a hand-held Chromameter (model CR-400, KonicaMinolta, Japan). The results were expressed in terms of: L (lightness), a (redness-greenness), and b (yellowness-blueness). The total color difference between uncooked control and cooked vermicelli samples was calculated according to the following equation: $\Delta E= [(\Delta L)^2+ (\Delta a)^2+ (\Delta b)^2]1/2$. All measurements were performed and the reported values represent the average. The detailed procedure is outlined in (Francis 1983).

Texture Profile Analysis

The textural properties of uncooked (dry) vermicelli were evaluated using a Texture Analyzer (Brookfield Engineering Lab. Inc., Middleboro, MA, USA). The analysis focused on hardness, cohesiveness, springiness, gumminess, and chewiness. Three pieces of uncooked vermicelli were positioned perpendicularly to the probe, ensuring they touched along their entire length. The samples were then compressed twice at a speed of 2.0 mm/s to a compression ratio of 70%, following the method outlined in (AACC 2010). All measurements were performed in triplicate, and the reported values represent the average.

Sensory Evaluation

50 grams of processed vermicelli were fried in 20 grams of butter, hot milk (150 ml), sweetened with twenty grams of sugar, was then added. Milk was added to increase the essential amino acids and calcium content of the meal. The meal was served hot for evaluation. Ten semi-trained panelists evaluated the vermicelli with milk and sugar. They assessed the overall acceptability based on several sensory attributes: color, taste, flavor, texture, and overall impression (Bashir et al., 2012).

Determination of Amino Acids

The amino acid profile of the vermicelli was determined using a High-Performance Amino Acid Analyzer following the method outlined in (AOAC 2019). Calculating the daily requirement in amino acids, protein and some minerals for children from 4 to 8 years according to (FAO/WHO 2007).

Statistical Analysis

Analysis of variance (ANOVA) was conducted using the statistical software SPSS Version 20 to assess the significance of differences between groups (Steel et al., 1996). If the ANOVA indicated statistically significant differences ($p \leq 0.05$), Duncan's multiple range test was employed to identify which specific groups differed from each other.

3. Result and Discussion

Nutritional qualities of raw materials and uncooked vermicelli

The data in Table 1. shows the proximate chemical composition of the raw materials and uncooked vermicelli. Germinated chickpea flour is significantly higher in protein, fat and fiber (24.38, 7.6 and 5.4%, respectively) compared to other ingredients. Whole pumpkin powder, on the other hand, has the highest ash content (5.68%) are consistent with findings by (Tezcan et al., 2023) who observed a 14.2% increase in crude protein content and a 0.45% increase in carbohydrate content following the germination process. These findings highlights the potential of germination as a valuable method to enhance the nutritional value of legumes, thereby making them more advantageous and suitable for consumption. Furthermore, the findings align with the research of (Kaur and Prasad 2021), which emphasizes the high protein content of legumes and highlights chickpeas as an affordable protein source for individuals from economically disadvantaged backgrounds, including the low in-come families, and vegetarians. Table 1. also demonstrates that adding 15% germinated chickpea flour to make vermicelli led to a significant increase in protein, fat, fiber and ash compared to the control sample made with 72% extraction wheat flour. These results agree with (El-Sohaimy et al., 2020). The addition whole pumpkin powder further increased in fiber and ash. These findings are in line with the work by (Nanthachai et al., 2020).

Table 1. Chemical composition of raw materials and uncooked vermicelli (on dry weight basis)

