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Investigating the Potential of Chicken Meat Oat Flour Noodles as a Wholesome Food Option for Growing Children

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ABSTRACT

Background: Malnutrition remains a serious global issue, especially among children, as it directly impacts their growth, brain development, and overall well-being. Poor nutrition in school-aged children can result in stunted growth, weaker immune systems, and difficulties in learning. This study aims to improve children's nutrition by incorporating protein-rich and nutrient-dense ingredients into their diets, ultimately promoting better health and development.

Objectives:
The study aims to evaluate how a dietary intervention can improve the nutritional status of children aged 7–12 years.

Methodology:
For this intervention, nutrient-rich noodles were prepared using oats and chicken meat, along with other ingredients to boost their nutritional value. These noodles were carefully analyzed for their nutrient content, texture, and taste to ensure they met quality standards. A 42-day dietary trial was conducted with 15 school-aged children (7–12 years), who were divided into groups based on their diets. Changes in their nutritional status were monitored, and the results were analyzed to determine the effectiveness of the intervention.

Results:
The study showed that adding these fortified noodles to children's diets had a positive impact on their nutrition. Analysis confirmed that the noodles provided essential nutrients, making them a beneficial addition to a child's diet. Taste tests showed that children found them highly acceptable. The children in Group G2, who received both their usual meals and the fortified noodles, showed the most significant improvements in their overall nutrition compared to other groups.

Conclusion: Combining protein-rich and nutrient-dense foods proved to be an effective way to improve children's health and nutritional well-being. The findings suggest that incorporating such fortified foods into daily meals could help address common nutrient deficiencies in school-aged children.

Keywords: Protein energy malnutrition (PEM), marasmus, fortified noodles, child nutrition, dietary intervention.

Introduction

Nutrition and medical science have replaced lifestyle modification and sedentary lifestyle with new rules for diet, affecting all age groups. [1] Traditions about what to eat and what not to eat have reduced food related anxieties, and people prefer food over chemical medicine due to increased side effects. Functional foods have decreased disease load.[2]

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Malnutrition is a life-threatening problem caused by an imbalance of energy and nutrients, with a high mortality rate among young children and infants.[3] Malnutrition has had a major impact on developing countries, with over 150 million children globally suffering from malnutrition and causing 50% deaths.[4]

Malnutrition of protein is the burning issue in developing countries and results in protein energy malnutrition.[5] It is a pathological imbalance as a function of quality and quantity due to non-optimal eating of food. Primary malnutrition (PEM) is a serious health issue caused by insufficient food, inadequate crop production, rapidly growing population, low income and ignorance of nutritional improvement. It has a major impact on school-going children.[6] PEM is a term that defines malnutrition from mild to severe conditions like Kwashiorkor and Marasmus.[7] It is caused by incorrect diet, infectious diseases, lack of nutrient consumption, lack of breastfeeding and poor hygiene. School-going children are at the highest risk of becoming malnourished, with over 70% suffering in Asia, 26% in Africa and 4% in America. Inadequacy, ignorance and other social issues can decrease early growth of children.[8]

Protein is essential for proper metabolism, tissues and muscle development, and is linked to amino acids through peptide bonds. Inadequate dietary intake, poor socio-economic status, availability of food, prolonged starvation, poor eating habits, poor hygiene and sanitary conditions are the main causes of protein deficiency.[9] In Pakistan nutrition surveys have found out various susceptible groups of community with varying degrees of PEM. Consumption of low-quality protein was announced to be a major cause of malnutrition.[10] A balanced diet is the diet one which meets all the nutritional requirements of individuals which require body maintenance and repairing of physiological processes, growth and development.[11] School feeding programs enhance the diet for the availability of energy and kilocalories to the children, improving their growth and development, nutrition, health and well-being, protection against diseases and development of good eating habits.[12] One of the most important approaches to overcoming malnutrition and micronutrient deficiencies is agriculture based nutritional interventions.[13] A balanced diet is the most important approach, but it is difficult to achieve due to different likes and dislikes and socio-economic status. Fortification is more helpful and effective than supplementation, as it is easy, cheap and sustainable.[14]

