***Original Research Article***

**Effect of supplementation of carrot pomace and soaked chickpea flour based developed functional food on nutritional status of children**

##### **Abstract**

Carrot (*Daucus carota L*.) is an important horticultural crop that is prized for both its economic and nutritional value on a global scale. The byproduct of carrot juice extraction, carrot pomace, contains abundance of nutrients primarily beta-carotene and vitamin C range from 9.9-11.6 mg/100g and 13.53-22.95 mg/100g respectively. Raw chickpeas are rich in protein (15–30%) and carbohydrates (60–70%). Processing fresh carrots into dried pomace significantly (p<0.05) increases dietary fiber (29.67-63.67%), ash (6.19-6.73%), calcium (29.67-63.67 mg/100g), iron (2.04-3.67mg/100g), zinc (3.00-3.22mg/100g), and magnesium (10.92-29.33 mg/100g). Soaking of chickpeas increases significantly (p<0.05) total dietary fiber (30.42-32.72%) and moisture (8.84-9.05%). With varying ratios of carrot pomace powder (2%, 4%, 6%) and soaked chickpea (20%, 30%, 40%), cookies and *laddu* were made. *Laddu* and cookies were organoleptically assessed. *Laddu* made with carrot pomace powder (4%) and chickpea flour (30%) was extremely satisfactory following organoleptic examination. Supplemental *laddu* showed significant (p<0.05) improvements in crude protein, fiber, total ash, carbs, energy, minerals, β-carotene, lysine, tryptophan, total dietary fiber, antioxidants, and bioactive components compared to control *laddu*. To study the positive improvement in nutritional status of children, total 30 subjects (3-5 years) were selected from slum areas of, Ludhiana. Selected children were treated as control group for period of one month and experimental group for period of three months. During experimental period significant (p<0.05) improvement was recorded in the daily intake of food, nutrients, anthropometric profile and prevalence of malnutrition of selected children. Significant (p<0.05) improvement was also noted in the serum albumin (3.19 to 4.37 g/dL). Thus, carrot pomace and chickpeas were recommended to supplement in bakery and traditional products to enhance their nutritional value.

**Keywords:** Carrot pomace, malnutrition, environmental concerns, serum albumin.

**Introduction**

The Food and Agricultural Organization (FAO) reports that the global production of carrots and turnips was 40.24 Mt from 1082967 ha in 2020 and around 41.67 Mt from 1096007 ha in 2021 (FAO STAT, hħps://www.fao.org/faostat/en/#data/QCL) [1]. The most widely farmed and eaten vegetable in the world is carrot, which is used in soups and salads. Commercial processing might provide a variety of nutritionally dense products, including concentrate, juice, puree, canned products, dry powder, and other products [2]. Due to the poor yield of carrot juice extraction, up to 50% of the raw material is wasted as carrot pomace, a byproduct [3]. By providing beneficial health effects, the correct use of raw materials would let the manufacturing unit appreciate financial benefits as well as avoid nutrition-related challenges [4].

Carrot pomace has an insoluble fiber-rich component of 56.3 g/100 g of cellulose, pectic polysaccharides, and hemicellulose. It has excellent physico-chemical properties, including the ability to exchange cations, retain large amounts of water and oil, suppress amylase activity, and bind glucose [5]. Dry matter protein content (4-5%), carbohydrate content (8–9%), mineral content (6%), and total dietary fiber content (37–48%) are all present in carrot puree. Pomace fiber lowers blood triglyceride, total cholesterol, and liver cholesterol concentrations while increasing fecal total lipid, cholesterol, and bile acid concentrations [6]. On the other hand, chickpea seeds are an important legume that are high in lipids, proteins, carbohydrates, fiber, and minerals. When creating new varieties, breeders primarily concentrated on the crop's ability to produce and what was needed for disease resistance; they gave the crop's nutritional constitution and content little consideration.

Considering the nutritional and health-related potential of chickpeas and carrot pomace, their use in a variety of food products, including biscuits, muffins, bread, noodles, fiber-rich beverages, extruded snacks, soup mixes, and native traditional foods, can help people stay healthy. Additionally, chickpeas have a number of therapeutic benefits. Several food sources have been added to chickpea flour to create a variety of products. A thirty percent substitution showed that processed chickpea-based foods such cookies, tarts, butter cakes, waffles, egg drops, bars, and buns were acceptable. The purpose of the current research is to develop and supplement carrot pomace powder and chickpea-based supplementary food to children, to improve their nutritional status.

**Materials and methods**

**Procurement of raw materials**

The sample of chickpea variety L-552 was procured from the Department of Plant Breeding and Genetics. The sample of Carrot (PC-161) was procured from Department of Vegetable Science, College of Agriculture, Punjab Agricultural University, Ludhiana. Other required ingredients were procured from the local market.