Item	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	*Total Carbohydrate (%)	Beta carotene (mg/g)
Raw material						
Wheat flour	$10.50^{b}\pm0.08$	$0.75^{b}\pm0.03$	$0.75^{c}\pm0.03$	$0.58^{c}\pm0.13$	$87.42^{a}\pm0.15$	ND
Germinated chickpea flour	$24.38^{a}\pm0.11$	$7.60^{a}\pm0.06$	$5.40^{a}\pm0.07$	$2.52^{b}\pm0.05$	$60.37^{c}\pm0.12$	ND
Whole pumpkin powder	$7.44^{c}\pm0.15$	$0.64^{c}\pm0.10$	$4.83^{b}\pm0.05$	$5.68^{a}\pm0.08$	$81.41^{b}\pm0.07$	14.48 ± 0.13
Uncooked vermicelli						
Control (100% wheat flour72%)	$10.46^{c}\pm0.15$	$0.99^{b}\pm0.11$	$1.93^{f}\pm0.13$	$2.46^{f}\pm0.08$	$84.16^{a}\pm0.12$	ND
85% wheat flour+15% Germinated chickpea flour	$12.48^{a}\pm0.12$	$1.97^{a}\pm0.09$	$3.10^{e}\pm0.11$	$2.60^{e}\pm0.10$	$79.85^{b}\pm0.17$	ND
80% wheat flour+15% germinated chickpea flour +5% whole pumpkin powder	$12.34^{a}\pm0.10$	$1.95^{a}\pm0.15$	$3.22^{d}\pm0.12$	$2.70^{d}\pm0.13$	$79.79^{b}\pm0.11$	$0.73^{d}\pm0.02$
75% wheat flour+15% germinated chickpea flour+10% whole pumpkin powder	$12.17^{ab}\pm0.08$	$1.94^{ab}\pm0.06$	$3.33^{c}\pm0.15$	$2.89^{c}\pm0.10$	$79.67^{b}\pm0.15$	$1.45^{c}\pm0.05$
70% wheat flour+15% germinated chickpea flour +15% whole pumpkin powder	$12.03^{ab}\pm0.14$	$1.93^{ab}\pm0.08$	$3.44^{b}\pm0.06$	$3.02^{b}\pm0.11$	$79.58^{b}\pm0.07$	$2.18^{b}\pm0.11$
65% wheat flour+15% germinated chickpea flour +20% whole pumpkin powder	$11.88^{b}\pm0.11$	$1.91^{ab}\pm0.06$	$3.91^{a}\pm0.09$	$3.14^{a}\pm0.12$	$79.16^{c}\pm0.10$	$2.91^{a}\pm0.04$

Data are presented as mean (n = 3) with standard deviation. Data values of each parameter with different superscript letters are significantly different at $p < 0.05$.* Total carbohydrates was calculated by difference. ND: Not Detected on the same column

Table 2. Mineral content of raw materials and uncooked vermicelli

	Ca	Fe	Zn	K
Raw material (mg/100g)				
Wheat flour	55.00[a]±0.05	0.90[c]±0.10	0.65[b]±0.03	145.30[c]±0.04
Germinated chickpea flour	55.15[a]±0.10	8.80[a] ±0.04	6.05[a]±0.07	1450.7[a]±0.05
Whole pumpkin powder	15.39[b]±0.03	1.71[b]±0.02	0.272[c]±0.04	439.02[b]±0.02
Uncooked vermicelli (mg/100g)				
Control(100% wheat flour72%)	16.43[b] ±0.11	1.19[c] ±0.14	0.73[c] ±0.10	108.40[f] ±0.13
85% wheat flour+15% Germinated chickpea flour	22.33[a] ±0.12	2.34[ab]±0.10	1.52[a] ±0.14	307.68[e] ±0.15
80% wheat flour+15% germinated chickpea flour	22.31[a] ±0.10	2.36[ab]±0.15	1.50[a] ±0.12	325.76[d] ±0.10
75% wheat flour+15% germinated chickpea flour	22.33[a] ±0.13	2.39[ab]±0.13	1.48[ab] ±0.15	342.38[c] ±0.13
70% wheat flour+15% germinated chickpea flour	22.35[a] ±0.11	2.42[a]±0.10	1.46[ab] ±0.13	359.13[b] ±0.12
65% wheat flour+15% germinated chickpea flour +20% whole pumpkin powder	22.37[a] ±0.14	2.44[a]±0.12	1.44[ab] ±0.11	375.01[a] ±0.11