Food grains are an important part of the human diet and are considered the cheapest source of energy and protein for developing countries. They belong to the grass family and are chief sources of carbohydrates, vitamins, minerals and protein.[15] Wholegrain cereals have high energy values mainly consisting of 12-14% moisture content, 65-75% carbohydrates (mainly starch), 6-12% protein and 1-5% fat and contain inedible substances like cellulose.[16] Cereals are a staple food in many countries due to their bio-active ingredients and dietary fiber. They are a good source of carbohydrates, oils, vitamins, lipids, minerals, and protein, and are chosen for consumption due to their high fiber content, which helps to avoid overweight, obesity, gastrointestinal problems, and cardiovascular diseases.[17] Cereals provide more than 60% of energy and 50% of global protein needs. However, they are limited in essential amino acids and their protein quality is poorer than animals .[18] To improve the protein content of cereals, many approaches have been used, such as fortification, supplementation or complementation with protein concentrates or other food sources.[19]

Oats are a nutritious cereal that are high in soluble fiber, proteins, and unsaturated fatty acids. They can help with diabetes control, lipid profiles, LDL cholesterol levels, and lower the risk of coronary heart disease.[20] As more information about the nutritional benefits of oats has become available, the use of oats in human foods has expanded. Granola bars, South American beverages, and pancake mixes contain oatmeal or oat flour.[21] Noodles are a popular traditional cereal food due to their ease of preparation, handling, cooking, and taste. They are low-cost and have a low protein content (15%), making them a staple in undernourished countries' diets.[22] Even in industrialized countries, poor men's diets are insufficient in protein. As a result, several research have been done to see if protein-rich commodities may be added to noodles. Diets high in protein and low in fat are in great demand among health-conscious consumers.[23] Today's market snacks such as noodles and other pasta are high in carbohydrates but low in proteins and amino acids.[24] This is insufficient to meet the World Health Organization's daily protein intake recommendations for average men, women, and children who engage in moderate physical activity. To address this, enriched noodles with various compounds are available on the market, and there is scope for fortification of noodles/vermicelli with minerals, vitamins, and proteins from other sources.[23]

Protein energy malnutrition is a great concern and can be overcome by provisioning good quality protein. Hence the present study was designed to develop noodles as a substitute for conventional snacks. The main objectives of the study were the preparation of value-added chicken meat oat flour noodles for growing children, evaluation of nutritional profile and shelf stability of the developed product, to check the consumer acceptability of noodles through sensory evaluation and the assessment of in vivo effectiveness of noodles in growing children

Materials and Methods

The research study was conducted at the Institute of Home Sciences, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad. Oats were procured from Ayub Agricultural Research Institute (AARI), Faisalabad and other raw materials like chicken meat for the preparation of noodles were procured from Metro cash and carry, Faisalabad. Cleaning and washing of raw materials were done manually. Afterwards, oats were converted to fine powder for further analysis and use in the study.

The trial was an open-labeled, single-arm study conducted over six weeks, with a one-week washout period, followed by a clinical assessment based on longitudinal data collection before and after the study interval. The test subjects were divided into three groups: G0, the control group, which consumed wheat flour noodles; G1, which followed a normal diet supplemented with the interventional product; and G2, which also followed a normal diet with the interventional product.

Noodles were prepared using oat flour, chicken meat, salt, oil with other required materials. Noodles were prepared by replacing oat flour with chicken meat according to the treatment plan as mentioned in Table I. Dough of noodles was prepared by following the method of Codină et al.[25] where all ingredients were blended properly with water and mixed the dough at 80rpm speed for 30 min at 28 to 30°C for uniform equilibrium and hydration. Afterwards, the dough was sheeted almost seven times to get elasticity. The noodle making machine was used to prepare noodles. The thickness and width of each noodle was about 1.5× 1.5 mm. Later, noodles were dried in solar in stick for 4h at 35-55°C. The developed product was stored at room temperature for 15 days.

