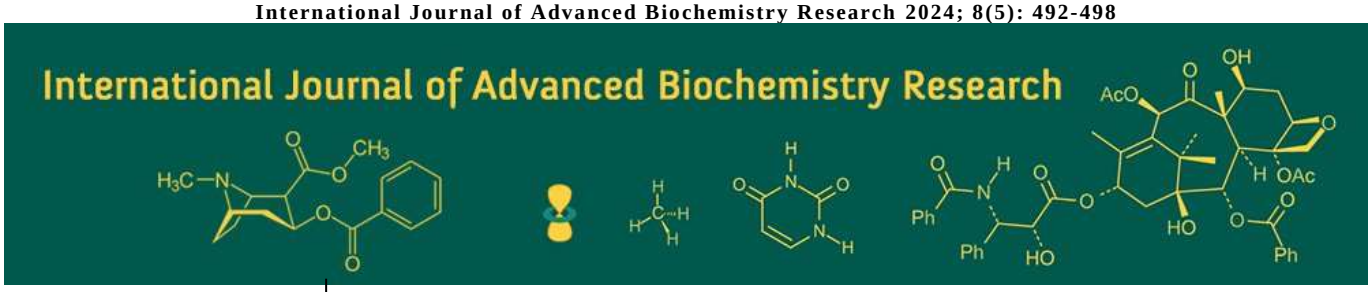

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Production of nutrient rich vermicelli enriched with quinoa flour and its quality assessment

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Abstract
The aim of this study was to develop a standardized method for preparing vermicelli infused with quinoa flour. Vermicelli was created using a blend of wheat suji and quinoa flour in varying ratios and the impact of these formulations on proximate composition, mineral content, and dietary fiber content was assessed. Different combinations of suji and quinoa flour namely 100:0 (V_0), 80:20 (V_1), 70:30 (V_2), 60:40 (V_3) and 50:50 (V_4) were utilized in the preparation process. As more quinoa flour was added to the vermicelli recipes there was a clear rise in protein, ash, fat, crude fiber and moisture levels while the amount of carbohydrate content decreased. The mineral content of all vermicelli samples increased likely due to the addition of quinoa flour which is naturally rich in minerals. The elevated mineral content in the developed vermicelli can be attributed to the high mineral content present in quinoa. Furthermore the dietary fiber content in the prepared vermicelli exhibited a consistent increase with the rise in quinoa flour concentration. Based on nutritional profile analysis vermicelli containing 50% quinoa flour demonstrated superior quality and enhanced nutritional value.

Keywords: Quinoa, vermicelli, proximate composition, minerals, dietary fiber

Introduction
The nutritional aspect of food is crucial for preserving human health and supporting physical fitness. Given that nutritional wellness is vital for unlocking human genetic potential and fostering development, ensuring the quality of food nutrition is essential for maintaining overall well-being (Radhika *et al*., 2011) [16]. Encouraging the diversification of food production is crucial both at the national and household levels aiming for enhanced yields and improved techniques as highlighted by (Singh and Raghuvanshi, 2012) [24]. Despite being highly nutritious certain agricultural foods remain underutilized for human consumption due to a lack of awareness among people. Quinoa stands out among these possessing significant nutritional and medicinal properties. However it remains a neglected and underutilized crop largely due to limited public knowledge and various challenges such as its bitter taste resulting from saponin content subpar cooking quality and low nutrient bioavailability. Addressing these issues could unlock the potential of quinoa as a valuable food source contributing to food and nutritional security.
Quinoa (*Chenopodium quinoa Willd*.) is categorized as a pseudo-cereal crop distinguished by its classification as a broadleaf plant with a starchy dicotyledonous seed. Unlike cereals which are characterized as monocotyledonous, quinoa does not fall under the cereal category. This ancient crop originates from the Andean region and belongs to the dicotyledonous class, *Chenopodiaceae* family, Chenopodium genus and quinoa species. Beyond its botanical classification quinoa serves as a cereal-like grain playing a vital role in the functional food sector. Quinoa grains are known for their high nutritional value and are also known as "mother grain" (Sharma *et al*., 2015) [23].
The quinoa grain is gaining popularity among consumers due to its status as a novel food source and its rich nutritional profile. Quinoa grains boast a protein content ranging from 13.9% to 17%. All nine essential amino acids required by humans namely isoleucine, lysine, leucine, methionine, tryptophan, histidine, valine, phenylalanine and threonine are present in quinoa. This grain stands out for its elevated amylose levels and a well-balanced composition of carbohydrates, starch and sugars. In addition to its protein and amino acid content, quinoa is a source of various vitamins including those from the B complex, vitamins