**Processing of carrot and chickpea**

Fresh carrots (PC-161) were thoroughly washed with water and then gently peeled to get rid of any extraneous particles. Carrots were cut into 2-3 cm slices. The juicer was used to extract the juice, and the raw pomace residue was collected for further processing. Raw carrot pomace was blanched in water at 80± 2ºC for three minutes, cooled right away by being exposed to air, and then dried in a tray dehydrator at 60± 2ºC for five hours. The dehydrated carrot pomace was finely crushed and passed through a 0.150µ particle size filter. After that, the powdered carrot pomace was stored in zip pouches for further chemical processing and analysis.

After being cleaned, the chickpeas (L-552) were allowed to soak in water for 18 hours. Water was replaced at regular intervals. After draining the water, the soaked seeds were dehusked and ground into fine flour before being left in the trays of a tray dehydrator for a whole night at 55°C. Before being used for another process, the flour was stored in an airtight container [7].

**Development and organoleptic evaluation of supplementary food**

Cookies and *laddu* were prepared by using different ratios of carrot pomace (2%, 4%, 6%) and soaked flour (20%, 30%, 40%) and other required ingredients in the Food Laboratory of Department of Food and Nutrition, Punjab Agricultural University, Ludhiana. Ten semi-trained judges used a nine-point Hedonic Rating Scale to assess the organoleptic quality of produced supplemental foods. The judges were given three experimental samples, one of each of the two supplemental foods made with varying amounts of soaked chickpea flour and carrot pomace powder. To prevent bias in the evaluation of prepared supplemental foods, samples were coded. The panelists tested each product and assigned a score based on their evaluations; the average score was then determined. Scoring of the samples of developed supplementary foods was done by panelists for their appearance, flavour, texture, taste, colour and overall acceptability by using nine- point Hedonic Rating Scale [8].

**Nutritional analysis of processed carrot pomace, soaked chickpea flour and highly acceptable product i.e. *laddu***

The highly acceptable product i.e. was *laddu* nutritionally analyzed along with raw carrot powder, carrot pomace powder, raw chickpea flour and soaked chickpea flour for various nutrients such as proximate composition, mineral content (calcium, iron, magnesium and zinc), amino acids (methionine, lysine availability and tryptophan), total antioxidant activity and bioactive compounds (antioxidant activity-DPPH, total phenols and flavonoids), β-carotene, ascorbic acid and dietary fibre.

**Selection of subjects**

A total of 30 children (3-5 years) were selected from slum area of Ludhiana. The research was conducted into two phases: control phase and experimental phase. The selected children were kept without supplementation and treated as control phase for a period of one month and same group of children were supplemented with highly acceptable supplementary food *laddu,* treated as experimental phase for period of 3 months. Further, the effectiveness of supplementation was also studied by assessing the dietary intake, anthropometric and biochemical parameters of children before and after the supplementation period.

**Collection of data**

A questionnaire was designed for the collection of general information, dietary pattern, anthropometric and biochemical profile related information of the subjects. Data related to food intake, by using 24-hour recall method, anthropometric measurements including height, weight, BMI, MUAC, chest and head circumference was also collected. To determine the average daily intake of selected children Diet Cal software was used. The mean daily intake of nutrients was compared with the recommended dietary allowances [9]. Serum albumin and serum retinol was also determined by taking blood samples of the selected children.

**Statistical analysis**

Data analysis was done using SPSS software. For various parameters, mean and standard deviation were computed. Using an independent sample t-test, the effect of processing on carrot pomace and soaked chickpea flours was evaluated. Using an organoleptic evaluation, the Kruskal-Wallis and Mann-Whitney tests were used to determine the optimal formulation. The effect of supplementation on the nutritional status of chosen subjects during the control and experimental periods was assessed using a paired t-test.