Table I: Treatments used in study.

Treatments	Wheat flour (%)	Oat flour (%)	Chicken meat (%)
T_0	100	0	0
T_1	0	70	30
T_2	0	30	70

T_0 = Noodles containing 100% wheat flour act as control
T_1= Noodles containing 0% wheat flour, 0% oat flour and 0% chicken
T_2= Noodles containing 0% wheat flour, 30% oat flour and 70% chicken

The samples of the product were evaluated for moisture (AACC Method No. 44-15A), crude protein (AACC Method No. 46-10), crude fat (AACC Method No. 30-25), crude fiber (AACC Method No. 32-10), total ash (AACC Method No. 08-01), NFE and mineral contents i.e. calcium, iron, potassium, magnesium, sodium and iron (AOAC Method No. 975.03B) according to their respective procedures (26).

The wet digestion method was used for the determination of calcium, magnesium, sodium and iron in samples. These were measured by spectrophotometer (Shimadzu UV 240, Japan), while potassium (K) was measured using flame emission spectroscopy. Following the method of AOAC (2019) atomic absorption spectrophotometry was used to calculate iron (Fe) and calcium (Ca). For 20 minutes on a hot plate 0.5g of dried sample was digested with 10mL of HN03 in 100mL conical flask at 60-70°C. The flask content was then digested with 5mL HClO4 at a high temperature of 190°C until it became visible. In the next step the digested sample was then placed in 100 mL volumetric flask. The volume of the sample was made with double distilled water. Samples whose strength was known were first tested for each mineral to get standard curve. The mineral contents of the samples were determined using the standard curves prepared for each mineral.

A two-liter saucepan was filled with one liter of tap water and brought to a boil with the lid on to prevent any water loss. The boiling water was mixed with 100 g of noodles. The water temperature, often referred to as the cooking temperature, was maintained between 98 and 100°C throughout the cooking process. The cooking process began as soon as the noodles were added to the boiling water. After compression, they were fried for three minutes, or until no white core was visible. The noodles were removed from the saucepan, rinsed, and let to cool under cold running water for one minute. Cooking loss was determined using the AACC approach by drying off the cooking water in an oven set to 100°C[27]

The prepared noodles were organoleptically evaluated by judges. The product was evaluated for various sensory quality characteristics such as color, texture, aroma, holding ability, stickiness and overall acceptability. Evaluation of the noodles was done on the basis of a 9-point hedonic score system as described by the Civille et al.[28] Triplicates with control by the test sample were given. From usual recipes control sample was prepared. To avoid any type of bias all samples were coded.

The current work was ethically approved by the University of Agriculture, Faisalabad's Institutional Biosafety Committee (IBC). All study information was explained to all participants, and written informed consent was obtained from each participant prior to intervention.

Test subjects were selected from Sunny public school, Chak no. 64 JB, Faisalabad city. Children of 7 to 12 years old were the target population for this study. A total of 15 were the participants of the trial. The study duration was 6 weeks along with 3 study intervals.

Anthropometric measurements like weight, and height were performed to calculate their BMI at the start, mid and completion of study. The weight of the children was measured at the 1st and 42nd day of the study. The weight was taken without shoes heavy clothes on digital weight machine. The height was also taken on the 1st and 42nd day of the study on stadiometer. The height was measured by standing the children in erect position without shoes and their feet were attached to the wall for accurate measurements. BMI of the children was measured using Quetelet equation and was recorded during study period. The percentile charts recommended by WHO were used to check the value of BMI. If value was below 5th percentile, then children fall under the category of underweight but if they are between 5th-95th than they are normal but greater than 95th mean they are overweight.

The CRD and factorial design was used to check the results of the study. The data for each measurement was statistically analyzed to evaluate the level of significance according to (29).