Data are presented as mean (n = 3) with standard deviation. Data values of each parameter with different at the same column are significantly different at $p < 0.05$

Addition of whole pumpkin powder in vermicelli caused an increase in beta carotene. The vermicelli with 20% whole pumpkin powder substitution had the highest beta- carotene content 2.91 mg/g. The beta-carotene content directly correlated with the concentration of whole pumpkin powder used, which agrees with the work of (Balaswamy et al., 2022). However, the beta-carotene content in the produced vermicelli might not be very high, as reported by (Zeb 2012). This is likely due to beta-carotene being susceptible to oxidation and degradation during heat processing.

Building upon the increased nutritional value observed with pumpkin powder addition, Table 2. demonstrates that substituting vermicelli with germinated chickpea flour resulted in a significant increase in the levels of the studied minerals compared to the control. These findings are in contrast to the work by (Abd El-Fatah et al., 2013). Furthermore, adding whole pumpkin powder to the vermicelli with germinated chickpea flour led to a further increase in all the studied minerals. This aligns with the research by (Sello and Mostafa 2017).

The radical scavenging activity, total phenolic compounds as well as total flavonoids in raw materials

Antioxidants play a crucial role in human health by inhibiting and neutralizing free radicals, offering protection against infections and degenerative diseases. The results in Table 3. illustrate the whole pumpkin displayed the highest percentage inhibition (61.69%) on free radical scavenging, followed by germinated chickpea (14.70%). Wheat flour exhibited significantly lower antioxidant activity (11.80%). Table 3. also displays the total phenolic content: wheat flour (0.88 mg GAE/g), germinated chickpea (0.60 mg GAE/g), and whole pumpkin flour (9.39 mg GAE/g). Similarly, whole pumpkin showed significantly higher total flavonoid content (2.24 mg quercetin/g) compared to germinated chickpea (0.10 mg quercetin/g) and wheat flour (0.11 mg quercetin/g). These findings demonstrate the high antioxidant potential and rich phenolic content of pumpkin. They align with the research of (López-Amorós et al., 2006), who observed changes in the quantity and quality of phenolic compounds in legumes during germination, influenced by legume type and germination conditions.

Additionally, (Tarzia et al., 2012) suggested chickpea sprout flour or extract as a potential source of natural antioxidants in functional foods. (Bochnak and Swieca 2020) examined how drying temperature affected the bio-accessible phenolic in pumpkin powder, and they discovered that the findings was 4.32 to 11.35 mg GAE/g sample. Their findings validated our research and showed that pumpkin flesh and peel have higher levels of total phenolic content than wheat flour and germinated chickpea flour. However, (Zilic 2016) mentioned that the wheat grains are a rich source of phenolic compounds with potential health benefits, their nutritional properties require further optimization for full utilization.

Table 3. The radical scavenging activity, total phenolic compounds as well as total flavonoids in wheat flour, germinated chickpea flour and whole pumpkin powder

Sample	The radical scavenging activity %	Total phenolic (mg gallic acid /g sample)	Total flavonoids (mg quercetin /g sample)
Wheat flour	$11.80^{c}\pm0.38$	$0.88^{b}\pm0.53$	$0.11^{b}\pm0.88$
Germinated chickpea flour	$14.70^{b}\pm0.40$	$0.60^{c}\pm0.69$	$0.10^{c}\pm0.48$
Whole pumpkin powder	$61.69^{a}\pm0.11$	$9.39^{a}\pm1.35$	$2.24^{a}\pm1.06$

Data are presented as mean (n = 3) with standard deviation. Any two means with the same subscript not significant at $p \leq 0.05$