**Results and discussion**

**Effect of processing of nutritional composition of carrot pomace and soaked chickpeas**

Raw and processed carrot pomace and raw and soaked chickpea were nutritionally examined for proximate composition, mineral content (calcium, iron, magnesium and zinc), amino acids (methionine, lysine availability and tryptophan), total antioxidant activity and bioactive compounds (antioxidant activity-DPPH, total phenols and flavonoids), β-carotene, ascorbic acid and dietary fibre by using standard methods, the results showed in Table 1. Proximate composition analysis was done per 100g of raw carrot powder and carrot pomace powder on dry weight basis. The nutritional evaluation of carrot powder and carrot pomace revealed that moisture content, crude protein, crude fat, carbohydrate and energy of carrot pomace powder decreased to 7.16, 4.93, 1.52, 61.93 percent and 280.32 Kcal in contrast to carrot powder. Total ash significantly increased to 6.73 percent and crude fibre content increased non-significantly to 17.95 percent in carrot pomace powder. The carrot pomace powder had higher amount of total dietary fibre (63.67%) when compared with carrot powder (29.67%). When the drying temperature increased, the moisture content and ascorbic acid content of carrot pomace decreased. At a temperature of 60 to 75°C, the dried carrot pomace samples moisture content ranged from 9.31 to 7.68 percent [10]. In the case of carrot pomace, moisture content may be implicit as being primarily water, that carrot contains a negligible amount of fats, i.e. 0.2-0.3 g/100 g [11]. Carrot pomace powder was found to have a high ash level of 6.38 percent, indicating a high mineral concentration [12]. The reason why carrot pomace has a higher ash level than carrot powder is because the ash content of carrot pomace would undoubtedly grow once the carrot's juice was extracted. Due to the removal of soluble solids with the juice, pomace powders were discovered to have high fibre and low carbohydrate levels in comparison to whole-vegetable powders [13], [14]. The calcium, iron, zinc and magnesium content of carrot pomace powder was increased significantly to 80.41, 3.67, 3.22 and 29.33 mg/100g and vitamin C and beta-carotene was decreased significantly to 0.76 mg/100g and 1736.85 µg/g in contrast to carrot powder. Carrot pomace contains a significant amount of ash and dietary fiber, which increases the amount of minerals and fiber in food products [15]. Carrot pomace powder was found to have a high ash level of 6.38 percent, indicating a high mineral concentration [11]. Blanching carrots before drying increases their ability to retain β-carotene [16]. But the dried carrots' β-carotene concentration, shreds lost the most β-carotene (43%) over a three-month storage period [17]. The antioxidant activity, total phenols and flavonoids content was decreased significantly to 65.26 percent, 907.82 mg GAE/100g and 636.03 mg QE/100g in carrot pomace powder. Fresh carrot pomace had a total antioxidant activity of 94.67 percent, which was greater than the 80.1 percent that had been previously reported for carrot pomace [18]. The loss of antioxidant activity was similarly greater at higher drying temperatures [19]. The decline may be caused by phenols' sensitivity to thermal treatment. Total phenolic concentration of whole carrot powder after drying is 1828 µg/g GAE, which is significantly lower than the fresh carrot before drying [20].

On the other hand, the proximate analysis of raw and soaked chickpea (Table 1) was showed increase in moisture, crude fibre, and energy to 9.05, 5.73 percent and 356.34 Kcal/100g in soaked chickpea. Significant reduction was seen in protein, fat, total ash and carbohydrate content to 15.06, 4.08, 2.47 and 60.03 percent in soaked chickpea flour as compared to the raw chickpea flour.

The processing of chickpeas leads to decline in crude protein, fat, ash and carbohydrates. The outcomes were consistent with the moisture content increased from 7.83 percent to 8.43 percent and a significant increase in protein by 3 percent and 8 percent after 6 hours asking and 9.28 percent after soaking of 12 hours [21]. The significant reduction was seen in crude fat and total ash 17 to 21 percent and 20 to 34 percent, respectively. Meanwhile, crude fibre of raw and soaked chickpea for 6 and 12 hours was 4.17, 4.88 and 5.36 percent respectively. The reason for decrease in ash content might be diffusion of certain minerals into the water that used for cooking. The significant increase was noted in crude fibre content of raw chickpea due to formation of protein-fibre compounds after soaking [22].

Lysine, methionine and tryptophan content decreased in soaked chickpea flour to 5.05, 1.42 and 1.11 g/100g of protein. The minerals including calcium, iron, zinc and magnesium was significantly decreased in soaked chickpea flour to 170.95, 6.04, 5.05 and 152.40 mg/100g and vitamin C increased to 2.01 from 1.24 mg/100g.

The amino acids include lysine, methionine and tryptophan content of raw chickpea was decreased significantly in soaked chickpea as compared to raw chickpea. The content of lysine, methionine and tryptophan were decreased dramatically when cooked after the soaking period of 6 and 12 hours from 7.51 to 6.89 and 6.10, 1.55 to 1.40 and 1.35 and 0.94 to 0.82 and 0.80 respectively. The reason for the dramatically reduction in the values may be that cooking methods reduced the concentration of lysine, tryptophan, sulphur amino acids and total aromatic amino acids [23].In this study we measured the amounts of calcium, iron, zinc, and magnesium in both raw and processed chickpea powder. After soaking the mineral concentration of calcium, iron, zinc and magnesium reduced significantly. Using of different cooking treatments results into the leaching of minerals into the water, while using the microwave cooking resulted the more retention of all minerals, followed by autoclaving then boiling [22].

Significant reduction was seen in the antioxidant activity from 18.44 to 12.55 percent and total phenols from 109.86 to 84.87 mg GAE/100g in soaked chickpea flour. Total dietary fibre significantly increased in soaked chickpea flour to 32.73 percent from 30.42 percent. Anti-nutritional factors including trypsin inhibitors, saponins and tannins was decreased after the soaking of chickpeas to 10.42 TIU/mg, 0.62 mg/g and 120.52 mg/100g.

Raw chickpeas were shown to have higher antioxidant activity which decreased non-significantly in the soaked chickpeas. Raw chickpeas had a total phenol concentration more than soaked chickpeas. The findings of the study are contradicted as they found that raw, cooked, and germinated seeds all had significantly different total phenol, flavonoid, and tannin contents (p<0.05) [24]. The effect of soaking was studied on the total phenolic content, total flavonoid content and antioxidant activity (FRAP). Soaking of chickpeas at 60°C shows significant decrease (70% to 80%) in TPC, TFC and FRAP, compared to soaking at room temperature (30% to 40%) [25].