Results

The investigation tested how adding oat flour and chicken meat to wheat flour affected the moisture, ash content, crude fat, crude fiber, crude protein, and nitrogen free extract (NFE) of noodles (Table II). The results showed that increasing the proportion of oat flour and chicken meat in the wheat flour reduced the moisture level significantly. The mean values for moisture content revealed that values range from 8.43% - 13.05%. The lowest value was seen in T2 (8.43%) and the highest value for moisture was seen in T0 (13.05%). The control group (100% wheat flour) had the lowest moisture value, while the group with a greater proportion of oat flour and chicken meat supplements had the greatest. Ash content was increased from T0 to T2 as T0 had lowest crude ash (1.19±0.01) and T2 (1.36±0.01) had highest ash content and crude fat was increased from T0 to T2 as T0 had lowest crude fat (23.78±0.01) and T2 (28.13±0.02) had highest crude fat content. Hence, the ash level and crude fat increased with the addition of oat flour and chicken meat. The group containing 30% oat flour and 70% chicken meat had the highest ash and crude fat content. Furthermore, the crude fiber content in the same group was greatest, showing that oat flour led to higher fiber content. Furthermore, because oat flour and chicken meat are higher in protein than wheat flour, the protein level increased dramatically. The lowest percentage observed in T0 (9.53±0.11) whereas highest protein content was observed in T2 (17.13±0.03). However, with 30% oat flour and 70% chicken meat, the NFE level was the lowest in the group. While the maximum range is observed in control (wheat flour noodles). Hence noodles with 30% supplementation of oat flour and 70% chicken meat showed minimum NFE content.

The mineral content of noodles with varied quantities of oatmeal and chicken meat (T0, T1, T2) was investigated (Table III). The calcium level ranged from 48.93 to 84.12 mg/100g, with T0 having the lowest (48.93±0.70) and T2 having the highest (84.12±0.23). The iron concentration ranged from 1.13 to 1.81 mg/100g, with T0 containing the least (1.13±0.11) and T2 containing the most (1.81±0.29). The potassium level of the samples ranged from 99.83 to 156.13 mg/100g, with T0 having the lowest (99.83±0.90) and T2 having the highest (142.66±0.71). Magnesium content ranged from 53.56 to 71.037%, with T0 having the lowest level (53.56±0.91) and T2 having the highest (71.037±0.43). Sodium content ranged from 19.12 to 51.220 mg/100g, with T0 having the lowest level (19.12±0.92) and T2 having the highest (51.220±0.49). Zinc content was lowest in T0 (0.97±0.03), followed by T1 (1.45±0.06), and highest in T2 (3.170±0.13).

The Table IV data shows that there are significant variations in color, aroma, taste, texture, and overall acceptance scores among different noodle formulas. The mean color score ranged from 6.80 to 8.05, with T1 receiving the greatest score (70% oat flour and 30% chicken meat) and T2 receiving the lowest. T2

Table II: Proximate composition (%) of value-added chicken meat oat flour noodles. (Means ± SE)

Treatments	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Fiber (%)	Crude Protein (%)	Nitrogen Free Extract (%)
T_0	13.05±0.02c	1.19±0.01a	23.78±0.01c	1.66±0.01a	9.53±0.11c	52.79±0.07a
T_1	10.54±0.02b	1.29±0.02b	26.56±0.02b	1.91±0.16b	10.02±0.04b	52.68±0.11b
T_2	8.43±0.02a	1.36±0.01c	28.13±0.02a	2.07±0.16c	17.13±0.03a	51.87±0.15c

Means carrying different letters are significantly different from each other ($p<0.05$).