Cooking quality of vermicelli

Table 4. summarizes the cooking quality of the vermicelli. Cooked vermicelli exhibited a range of volume increases after 10 minutes, with the control sample (100% wheat flour) expanding to 195.11% and the vermicelli containing 65% wheat flour, 15% germinated chickpea flour, and 20% whole pumpkin powder expanding the most (235.30%). These findings align with research by (Surasani et al., 2019). Substituting wheat flour with whole pumpkin powder further increased cooked vermicelli volume. This can be explained by the high protein content in pumpkin, as reported by (Kaur et al., 2013). Proteins absorb more water than starch during cooking, leading to greater expansion. Interestingly, adding 15% germinated chickpea flour to the vermicelli reduce cooking losses (3.88 %), however increasing the percentage of pumpkin and chickpeas resulted in higher cooking loss compared to control sample (4.64%), These losses ranged from 4.88% to 7.85%. Additionally, the vermicelli prepared with germinated chickpea showed a significantly higher weight gain (181%) compared to the wheat flour control. Notably, substituting 20% wheat flour with whole pumpkin powder resulted in the highest weight gain (235.69%). Interestingly, the highest weight gain was observed in the vermicelli sample with 20% whole pumpkin, which also has a higher protein content compared to wheat flour. This finding appears to contradict the work of (Arora et al., 2018), who associated higher protein content with weaker gluten structure and increased cooking loss.

Cooking loss is defined as the amount of solids that dissolve in water during cooking and may be an indicator of noodle structural integrity during cooking (Li et al., 2015). As a result, the cooking water becomes cloudy and thick (Ajila et al., 2010). These findings align with (Minarovicova et al., 2017) concluded that addition of pumpkin powder (PP) increased cooking loss (CL). The highest cooking loss (CL) observed was 6.6%, which occurred after substituting 10% of wheat flour with pumpkin powder (PP). This increase in CL is likely due to a disruption of the protein-starch matrix and uneven water distribution within the pasta. The competitive hydration tendency of fiber in pumpkin powder may limit starch swelling by restricting water availability.

Table 4. Cooking quality of vermicelli

Item	Volume Increase (%)	Cooking Loss (%)	Weight gain (%)
Control(100% wheat flour72%)	$195.11^{f} \pm 0.14$	$4.64^{e} \pm 0.18$	$181.00^{f} \pm 0.14$
85% wheat flour+15% germinated chickpea flour	$235.30^{e} \pm 0.12$	$3.88^{f} \pm 0.17$	$195.79^{e} \pm 0.16$
80% wheat flour+15% germinated chickpea flour +5% whole pumpkin powder	$239.09^{d} \pm 0.16$	$5.11^{d} \pm 0.13$	$203.62^{d} \pm 0.12$
75% wheat flour+15% germinated chickpea flour +10% whole pumpkin powder	$245.10^{c} \pm 0.15$	$6.82^{c} \pm 0.16$	$211.20^{c} \pm 0.18$
70% wheat flour+15% germinated chickpea flour +15% whole pumpkin powder	$258.46^{b} \pm 0.13$	$7.10^{b} \pm 0.12$	$224.25^{b} \pm 0.15$
65% wheat flour+15% germinated chickpea flour +20% whole pumpkin powder	$267.68^{a} \pm 0.17$	$7.85^{a} \pm 0.14$	$235.69^{a} \pm 0.11$

Data are presented as mean (n = 3) with standard deviation8. Data values of each parameter with different superscript letters are significantly different at $p < 0.05$.

Color attributes of vermicelli

Color properties in Table 5. shows both the raw material samples and the manufactured vermicelli samples, where they were shown color values of vermicelli substituted with 15% germinated chickpeas flour and whole pumpkin powder at 0, 5, 10, 15 and 20% were significantly different ($p \leq 0.05$). Wheat flour vermicelli was light-yellow, whereas, whole pumpkin powder vermicelli was dark-yellow to brown. Compared to the light-yellow control (wheat flour vermicelli), vermicelli containing 15% germinated chickpea flour displayed a noticeable shift in color. These samples exhibited a decrease in lightness (L* value), an increase in redness (a* value), and a decrease in yellowness (b* value) (Table 5). These findings align with research by (Zhao et al., 2005). The observed color changes, particularly the increased darkness and decreased yellowness, can be attributed to the inherent color of the germinated chickpea flour itself (Table 5). (Demir et al., 2010) reported that the increasing mallard reaction risk due to the increasing protein content of chickpea may probably cause the color changes. The addition of whole pumpkin powder at higher levels resulted in decreasing L* values and increasing a* and b* values. ΔE showed a significant increase in the color attribute change compared to the control sample. Pumpkin contains high levels of beta-carotene which has a yellow to red color which are the probable causes of the color changes in both a* and b values. The results agree with work by (Nanthachai et al., 2020).