Raw chickpeas had significantly (p<0.001) less total dietary fiber than soaked chickpea powder, which includes both soluble and insoluble fiber. The pectin (4.2 to 4.8%) had little to no impact on chickpea soaking and different stages of germination, while hemicellulose (2.7 to 3.1%), cellulose (3.7 to 5.2%), and lignin (2.2 to 2.8%) increased significantly [26].

The decreased in the trypsin inhibitors may be caused due to the cooking treatments which inhibit the activity of the component by coagulation and denaturation. The similar findings showed, that different treatments like germination, pressure cooking and boiling lead to reduction in tannins up to 93 percent, may be due to the heat lability and water-soluble properties of tannins [27].

**Nutritional analysis of highly acceptable *laddu* developed by using carrot pomace and soaked chickpea**

Carrot pomace and soaked chickpea based *laddu* were nutritionally analyzed for proximate composition, amino acids (lysine, methionine, tryptophan), mineral and vitamin content (calcium, iron, zinc, magnesium, vitamin C, beta-carotene), antioxidant activity, total phenols, flavonoids, total dietary fibre and anti-nutritional factors (trypsin inhibitors, saponins, tannins). The results revealed in Table 2, that supplementary *laddu* was had increased amount of moisture (6.51%), protein (5.72%), fat (19.52%), fibre (8.09%), total ash (23.14%) and energy (370.48 Kcal/100g) as compared to control *laddu.*

Supplementing carrot pomace powder to buns boosted their moisture content by a range of 24.68 to 26.89 percent. The decrease in the starch percentage that causes starch gelatinization and expansion is the cause of the buns' increased moisture content [28]. The rice-based noodles using 10 percent chickpea protein isolate had the following moisture, protein, fat, fiber, ash, and carbohydrate contents: 9.2, 19, 0.82, 0.94, 0.67, and 68 percent, respectively. The dilution of chickpea protein in rice-based noodles is responsible for a decrease in the moisture, fat, fiber, ash, and carbohydrate content of the noodles [29]. The dietary fiber of supplemented *laddu* was significantly increased as compared to the control *laddu*. The treatment of wheat bran-2 (6 percent wheat bran incorporated chicken sausage) and dried carrot pomace-2 (6 percent dried carrot pomace incorporated chicken sausage) had significantly higher total and insoluble dietary fiber levels than the control sample [36].

The results showed significant improvement was seen in lysine and tryptophan content to 4.17 and 1.46 g/100g of protein and non-significant improvement was seen in methionine content from 1.07 to 1.71 g/100g of protein. Significant increase was seen in iron, zinc, vitamin C and beta-carotene content to 3.76, 1.84, 0.63 mg/100g and 188.14 µg/100g in supplementary *laddu* in contrast of control. Antioxidant activity, total phenols, flavonoids and total dietary fibre was increased significantly in supplementary *laddu* to 27.10 percent, 20.48 mg GAE/100g, 466.89 mg QE/100g and 23.37 percent as compared of control *laddu*. Significant reduction was shown in the anti-nutritional factors which includes trypsin inhibitors, saponins and tannins to 7.41 TIU/mg, 3.56 mg/g and 203.98 mg/100g in supplementary *laddu.*

Supplemented *laddu* was when, compared with control *laddu,* significant increase was seen in lysine and tryptophan. While, non-significant increase was seen in the methionine. The ability of chickpea to absorb protein is improved by soaking and sprouting. Generally speaking, soaking and sprouting beans may be used to boost nutritional density and bioavailability, making it a suitable technique for producing wholesome food for the population [30].

The results of current study found that control *laddu* has more amount of calcium and magnesium than supplemented *laddu.* While, iron and zinc concentrations were more in supplemented *laddu* than control *laddu.* The process of soaking and sprouting increased the bioavailability of calcium and iron as well as the digestion of protein. In general, chickpea soaking and sprouting may be used to boost nutritional density and bioavailability, making it a useful technique for producing wholesome food for the population [31]. Vitamin C and β-carotene levels were more in supplemented *laddu,* than control one. Replacing wheat flour cookies with carrot pomace powder made in a microwave oven increased the carotenoid content in the cookies significantly (p<0.05), rising from 0 mg/100g to 9.96±0.64 mg/100g in dry sample and 8.20±0.45 mg/100g for cookies made with hot air [32].

In a product prepared for the children, antioxidant activity, total phenols and flavonoids were higher as compared to control *laddu.* In contrast to rice muffins, carrot pomace and mushroom pomace-enriched muffins had increased antioxidant activity, total polyphenol content, and carotenoids concentration [33]. The improvement of DPPH with the addition of carrot pomace and mushroom pomace was also founds in some other studies [34] [35]. The total quantity of dietary fiber, total phenolic content, and total antioxidant capacity were shown to be positively correlated with the amount of apple pomace utilized in muffins.