E, C and K. Furthermore quinoa contains essential minerals such as potassium, calcium, magnesium, zinc, copper and iron. The comprehensive nutritional makeup of quinoa contributes to its appeal as a wholesome and nutrient-rich food option (Saeed *et al*., 2020) [19].

It is widely acknowledged that snack foods typically cereal-based either lack sufficient protein or contain proteins of inferior nutritional value. Therefore by incorporating quinoa flour into the cereal component the protein quality of such products could be significantly enhanced (Prasad *et al*., 2007) [15].

In developed nations numerous convenience foods are produced using the extrusion process employing extruders for their ability to imbue products with a variety of desired characteristics. Vermicelli is among the convenience foods crafted through this method and holds cultural significance in Asian traditions often symbolizing longevity and prosperity (Sowbhagya and Ali, 2001) [25].

Vermicelli which translates to "little worms" in Italian, is a type of pasta characterized by its round shape and slightly thinner profile compared to spaghetti. Pasta, including vermicelli is recognized as a highly suitable dish for meeting dietary requirements and maintaining overall health. Vermicelli has become a popular and readily available food option appreciated by both rural and urban populations for its convenience and affordability (Costantini, 1985) [3].

Vermicelli a traditional food item is made by cold extruding hard dough of whole or refined wheat semolina and then sun-drying it. Enhancing the nutritional value of vermicelli is essential to preserve its delicacy and improve its nutrient content (Naik, 2004) [10].

Keeping above points in view present study was planned to assess the feasibility of quinoa flour incorporation in vermicelli preparation and its impact on quality of these convenience food in terms of proximate and mineral composition with a prime objective to spread the awareness regarding nutritional qualities of quinoa based products as an alternative to the wheat and to popularize the recipes that can be easily prepared among rural and urban mass.

Considering the mentioned factors, the current study aimed to evaluate the viability of incorporating quinoa flour into vermicelli production and its influence on the quality of these convenience foods, focusing on their proximate and mineral compositions. The primary goal was to raise awareness about the nutritional benefits of quinoa-based products as a substitute for wheat and to promote easily preparable recipes among both rural and urban populations.

Materials and Methods

The current study was conducted at the College of Food Technology, VNMKV, Parbhani, during year 2022-2024.

Materials

The good quality of raw materials during this study such as quinoa and wheat were purchased from local market.

Chemicals and glasswares

The analytical grade chemicals and glassware utilized in this study were sourced from the College of Food Technology, VNMKV, Parbhani.

Equipments and Machinery

The College of Food Technology, VNMKV, Parbhani provided access to various equipment including an analytical weighing balance, hot air oven, grinder, vermicelli making machine, muffle furnace, soxhlet apparatus, and microkjeldhal digestion and distillation unit.

Methodology

Preparation of wheat suji

The wheat grains underwent a process of cleaning followed by tempering and conditioning treatment. Moisture was augmented in the wheat sample by 3% through the addition of water after which it was conditioned overnight. Subsequently, the conditioned grains were milled to produce suji using a laboratory flour mill.

Preparation of quinoa flour

High-quality quinoa is carefully chosen and then cleaned to eliminate any undesirable elements like dust, dirt, stones, mud particles and leaves. The quinoa grains are soaked in a 2% citric acid solution to effectively reduce the bitterness caused by saponin to a safe level. After soaking the grains are drained, washed with running tap water and then left to dry. Once dried the grains are finely milled to produce quinoa flour.