Texture profile analysis (TPA) of vermicelli

The finding in Table 6. presents the texture profile analysis (TPA) of uncooked vermicelli as measured by the parameters of gumminess, chewiness, cohesiveness, hardness, and springiness. Compared to the control sample (wheat flour vermicelli), a significant increase was observed in all TPA parameters for vermicelli fortified with both germinated chickpea flour and whole pumpkin powder. These findings align with research by (El-Sohaimy et al., 2020). The addition of germinated chickpea flour resulted in a significant increase in hardness (23.50±0.03) compared to the control sample (18.75 ±0.07). (Ogawa and Adachi, 2017) attribute this to the strengthened gluten network in fortified pasta which contributes increased hardness.

Gumminess and chewiness followed a similar pattern, exhibiting rising values with increasing germinated chickpea flour content. (Flores-Silva et al., 2015) explain this trend by relating it to the higher cooking loss values observed in Table 6. (likely due to the disruption of the gluten network by germinated chickpea flour).

Cohesiveness and springiness values recorded significant differences between vermicelli formulations containing germinated chickpea flour and those with whole pumpkin powder, the addition of whole pumpkin powder resulted in a decrease in uncooked vermicelli hardness, with this decrease becoming more pronounced as the pumpkin powder content increased. These results are consistent with the work of (Mirhosseini et al., 2015). Interestingly, (Lee et al., 2002) reported that while gumminess and hardness of cooked noodles varied considerably with pumpkin flour fortification, springiness, cohesiveness, and chewiness remained largely unaffected. This suggests that pumpkin powder may not significantly influence these specific parameters.

Table 5. Color attributes of raw materials and uncooked vermicelli

Item	L	a*	b*	ΔE
Wheat flour 72%	93.82^{a}±0.03	-0.81^{b}±0.11	8.88^{c}±0.07	-
Germinated chickpea flour	88.80^{b}±0.05	-1.44^{c}±0.09	18.96^{b}±0.10	-
Whole pumpkin powder	73.25^{c}±0.09	4.11^{a}±0.07	34.45^{a}±0.05	-
Uncooked vermicelli				
Control(100% wheat flour72%)	68.12^{a}±0.04	3.05^{e}±0.12	30.70^{e}±0.05	-
85% wheat flour+15% germinated chick-pea flour	61.50^{b}± 0.10	4.70^{d}±0.07	29.15^{f} ±0.03	7.00^{e} ±0.08
80% wheat flour+15% germinated chick-pea flour +5% whole pumpkin powder	58.10^{bc} ±0.12	6.25^{c}±0.10	35.00^{d} ±0.07	11.36^{d} ±0.05
75% wheat flour+15% germinated chick-pea flour +10% whole pumpkin powder	57.93^{bc}±0.07	11.43^{b} ±0.03	36.93^{c}±0.04	14.59^{c}±0.11
70% wheat flour+15% germinated chick-pea flour +15% whole pumpkin powder	55.89^{c}±0.05	12.00^{a} ±0.08	50.12^{b}±0.12	24.63^{b}±0.06
65% wheat flour+15% germinated chick-pea flour +20% whole pumpkin powder	55.61^{c}±0.11	12.48^{a} ±0.06	59.07^{a} ±0.05	32.41^{a} ±0.10

Data are presented as mean (n = 3) with standard deviation8. Data values of each parameter with different superscript letters are significantly different at $p < 0.05$.