Anti-nutritional factors were decreased in soaked chickpea. Extrusion and soaking of legumes have been shown to eliminate trypsin and amylase inhibitors, reduce tannins and polyphenols, and boost phosphorus availability (by reducing phytate and phytate phosphorus to total phosphorous percent). When food is cooked, the macro and micronutrient bioavailability is often changed [37]. Phytate and condensed tannin are examples of anti-nutrients that may be reduced and mineral bioavailability increased by soaking and sprouting.

**Efficacy of supplementation on average daily food intake of the selected children**

Supplementation of carrot pomace powder and soaked chickpea flour based supplementary *laddu* and counseling of the children families shows significant increase of average intake of cereals, pulses, other vegetables, fruits and fats from 62.40, 29.07, 37.30, 34.17 and 16.80 g/day during control phase to 66.06, 32.32, 42.09, 49.47 and 18.79 g/day respectively during experimental phase. Whereas, the intake of green leafy vegetables, roots and tubers, milk and milk products and sugars were increased non-significantly to 38.87, 41.25. 215.61 and 18.50 g/day during experimental phase.

Supplementation of carrot pomace powder and soaked chickpea flour based *laddu* results in significant increase in protein, minerals, beta-carotene, dietary fibre and vitamin C, as compared to control *laddu.* Very low consumption of green leafy vegetables by subjects also noted in some other studies, i.e. 11.6 g (1-3 years) and 19.4 g (4-6 years) [40]. Populations with low levels of animal-based food consumption often lack several of these micronutrients. Therefore, by including milk in their children's regular meals, parents may significantly reduce malnutrition [41]. Soya *ladoo*was prepared in an attempt to provide it as a complement to diet. The extra nutrients that are supplying for optional development and desired changes in health status must be provided by supplemental feeding. Each child received 50 g of this soy *ladoo* every day. Cereals and legumes, two important dietary categories, saw considerable shift in the soya *ladoo* supplemented group, whereas fat and oil had a very significant alteration [42]. Children with protein deficiencies develop more slowly and lose weight. The production of intestinal mucosal proteins and the efficient operation of the digestive system both depend on dietary proteins. Protein turnover in the digestive system and intestinal mucosa is very quick. A child who is malnourished due to a protein shortage has poor digestion and absorption of food, which leads to diarrhea, water loss in the stool, and abnormal electrolyte levels. Lack of protein compromises the ability of skeletal muscles to maintain their structural integrity, which may result in atrophy and muscle wasting [39].

**Efficacy of supplementation on mean daily nutrient intake of the selected children**

Supplementation of carrot pomace powder and soaked chickpea flour based supplementary *laddu* and counselling of the children families results inshows (Table 3) significant increase of mean daily nutrient intake of calcium and iron from 308.85 to 311.95 and 4.13 to 4.19 mg/day, respectively during control phase, whereas non-significant increase was seen in the intake of energy, protein, total fat, beta-carotene and retinol from 866.93 to 871.30 Kcal/day, 10.06 to 10.32 g/day, 16.58 to 16.80 g/day, 61.84 to 62.66 µg/day and 101.72 to 102.73 µg/day, respectively during the control phase of period of one month.

**Fig. 1: Efficacy of supplementation on the percent adequacy of Nutrient intake of selected children during Control and Experimental Phase**

On the other hand, during experimental period of three months significant increase was seen in the daily intake of energy, protein, total fat, beta-carotene, calcium and iron from 871.30 to 897.76 Kcal/day, 10.32 to 11.94 g/day, 16.80 to 21.85 g/day, 62.66 to 63.41 µg/day, 311.95 to 320.88 mg/day and 4.19 to 5.47 mg/day respectively. Whereas, non-significant increase was seen in the intake of retinol from 102.73 to 104.89 µg/day during experimental phase. Fig. 1 illustrated the percent adequacy of energy, protein, fat, calcium, iron, retinol and beta-carotene intake among the control and experimental period. Prior to the supplementation, control group had an energy, protein, fat, calcium, iron, retinol and beta-carotene intake 80.97, 80.41, 61.41, 61.77, 68.83, 26.08 and 1.93 percent that increased to 81.38, 82.49, 62.22, 62.39, 69.83 26.34 and 1.96 percent, respectively. While, during the experimental phase an energy intake was 81.38, 82.49, 62.22, 62.39, 69.83 26.34 and 1.96 percent that increased to 81.38, 95.44, 80.92, 82.28, 91.17, 26.89 and 2 percent, respectively after supplementation for period of three months.

**Efficacy of supplementation on anthropometric profile and z-score of the selected children**

The anthropometric profile of selected children includes the parameters of height, weight, BMI, MUAC, head circumference, chest circumference which increased significantly during the experimental period from 90.88 to 91.33 cm, 11.62 to 12.89 kg, 14.21 to 16.36 Kg/m2, 15.18 to 15.45 cm, 43.59 to 44.01 cm, 49.87 to 50.01 cm, respectively. Weight-for-age and BMI-for-age also improved significantly from -2.96 to -1.36 and -1.81 to 0.15, respectively whereas height-for-age improved non-significantly from -2.51 to -2.14 during experimental phase.