Formulation for preparation of vermicelli

Vermicelli was made using a blend of quinoa flour and suji with the addition of salt to enhance sensory qualities. Various formulations were created by adjusting the proportions of ingredients as outlined in Table 1. A stiff dough was prepared by modifying the ingredient composition including quinoa flour, suji and salt. Suji and quinoa flour were mixed in different ratios such as 100:0 (V_0), 80:20 (V_1), 70:30 (V_2), 60:40 (V_3) and 50:50 (V_4). These predetermined blends of suji and quinoa flour were combined with 3% salt and water was gradually added to achieve the desired dough consistency ensuring thorough kneading for uniformity. The dough forming a stiff and cohesive mass was then fed into a conventional cold extruder and pressed through a round whole mould under high pressure resulting in vermicelli with a diameter of 1.25 mm. The extruded dough was dried using a cabinet dryer in the shade and for extended storage the dried vermicelli was packed in polyethylene bags.

Table 1: Formulation of vermicelli incorporated with quinoa flour

Ingredients	V_0	V_1	V_2	V_3	V_4
Suji (g)	100	80	70	60	50
Quinoa Flour (g)	00	20	30	40	50
Salt (g)	3.0	3.0	3.0	3.0	3.0
Water (ml)	30	30	30	30	30

Flow chart for preparation of vermicelli incorporated with quinoa flour

The vermicelli was prepared with slight modification according to the method given by (Lande *et al*., 2017) [8].

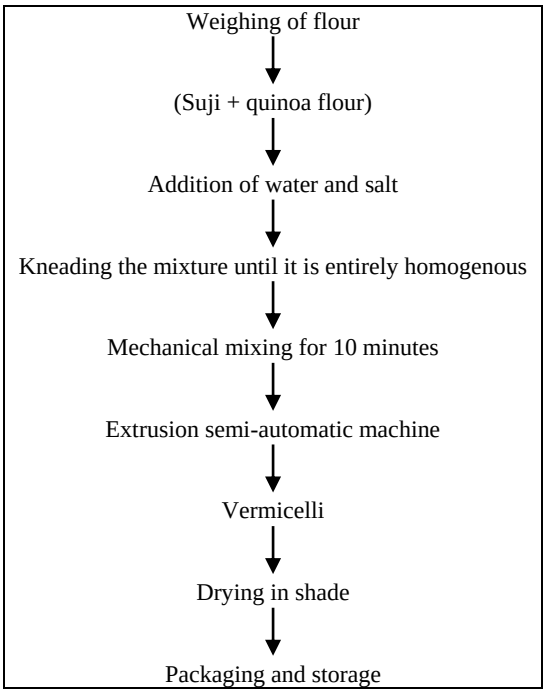


Fig 1: Preparation of vermicelli incorporated with quinoa flour

Proximate Analysis

Various chemical properties of the samples were examined such as moisture content, ash, fat, protein and total carbohydrate. Each process was performed three times and the results were reported as the average value according to their respective standard methods as described in (A.O.A.C., 2005) [1].

Determination of minerals

Two grams of the defatted sample was weighed and burned at 550 °C. The obtained ash was then treated with concentrated hydrochloric acid (HCl) on a hot plate. After digestion the material was filtered using Whatsman No. 42 filter paper and the volume was makeup to 100 ml with distilled water for mineral analysis by following the procedures given by (A.O.A.C., 2005) [1].

Determination of dietary fiber

The dietary fiber such as total dietary fiber (TDF), soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) was estimated from samples using (AOAC, 2005) [1] method.

Statistical analysis

The data obtained was analyzed statistically by Completely Randomized Design (CRD) as per the procedure given by Panse and Sukhatme (1985) [13]. The analysis of variance revealed at significance of $p<0.05$ level S.E. and C.D. at 5% level is mentioned wherever required.

Results and Discussion

Proximate composition of raw materials used for preparation of vermicelli

Proximate analysis is typically indicative of a products nutritional value. Wheat semolina (suji) serves as the primary ingredient for making vermicelli. Quinoa flour utilized in various proportions in vermicelli preparation requires an assessment of its chemical composition alongside wheat to determine its suitability for vermicelli production. The proximate composition of both quinoa and wheat was analyzed and is detailed in Table 2.