Table 6. Texture profile analysis (TPA) of substituted uncooked vermicelli

	Hardness	Cohesiveness	Springiness	Gumminess	Chewiness
Control(100% wheat flour72%)	18.75^{d}± 0.07	0.87^{b}± 0.02	0.81^{b}± 0.06	17.13^{d}± 0.04	19.50 ^{c}± 0.03
85% wheat flour+15% Germinated chickpeaflour	23.50^{a}± 0.03	1.15^{a}± 0.06	1.11^{a}± 0.02	21.50^{a}± 0.05	21.73^{a}± 0.04
80% wheat flour+15% germinated chickpea flour +5% whole pump-kin powder	23.32^{a}± 0.06	1.15^{a}± 0.07	1.10^{a}± 0.03	21.39^{a}± 0.07	21.59^{a}± 0.05
75% wheat flour+15% germinated chickpea flour +10% whole pump-kin powder	23.00^{ab}± 0.02	1.14^{a}± 0.02	1.09 ^{a}± 0.05	21.00^{ab}± 0.03	21.43^{ab}± 0.07
70% wheat flour+15% germinated chickpea +15% whole pumpkin-powder	22.50^{b}± 0.05	1.13^{a} ± 0.04	1.09^{a}± 0.04	20.67^{b}± 0.06	21.39^{ab}± 0.02
65% wheat flour+15% germinated chickpea flour +20% whole pump-kin powder	21.75^{c}± 0.08	1.13^{a}± 0.03	1.08^{a}± 0.07	20.00^{c}± 0.02	21.30^{b}± 0.06

Data are presented as mean (n = 3) with standard deviation8. ** Data values of each parameter with different superscript letters are significantly different at $p < 0.05$.

Sensory evaluation of vermicelli

The sensory evaluation scores of the manufactured vermicelli samples are shown in Table 7. There were noticeable and significant differences in the color characteristic between the samples to which pumpkin powder was added and the samples to which only 15% sprouted chickpea flour was added, and the lowest value in color was the control sample (6.57 ±0.04). There were no significant differences in most of the samples in terms of texture, but by increasing the added percentage of pumpkin powder, there was a significant decrease in texture (7.10 ±0.06). Regarding the characteristics of taste, flavor, and overall acceptance, the results showed that there were noticeable significant differences between the samples made from sprouted chickpea flour and pumpkin powder and the control sample, where the control sample made from wheat flour recorded 72% extraction of the lowest values in these characteristics, and the sample to which 20% powder was added the sample with 20% pumpkin powder, compared to the other samples containing pumpkin powder, had lower sensory acceptability, scoring only slightly above the control sample. The results agree with work by (El-Sohaimy et al., 2020) who stated that the high acceptability of pasta fortification with chickpea protein isolate or flour might be due to its high protein content. According to (Gurung et al., 2016), substituting pumpkin paste for 20% of the wheat flour improved the color of the cookies. The results showed that replacing wheat flour with 15% germinated chickpea flour and 15% whole pumpkin powder was sensory acceptable for all tested characteristics. Therefore, the essential and non-essential amino acids for this mixture and control were estimated and compared to the daily needs according to the FAO for children aged 4 to 8 years.

Table 7. Sensory evaluation of cooked vermicelli

Formula	Color (10)	Taste (10)	Flavor (10)	Texture (10)	Overall
Control(100% wheat flour72%)	6.57^{c}±0.04	7.10^{b}±0.06	7.77^{b} ±0.04	8.30^{a}±0.07	7.40^{d}±0.07
85% wheat flour+15% Germinated chickpea flour	7.50^{b}±0.08	8.50^{a}±0.03	8.00^{a} ±0.08	8.10^{a}±0.03	8.19^{b}±0.03
80% wheat flour+15% germinated chickpea flour +5% whole pumpkin powder	8.27^{a}±0.06	8.55^{a}±0.08	8.10^{a} ±0.08	8.00^{a}±0.07	8.25^{b}±0.07
75% wheat flour+15% germinated chickpea flour +10% whole pumpkin powder	8.57^{a}±0.05	8.51^{a}±0.06	8.11^{a} ±0.06	8.12^{a}±0.05	8.42^{b}±0.05
70% wheat flour+15% germinated chickpea flour +15% whole pumpkin powder	8.85^{a}±0.03	8.60^{a}±0.07	8.15^{a}±0.07	8.25^{a}±0.04	9.45^{a}±0.04
65% wheat flour+15% germinated chickpea flour +20% whole pumpkin powder	8.85^{a}±0.07	8.00^{ab}±0.05	8.13^{a} ±0.06	7.10^{b}±0.06	7.85^{c}±0.06