**Efficacy of supplementation on biochemical parameters of the selected children**

Supplementation of carrot pomace and soaked chickpea flour based supplementary *laddu* helps to improve the serum albumin level non-significantly from 3.04 to 3.19 g/dL and there was no improvement seen in serum retinol level during control phase. On the other hand, during experimental there was a significant increase seen in serum albumin from 3.19 to 4.37 g/dL and non-significant increase was seen in the serum retinol level from 191.38 to 192.06 ng/ml. A study in China found that biscuits fortified with different doses of vitamin A significantly decreased the prevalence of vitamin A deficiency (VAD), anemia, and physical growth in pre-school children. The study involved 580 children aged 3-6 years, divided into four groups: those given biscuits at 30 percent of the recommended daily intake (RDA), those given biscuits at 100 percent of the RDA once a day, and those given a 200000 IU vitamin A capsule once. Blood samples were collected at the beginning and end of the study, and the results showed no significant difference in height-for-age, weight-for-age, and weight-for-height scores between the groups. The study concluded that consuming vitamin A-fortified biscuits with daily 100 percent RDA for 3 months had the same effect on improving VAD, anemia, and physical growth in pre-school children [45]. Study aimed to determine the serum vitamin A, mid-upper arm circumference (MUAC), and albumin levels of 100 children, including 50 malnourished children under five years old and 50 well-fed age-matched children. The study classified the malnourished children into kwashiorkor and marasmic cohorts. The well-fed group had significantly higher serum vitamin A, MUAC, and albumin levels than the malnourished group. The mean albumin level of the kwashiorkor group was lower than that of the marasmic group. The mean MUAC of the kwashiorkor subjects was higher than that of the marasmic group. Serum vitamin A was not significantly different between the kwashiorkor and marasmic groups. In the marasmic group, serum vitamin A correlates negatively with albumin, while in the kwashiorkor group, it correlates positively with albumin. The study concluded that malnourished children with kwashiorkor and marasmus have lower albumin, serum vitamin A, and MUAC levels compared to well-fed children [46].

**Conclusion**

Carrot pomace powder, by-product of carrot juice extraction process, have a good amount of calcium, iron, zinc and magnesium 80.41, 3.22, 3.67, and 29.33 mg/100 g respectively, vitamin C (0.76 mg/100g), beta-carotene (1736.84 µg/g) and rich source of dietary fiber having total dietary fibre 63.67 g/100g.Chickpea seeds are rich source of protein (15.38 g/100g) and have a good amount of minerals like calcium, iron, zinc and magnesium levels were 170.95, 6.04, 5.05 and 152.40 mg/100g respectively. Soaking of chickpeas helps to reduce the anti-nutritional load and improve the bioavailability of the nutrients. A low-cost supplementary food was made with the incorporation of 4 percent of carrot pomace powder and 30 percent of soaked chickpea flour to improve the nutritional status of children. Higher levels of protein, fat, ash, fiber, antioxidant activity, β carotene, ascorbic acid, phenols, dietary fiber, and minerals were found in the highly acceptable supplemental *laddu.* Subjects' average daily consumption of nutrients such as protein, dietary fibre, β carotene, ascorbic acid, calcium, zinc, iron, and magnesium improved when *laddu* was supplemented. After intervention of supplemented *laddu* for three months, the anthropometric and biochemical profiles of the chosen subjects significantly improved, as seen by improvements in serum albumin levels, body weight, BMI, weight-for-age, height-for-age, and BMI-for-age. This improvement in the parameters specified above was because of the nutritional benefits of carrot pomace and soaked chickpea flour supplemented *laddu* that helped in improving the nutritional status of selected subjects.

**Declarations**

**Conflict of interest:** The authors declare no conflict of interest.

**Ethical approval:** The research study was approved by the ethical committee of Punjab Agricultural University, Ludhiana (No. DR.III.AU.2023/13279-90).