Table 2: Proximate composition of raw materials used for preparation of vermicelli

Nutrients	Content (%)	
	Quinoa	Wheat
Moisture	9.60±0.3	11.30±0.15
Fat	6.20±0.4	0.80±0.27
Protein	15.60±0.6	10.20±0.50
Crude fiber	3.60±0.5	2.60±0.13
Ash	3.40±0.2	0.80±0.10
Carbohydrate	61.60±0.1	74.30±0.23

*Each value is average of three determinations

The results indicated that the quinoa flour contains 61.6% carbohydrate, 15.6% protein and 6.2% fat content. The ash content of quinoa flour was about 3.4%. Quinoa seed contain fair amount of crude fiber 3.60%. Low moisture 9.6% content of quinoa is an indicative of used dried seed. The observed differences may be due to environmental factors like climate and location etc. The obtained results for the proximate composition of quinoa seed flour were found similar to findings of results of **(**Viktoria *et al*., 2020 and Vazquez-Luna *et al*., 2019) [29, 28].

Proximate composition of wheat flour indicates that the moisture, fat, protein, crude fiber, ash and carbohydrate content of wheat found to be 11.30, 0.80, 10.2, 2.6, 0.8 and 74.30% respectively. Similar results were reported by (Renu and Seema, 2013 and Jyotsana *et al*., 2015) [17, 6].

Mineral composition of raw materials used for preparation of vermicelli

Analyzing the mineral content of raw materials is crucial for assessing their nutritional value. Minerals are vital for various physiological functions particularly in processes related to growth and regulation within the body. Minerals like calcium, phosphorus, magnesium, potassium, iron and zinc were examined. The findings regarding the mineral composition of both quinoa and wheat are outlined in Table 3.

Table 3: Mineral composition of raw materials used for preparation of vermicelli

Minerals	Mineral content (mg/100 g)	
	Quinoa	Wheat
Calcium	86±0.40	21.10±0.13
Phosphorus	412±0.10	165.20±0.25
Magnesium	430±0.90	31.40±0.42
Potassium	732±0.50	170±0.21
Iron	9.2±0.17	2.40±0.35
Zinc	3.8±0.25	1.30±0.20

*Each value is average of three determinations

The mineral composition of quinoa seed was assessed and it was discovered that quinoa has the greatest potassium content (732 mg/100 g) compared to the other minerals. Furthermore, calcium is 86 mg/100 g, phosphorus is 412 mg/100 g, magnesium is 430 mg/100 g, iron is 9.2 mg/100 g and zinc is 3.8 mg/100 g. Quinoa seed is an excellent provider of calcium, phosphorus, magnesium, potassium, iron and zinc according to the research. The same outcomes

were reported with (Maldonado-Alvarado *et al*., 2023 and Galvez *et al*., 2010) [9].

It can also be revealed that the calcium, phosphorous, magnesium, potassium, iron and zinc content of wheat was found to be 21.10 mg/100 g, 165.20 mg/100 g, 31.40 mg/100 g, 170 mg/100 g, 2.4 mg/100 g and 1.3 mg/100 g respectively. The results are also in close agreement to (Renu and Seema, 2013 and Jyotsana *et al*., 2015) [17, 6].

Proximate composition of vermicelli incorporated with quinoa flour

The proximate composition of a food product holds significant importance in both its processing and consumption. A nutritionally complete food should contain adequate amounts of both macronutrients (such as carbohydrates, proteins, fats, fiber) and micronutrients (including vitamins and minerals). Thus formulating nutrient-rich foods not only ensures a balanced diet but also promotes good health in individuals. Assessing the nutritional value of a product relies heavily on its chemical characteristics. For instance the levels of moisture, fat, protein, carbohydrates, crude fiber and ash in vermicelli enriched with quinoa flour were measured and are detailed in Table 4.

Table 4: Proximate composition of vermicelli incorporated with quinoa flour

Treatments	Parameters					
	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)
V_0	5.80	1.20	10.20	2.45	3.20	77.15
V_1	5.90	2.00	11.28	2.64	3.28	74.90
V_2	6.10	2.50	11.82	2.74	3.32	73.52
V_3	6.25	3.05	12.36	2.83	3.36	72.15
V_4	6.34	3.40	12.90	2.95	3.40	70.01
SE ±	0.037	0.062	0.034	0.009	0.064	0.173
CD at 5%	0.113	0.188	0.104	0.028	0.195	0.523