Values are means of 10 replicates ± SD, numbers in the same column, followed by the same letter, are not significantly different at 0.05 level

Amino acids content of vermicelli

The nutritional value of protein depends on the presence and amounts of essential amino acids it contains. The nutritional value of protein would rise if one or more of the required amino acids were present in sufficient proportions. It is clear the Table 8. that the vermicelli sample made from 15% germinated chickpea flour, 15% whole pumpkin powder, and wheat flour 72%extraction increased in its content of total essential amino acids (301.80mg/ g of protein) compared to the control sample made from wheat flour 72% extraction

(253.60 mg/protein). The results agree with (Yegrem 2021) who reported that chickpeas have significant amounts of essential amino acids (EAAs). Also, (Bahramsoltani et al., 2017) reported that a range of amino acids has been detected in pumpkin especially in peel. Table 8. further reveals that adding 15% germinated chickpea flour and 15% whole pumpkin powder not only increased the total essential amino acid content but also significantly boosted the levels of individual EAAs, particularly lysine. This is a significant improvement as wheat flour, the control sample's sole ingredient, is naturally deficient in lysine. The increased lysine content can likely be attributed to chickpeas, which are well-known for being rich in lysine. These findings align with research by (Xiao et al., 2023) who emphasized chickpeas as a valuable legume crop with abundant protein, pen_spark. To assess the practical implications, we calculated the percentage increase in the fortified vermicelli's contribution to meeting the daily essential amino acid requirements of children aged 4-8 years. Compared to the control, the fortified sample increased the fulfillment of daily needs by 6.87, 25.36, 70.35, 18.44, 21, 11.62 and 6.49% in isoleucine, leucine, lysine, and threonine, and valine, respectively.

Table 8. Content of amino acids (mg/g protein) and contribution of the RDA for children (%) in the control and formula

Amino acid (mg/gm protein)	Control (100% wheat flour)	Contribution to *RDA for children (%) (control)	70% wheat flour+15% germinated chickpea flour +15% whole pumpkin powder	Contribution to* RDA for children (%) (formula)	Daily requirement FAO/WHO for children (4-8 years)
Isoleucine	32.5	104.8	34.7	112.0	31
Leucine	54.4	340.0	68.2	426.25	16
Lysine	10.8	22.5	18.4	38.33	48
Methionine	11.5	103.0	13.2	122.0	24 (methionine+ cystine)
Cystine	13.2		16.1		
Phenylalanine	32.9	170.7	43.3	206.6	
Tyrosine	37.1		41.4		41 (phenylalanine + tyrosine)
Threonine	25.8	103.2	28.8	115.2	
Valine	35.4	88.5	37.7	94.25	
Total essential amino acids	253.6		301.8		25
Aspartic acid	88.2		88.9		40
Serine	53.5		61.3		
Glutamic	164.8		221.0		
Proline	10.7		9.4		
Glycine	24.7		16.3		
Alanine	65.9		100.2		
Arginine	71.7		33.1		
Histidine	44.5		98.1		
Total amino acids	777.6		930.1		

* RDA=Recommended daily Allowance. % contribution to RDA of protein and some minerals for the children (4-8 years)

The fortified vermicelli demonstrated a significant increase in its ability to fulfill daily protein requirements. Calculated as a percentage of the Recommended Daily Allowance (RDA) for children aged 4-8 years, protein content rose from 40.46% to 60.96%. In terms of minerals, the addition of chickpea flour and pumpkin powder also yielded positive results. When served with milk, the calcium content of the vermicelli increased from 9.6% to 12.41% of the RDA. Both iron and zinc content doubled compared to the control sample, reaching 20% and 12.25% of the RDA, respectively (previously 6% and 12% RDA). Finally, carotene content saw a substantial increase, jumping from 5.05% to 30.1% of the RDA (Figure 1). These results are in accordance with those reported by (Fan and Li 2005), pumpkin is a good source of important minerals required for good health.