**Disclaimer (Artificial intelligence):** Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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**Table 1: Nutritional composition of raw carrot, carrot pomace powder raw chickpea and processed chickpea flour (on dry weight basis)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Nutrients** | **Carrot powder** | **Carrot pomace powder** | **t-test (p-value)** | **Raw chickpea** | **Soaked chickpea** | **t-test (p-value)** |
| Moisture (%) | 7.19±0.14  | 7.16±0.11 | 0.32 (0.765) | 8.84±0.09 | 9.05±0.03 | 15.79 (0.004) |
| Crude Protein (%) | 5.08±0.14 | 4.93±0.10 | 3.51 (0.625) | 15.13±0.21 | 15.06±0.41 | 3.83 (0.042) |
| Crude Fat (%) | 1.68±0.04 | 1.52±0.05 | 4.05 (0.015) | 4.51±0.18 | 4.08±0.09 | 2.91 (0.041) |
| Crude Fibre (%) | 17.25±0.57 | 17.95±0.88 | 0.51 (0.306) | 5.60±0.39 | 5.73±0.45 | 0.68 (0.566) |
| Total Ash (%) | 6.19±0.27  | 6.73±0.12 | 1.58 (0.050) | 2.52±0.06 | 2.47±0.27 | 0.27 (0.012) |
| Carbohydrate (%) | 62.75±0.57 | 61.93±0.84 | 1.39 (0.237) | 63.33±0.87 | 60.03±0.67 | 0.38 (0.042) |
| Energy (Kcal/100g) | 286.44±1.91 | 280.32±0.81 | 8.71 (<0.001) | 353.12±1.07 | 356.34±0.79 | 3.42 (0.046) |
| Calcium (mg/100g) |  59.34±1.03 | 80.41±7.95 | 23.22 (<0.001) | 185.38±0.57 | 170.95±0.55 | 25.67 (0.002) |
| Iron (mg/100g) | 2.04±0.07 | 3.67±0.35 | 11.86 (<0.001) | 6.34±0.01 | 6.04±0.07 | 5.88 (0.028) |
| Zinc (mg/100g) | 3.00±0.21  | 3.22±0.23  | 9.00 (<0.001) | 5.77±0.07 | 5.05±0.05 | 20.36 (0.002) |
| Magnesium (mg/100g) | 10.92±0.54 | 29.33±1.53 | 13.35 (<0.001) | 162.40±0.36 | 152.40±0.10 | 15.62 (0.004) |
| Vitamin C (mg/100g) | 1.80±0.13 | 0.76±0.08 | 11.5 (<0.001) | 1.24±0.34 | 2.01± 0.04 | 2.98 (0.456) |
| Antioxidant activity (%) | 68.02±0.87  | 65.26±0.61 | 4.52 (0.011) | 18.44±0.63 | 12.55±0.35 | 7.89 (0.016) |
| Total phenols (mg GAE/100g) | 1152±2.22 | 907.82±1.36 | 13.89 (<0.001) | 109.86±0.01 | 84.87±0.48 | 18.64 (<0.001) |
| Soluble dietary fibre (%) |  7.68±0.27 | 12.72±0.92 | 13.19 (<0.001) |  3.39±0.07 | 4.55±0.44 | 3.96 (0.029) |
| Insoluble dietary fibre (%) | 22.72±0.54 | 42.23±0.65 | 40.48 (<0.001) | 27.95±0.38 | 28.89±0.17 | 3.11 (0.089) |
| Total dietary fibre (%) | 29.67±0.67 | 63.67±0.82 | 72.94 (<0.001) | 30.42±0.64 | 32.72±0.35 | 4.47 (0.047) |

Values are Mean ± S.D.

**Table 2: Nutritional Analysis of control and experimental *laddu***

|  |  |  |  |
| --- | --- | --- | --- |
| **Nutrients** | **Control *laddu*** | **Experimental *laddu***  | **t-test (p-value)** |
| Moisture (%) | 5.87±0.09 | 6.51±0.15 | 15.79 (0.354) |
| Crude Protein (%) | 4.98±0.12 | 5.72±0.10 | 4.61 (0.032) |
| Crude Fat (%) | 17.78±0.43 | 19.52±0.48 | 2.45 (0.061) |
| Crude Fibre (%) | 6.98±0.32 | 8.09±0.26 | 0.68 (0.046) |
| Total Ash (%) | 21.87±0.76 | 23.14±0.72 | 0.42 (0.032) |
| Carbohydrate (%) | 42.52±0.76 | 37.02±0.84 | 0.38 (0.042) |
| Energy (Kcal/100g) | 362.02±3.76 | 370.48± 3.32 | 3.42(0.046) |
| Lysine (g/100g of protein) | 3.89±0.09 | 4.17±0.06 | 2.65 (0.047) |
| Methionine (g/100g of protein) | 1.07±0.15 | 1.71±0.13 | 1.21 (0.074) |
| Tryptophan (g/100g of protein) | 1.12±0.18 | 1.46±0.11 | 1.94 (0.049) |
| Calcium (mg/100g) | 78.48±0.97 | 72.08±1.04 | 57.62 (0.021) |
| Iron (mg/100g) | 3.22±0.11 | 3.76±0.10 | 4.46 (<0.001) |
| Zinc (mg/100g) | 1.32±0.03 | 1.84±0.05 | 4.30 (0.031) |
| Magnesium (mg/100g) | 139.98±0.48 | 138.04±0.55 | 23.65 (<0.001) |
| Vitamin C (mg/100g) | 0.46±0.03 | 0.63±0.05 | 23.65 (<0.001) |
| β-carotene (µg/100g) | 75.87±0.57 | 188.14±0.66 | 76.82 (0.041) |
| Antioxidant activity (%) | 18.87±0.26 | 27.10±0.30 | 3.87 (0.034) |
| Total phenols (mg GAE/100g) | 15.98±2.23 | 20.48±2.98 | 12.56 (<0.001) |
| Flavonoids (mg QE/100g) | 367.54±2.21 | 466.89±2.73 | 134.46 (0.021) |
| Soluble dietary fibre (%) | 6.23±0.14 | 6.42±0.15 | 4.86 (0.169) |
| Insoluble dietary fibre (%) | 12.87±0.56 | 16.28±0.64 | 3.11 (0.089) |
| Total dietary fibre (%) | 19.64±0.34 | 23.37±0.49 | 4.47 (0.047) |
| Trypsin inhibitors | 13.75±0.34 | 7.41±0.45 | 5.02 (0.007) |
| Saponins (mg/g) | 8.85±0.23 | 3.56±0.26 | 13.22 (0.017) |
| Tannins (mg/100g) | 203.98±0.22 | 188.07±0.29 | 165.26 (<0.001) |