Table III: Mineral content (mg/100g) of value-added chicken meat oat flour noodles (Means±SD)

Treatments	Calcium	Iron	Potassium	Magnesium	Sodium	Zinc
T_0	48.93±0.70f	1.13±0.11f	99.83±0.90c	53.56±0.91c	19.12±0.92a	0.97±0.03c
T_1	81.22±0.03b	1.73±0.09b	131.10±0.57b	69.01±0.43b	45.98±0.37b	3.12±0.03b
T_2	84.12±0.23a	1.81±0.29a	142.66±0.71a	71.037±0.43a	51.220±0.49c	3.170±0.13a

Table IV: Sensory evaluation of value-added chicken meat oat flour noodles. (Means±SE)

Treatment	Color	Aroma	Taste	Texture	Overall acceptability
T_0	7.04±0.01^c	8.35±0.02^c	8.02±0.01^c	8.43±0.01^a	8.03 ± 0.01^c
T_1	8.05±0.06^a	8.82±0.01^a	8.82±0.01^a	8.02±0.01^c	8.17±0.02^a
T_2	7.65±0.30^b	8.63±0.01^b	8.32±0.02^b	8.13±0.01^b	8.14±0.01^b

Means carrying different letters are significantly different from each other (p<0.05).

Table V: Nutritional Status before and after intake of value-added chicken meat oat flour noodles.

Groups	Weight (Kg)		Height (cm)		BMI (Kg/m2)	
	Day 0	Day 42	Day 0	Day 42	Day 0	Day 42
G_0	37.53 ± 3.89	38.23 ± 3.37	143.61 ± 4.89	143.91± 5.37	17.95 ± 0.21	17.09 ± 0.18
G_1	36.93 ± 3.98	37.99 ± 3.45	144.22 ± 4.98	144.47 ± 5.45	18.10 ± 0.01	18.99 ± 0.32
G_2	36.33 ± 3.03	39.21 ± 3.60	144.67 ± 5.03	144.82± 5.60	18.48 ± 0.20	19.95 ± 0.13

G_0 = Regular diet
G_1 = Regular diet + interventional product (noodles T_1)
G_2 = Regular diet + interventional product (noodles T_2)

obtained the highest aroma score of 8.82, followed by T1 and T0. The aroma score for T0 was 6.02. The taste scores ranged from 6.61 to 8.02, with T1 obtaining the highest rating and T0 receiving the lowest. T1 had the greatest texture score, followed by T0, while T2 had the lowest. Overall acceptability scores varied from 6.03 to 8.17, with T1 obtaining the highest and T2 receiving the lowest. These findings indicate that the inclusion of oat flour and chicken meat supplementation had a significant impact on the sensory attributes of the noodles.

Children's weight and height were measured before and after a 42-day intervention involving counseling and dietary adjustments (Table V). The children's average weight ranged from 37.32± 0.59 to 40.41± 0.84 kg. The findings revealed that when the children's weight increased, there were considerable improvements noted. G0 (regular diet), G1 (regular diet + dietary intervention), and G2 (regular diet + dietary intervention) were the study's three groups. The weight in G0 decreased slightly, from 37.53 ±3.89 to 36.23±3.37 kg. Weight increased from 36.93± 3.98 to 37.99± 3.45 kg in G1 but increased more considerably in G2 from 36.33 3.03 to 39.21 3.60 kg. According to recommendation of WHO, the weight of the children should be 32- 42 kg for 9-13 years old children. The children's heights ranged from 143.61± 4.89 to 144.67± 5.03 cm at the beginning of the study. Following the intervention, G0's height increased slightly from 143.61± 4.89 to 143.91± 5.37 cm, G1's height increased from 144.22± 4.98 to 144.47± 5.45 cm, and G2's height increased from 144.67± 5.03 to 144.82± 5.60 cm.

Discussion

Moisture levels in protein-enriched quick noodles ranged from 8 to 12% in microwave-dried instant noodles with chicken meat, egg yolk, and seaweed supplementation, which is consistent with our findings.[30] Comparable ash concentration in control and experimental cookies enhanced with oat flour was discovered by researchers.[31] A similar trend in crude fat levels in their investigation on biscuits produced from defatted cashew nut and wheat flour was reported.[32] Furthermore, it was found that adding pumpkin seed flour to noodles increased their fiber content, which is consistent with our findings.[33] Finally, similar trend was discovered by scientists.[34] In conclusion, the study found that the incorporation of oat flour and chicken meat in noodles affected various nutritional parameters, such as moisture, ash content, crude fat, crude fiber, crude protein, and NFE.