*Each value is average of three determinations

The study examined the proximate composition of various vermicelli formulations incorporating quinoa flour. The data depicted in the table above indicates that as the proportion of quinoa seed flour increased in the vermicelli there was a notable rise in protein, ash, fat, crude fiber and moisture content along with a decrease in carbohydrate content. Notably the control sample exhibited the lowest moisture content at 5.8% compared to other samples with sample V_1 slightly higher at 5.9%, while sample V_4 recorded the highest moisture content at 6.34%. Samples V_2 and V_3 showed moisture content of 6.1% and 6.25% respectively. Sample V_4 had the highest moisture content which was on par with samples V_2 and V_3, and significantly higher than samples V_0 and V_1. This increase in moisture content could be attributed to the higher moisture retention capacity of quinoa seed flour compared to wheat flour. The variation in moisture levels among the vermicelli samples may be explained by the elevated fiber content present in quinoa flour. The increased presence of hydroxyl groups in cellulose a component of fiber facilitates stronger binding with free water molecules through hydrogen bonding as suggested by (Rosell *et al*., 2001) [18]. Consequently this leads to an enhanced capacity to retain water. Hence the higher the incorporation of quinoa flour the higher the observed moisture content value.

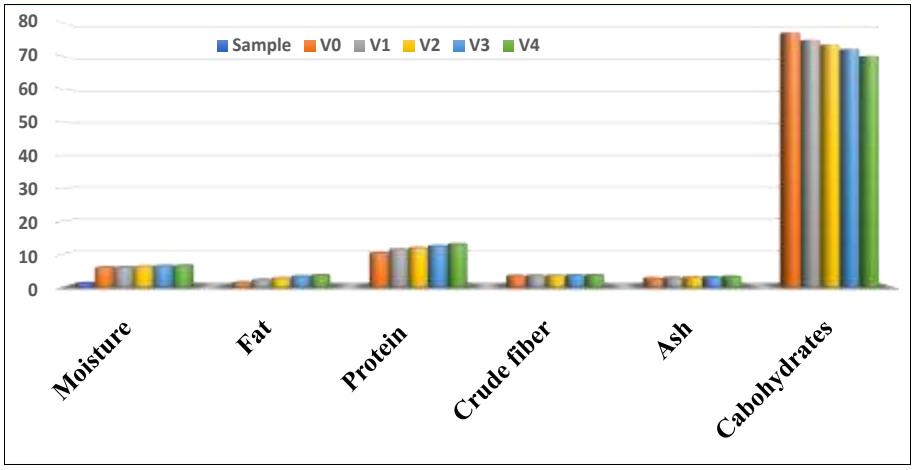
The fat content of vermicelli also recorded fairly rise in fat. The sample V_4 recorded highest fat content (3.4%) which was at par with sample V_3 and significant over sample V_0, V_1 and V_2. The lowest fat content was observed in the control sample (1.20%), whereas the fat content of samples V_1, V_2 and V_3 was found to be (2.0%), (2.5%) and (3.05%) respectively. The fat content of vermicelli samples with the incorporation of quinoa flour, on the other hand, was shown to be increased. These changes could be attributed to the more fat content of quinoa flour than that of wheat semolina. With the incorporation of quinoa flour, the protein content of vermicelli was slightly increased. The highest value of protein content was observed in sample V_4 (12.90%), while the lowest value was reported in the control (10.20%). The protein content in the V_1, V_2 and V_3 samples was (11.28%), (11.82%) and (12.36%), respectively. The results showed that samples have enhanced protein levels by adding high protein quinoa flour (Sanchez-Resendiz *et al*., 2019) [20]. Stikic *et al*., (2012) [26] recorded the similar finding with regards to protein enhancement through supplementation by quinoa.

The fat content of the vermicelli exhibited a notable increase particularly in sample V_4 which recorded the highest fat content at 3.4% at par with sample V_3 and significantly higher than samples V_0, V_1 and V_2. Conversely the control sample displayed the lowest fat content at 1.20% while samples V_1, V_2 and V_3 showed fat content of 2.0%, 2.5% and 3.05% respectively. This increase in fat content in vermicelli samples incorporating quinoa flour can be attributed to the higher fat content present in quinoa flour compared to wheat semolina. Moreover the incorporation of quinoa flour led to a slight increase in the protein content of the vermicelli. Sample V_4 exhibited the highest protein content at 12.90% whereas the control sample had the lowest at 10.20%. Samples V_1, V_2 and V_3 displayed protein contents of 11.28%, 11.82% and 12.36% respectively. These findings suggest that the addition of high-protein quinoa flour enhanced the protein levels in the samples as noted by (Sanchez-Resendiz *et al*., 2019) [20]. The indicating a protein enhancement through quinoa supplementation similar results were reported by (Stikic *et al*., 2012) [26].