Values are Mean ± S.D. Experimental *laddu* = 30% soaked chickpea, 4% carrot pomace

**Table 3: Efficacy of supplementation on the average daily nutrient intake of selected children (N=30)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Nutrients** | **Control Group (n=30)** | **Experimental Group (n=30)** |  |
| **Before** | **After** | **Paired t-value****(p-value)** | **Before** | **After** | **Paired t-value (p-value)** | **EARa/ RDA** |
| **Energy (Kcal/day)** | 866.93±150.71 | 871.30± 149.88 | 8.16 (0.341) | 871.30± 149.88 | 897.76±187.14 | 6.97 (<0.001) | 1070.7a |
| **Protein (g/d)** | 10.06± 1.39 | 10.32±1.42 | 8.84 (0.076) | 10.32±1.42 | 11.94± 1.92 | 6.76 (<0.001) | 12.51 |
| **Total fat (g/d)** | 16.58±1.42 | 16.80±1.42 | 0.28 (0.078) | 16.80±1.42 | 21.85±4.29 | 19.49 (0.046) | 27 |
| **β- carotene (µg/d)** | 61.84±3.74 | 62.66±3.66 | 8.64 (0.864) | 62.66±3.66 | 63.41±10.36 | 8.12 (0.048) | 3200 |
| **Retinol (µg/d)** | 101.72±23.42 | 102.73±23.41 | 0.26 (0.490) | 102.73±23.41 | 104.89±29.31 | 31.00 (0.254) | 390 |
| **Calcium (mg/d)** | 308.85± 38.79 | 311.95±38.46 | 11.80 (<0.001) | 311.95±38.46 | 320.88±58.55 | 12.66 (0.049) | 500 |
| **Iron (mg/d)** | 4.13± 0.49 | 4.19± 0.48 | 3.62 (<0.001) | 4.19± 0.48 | 5.47±0.94 | 24.79 (0.030) | 6 |

Values are expressed as Mean ± SD ICMR (2023), RDA (2023 & 2010)

**Table 4: Anthropometric profile and Biochemical Parameters of the selected children (N= 30)**

|  |  |  |
| --- | --- | --- |
| **Anthropometric measurements** | **Control Group (n=30)** | **Experimental Group (n=30)** |
| **Before** | **After** | **Paired t-value****(p-value)** | **Before** | **After** | **Paired t-value (p-value)** |
| **Height (cm)** | 90.77±10.89 | 90.88±10.90 | 5.90 (0.067) | 90.88±10.90 | 91.33±16.82 | 8.89 (<0.001) |
| **Weight (Kg)** | 11.42±1.90 | 11.62±1.87 | 7.77 (0.044) | 11.62±1.87 | 12.89±2. | 26.76 (<0.001) |
| **BMI (Kg/m2)** | 13.93±2.55 | 14.21±2.54 | 8.54 (<0.001) | 14.21±2.54 | 16.36±3.45 | 29.01 (<0.001) |
| **MUAC (cm)** | 15.06±1.29 | 15.18±1.23 | 7.66 (<0.001) | 15.18±1.23 | 15.45±2.91 | 30.96 (<0.001) |
| **Head Circumference (cm)** | 43.43±9.69 | 43.59±9.74 | 6.94 (<0.001) | 43.59±9.74 | 44.01±10.73 | 6.84 (<0.001) |
| **Chest Circumference (cm)** | 49.53±3.32 | 49.87±3.17 | 6.50 (0.052) | 49.87±3.17 | 50.01±9.44 | 6.84 (<0.001) |
| **Serum Retinol (ng/ml)** | 191.38±32.79 | 191.38±32.89 | 4.95 (0.354) | 191.38±32.89 | 192.06±46.59 | 9.83 (0.053) |
| **Serum Albumin (g/dL)** | 3.04±0.33 | 3.19±0.34 | 3.85 (0.132) | 3.19±0.34 | 4.37±0.80 | 19.56 (<0.001) |

Values are Mean ± SD.