Pumpkin blended with common beans proved a good source of complementary diet rich in iron, zinc and vitamin A for children (Buzigi et al., 2020). As a good source of minerals, pumpkin is an important part of human health, due to presence of calcium and potassium pumpkin is used as a healthy food for mid to aged people as it prevents osteoporosis. (Segev et al., 2010) reported that chickpea could be a potentially functional food in addition to its traditional role of providing dietary proteins and dietary fibers.

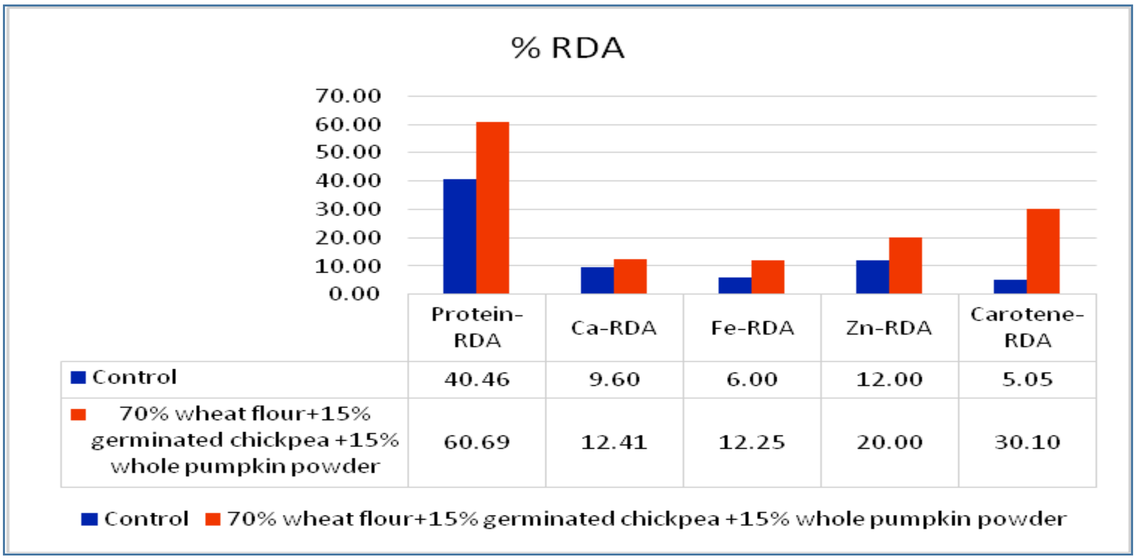

Figure 1. Recommended daily allowances (% RDA) for children aged 4 to 8 derived from 100g of vermicelli

4. Conclusion

This study successfully developed and evaluated vermicelli containing up to 15% germinated chickpea flour and 15% whole pumpkin powder. The resulting vermicelli was sensor ally acceptable and offered a significant nutritional boost. While the substitutions caused measurable changes in quality parameters, these changes remained within satisfactory limits. Our findings highlight the potential of food-based systems approaches to address malnutrition and micronutrient deficiencies. Chickpea flour emerged as a particularly promising ingredient due to several advantages:

- High production volumes and affordability
- Excellent balance of essential amino acids
- High bioavailability
- Low allergenicity

Furthermore, incorporating whole pumpkin powder into the vermicelli formulation presents a valuable alternative for vitamin A supplementation, potentially combating deficiencies in growing children. Our research suggests that up to 15% whole pumpkin powder inclusion yields an acceptable product.

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