In the present study, calcium levels ranged from 48.93 mg/100g (T0) to 84.12 mg/100g (T2). These values are higher than those reported by Kaur et al. (35) for plain wheat noodles (35.2 mg/100g) but lower than those observed in calcium-fortified noodles (120 mg/100g) by Zhang et al. ([36]). The increase in calcium content in T2 can be attributed to the inclusion of oatmeal, which is a natural source of calcium, and chicken meat, which may enhance mineral retention during processing. The iron content in this study ranged from 1.13 mg/100g (T0) to 1.81 mg/100g (T2). These values are higher than those reported by Singh et al.[37] for traditional wheat noodles (0.8 mg/100g) but lower than iron-fortified noodles (2.5 mg/100g) studied by Kumari et al.[38] The increase in iron content in T2 is likely due to the combination of non-heme iron from oatmeal and heme iron from chicken meat, which is more bioavailable. Potassium levels in this study ranged from 99.83 mg/100g (T0) to 142.66 mg/100g (T2). These values are comparable to those reported by Gull et al.[39] for oat-based products (130–150 mg/100g) but lower than those in potassium-enriched noodles (200 mg/100g) studied by Wang et al.[40] Magnesium content in this study ranged from 53.56 mg/100g (T0) to 71.037 mg/100g (T2). These values are higher than those reported by Kaur et al.[35] for wheat noodles (45 mg/100g) but lower than those in magnesium-fortified noodles (85 mg/100g) studied by Li et al.[41] The increase in magnesium content in T2 can be attributed to the inclusion of oatmeal, which is a rich source of magnesium. Sodium levels in this study ranged from 19.12 mg/100g (T0) to

51.220 mg/100g (T2). These values are significantly lower than those reported by He et al.[42] for commercially available instant noodles (800–1200 mg/100g). Zinc content in this study ranged from 0.97 mg/100g (T0) to 3.170 mg/100g (T2). These values are higher than those reported by Singh et al.[37] for wheat noodles (0.5 mg/100g) but lower than those in zinc-fortified noodles (4.0 mg/100g) studied by Kumari et al.[38] These findings are consistent with recent research emphasizing the importance of fortifying staple foods with nutrient-rich ingredients to improve public health outcomes. [43]

According to the World Health Organization (WHO), the average height range for children aged 9–13 years should be between 136 cm and 149 cm. In this study, participants' Body Mass Index (BMI) was also assessed, revealing that dietary interventions and counseling had a noticeable impact.

Group G1 showed only a slight change in BMI over the 42-day period, starting at 18.10 ± 0.01 and increasing to 18.99 ± 0.32. Similarly, Group G2 experienced a comparable change, with BMI values starting at 18.48 ± 0.20 and reaching 19.95 ± 0.13 by the end of the study. However, the most significant improvements were observed in G2, which received both the interventional diet and counseling in addition to their regular meals.

These findings suggest that a combination of a nutrient-rich diet, counseling, and a balanced daily diet can positively influence BMI. The results align with those of Atuonwu et al., who highlighted the benefits of a multidisciplinary approach to weight management in overweight and obese children and adolescents.

Conclusions

The present study found that adding protein-rich components to noodles increased nutritional composition, including higher levels of calcium, iron, potassium, magnesium, and zinc. Participants preferred the noodles with oat flour and chicken meat supplementation, according to the sensory analysis. Furthermore, counseling and dietary adjustments involving these enriched noodles had a significant positive influence on the nutritional status and BMI of school-aged children. These findings imply that food-based therapies can effectively address malnutrition and nutrient deficiencies in a simple, cost-effective, and nutritious manner.

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