The fiber content of the vermicelli ranged from 3.2% to 3.4%. Sample V_4 exhibited the highest fiber content at 3.4% while the control sample had the lowest at 3.2%. Samples V_1, V_2, and V_3 showed fiber content of 3.28%, 3.32% and 3.36% respectively. Regarding ash content there was some variation among samples with values ranging from 2.45% to 2.95%. Sample V_4 recorded the highest ash content at 2.95% while the control sample had the lowest at 2.45%. Samples V_1, V_2 and V_3 displayed ash content of 2.64%, 2.74% and 2.83% respectively. These findings align with the results reported by (Olga *et al*., 2021) [12].

Moreover there was a gradual decrease in the carbohydrate level across all samples with a noticeable declining trend from V_1 to V_4. This decrease could be attributed to the higher protein and fiber content present in quinoa. Sample V_0 exhibited the highest carbohydrate content at 77.15% while the lowest value was recorded in sample V_4 at 70.01%. Sample V_3 on the other hand showed a carbohydrate content of 72.15%. The reduction in carbohydrate content may result from processes such as transglucosidization which generates unconventional glycoside links not recognized by amylolytic enzymes as indicated by (Hernandez *et al*., 2017) [5]. There were minimal changes observed in the proximate composition of vermicelli incorporating quinoa flour compared to vermicelli without quinoa flour (control).

Navruz and Sanlier (2016) [27] stated that the superiority of quinoa over other grains stems from its higher protein, lipid and ash content when incorporated into products. The decrease in carbohydrate content across all formulated samples can be attributed to quinoa's lower percentage of carbohydrates compared to wheat. Sharma *et al*., (2017) [21] also reported that there was a slight change in the fat and protein content of all vermicelli samples prepared by the incorporation quinoa flour.



Mineral composition of vermicelli incorporated with quinoa flour

The mineral composition of the developed vermicelli samples was analyzed and compared to the control sample. The results presented in Table 5 demonstrate the impact of adding quinoa flour on the mineral content of the vermicelli. It was observed that incorporating quinoa flour had only a slight effect on the mineral content of the vermicelli. The details regarding the mineral content of vermicelli enriched with quinoa flour are outlined in Table 5.

Table 5: Mineral composition of vermicelli incorporated with quinoa flour

Treatments	Parameters (mg/100 g)					
	Calcium	Phosphorus	Magnesium	Potassium	Iron	Zinc
V_0	18.80	125.80	15.40	98.36	1.24	1.05
V_1	28.60	176.12	52.60	212.70	2.60	1.65
V_2	32.40	204.14	70.50	273.40	3.40	1.94
V_3	38.80	232.60	89.90	334.80	4.20	2.24
V_4	46.20	252.80	107.60	395.50	5.10	2.46
SE ±	0.040	0.850	0.329	0.668	0.048	0.008
CD at 5%	0.122	2.559	0.992	2.013	0.144	0.024

*Each value is average of three determinations

It could be demonstrates from Table 5 that the inclusion of quinoa flour in vermicelli led to notable enhancements in mineral content. The control batch exhibited 18.80 mg/100 g of calcium, 125.8 mg/100 g of phosphorus, 15.4 mg/100 g of magnesium, 98.36 mg of potassium, 1.24 mg/100 g of iron and 1.05 mg/100 g of zinc. Conversely sample V_3 showed increased levels with 38.80 mg of calcium, 232.6 mg of phosphorus, 89.9 mg of magnesium, 334.8 mg of potassium, 4.2 mg of iron and 2.24 mg of zinc. These findings align with those reported by (Sharma *et al*., 2023) [22].

The calcium content in samples V_1, V_2 and V_4 measured at 28.60, 32.40 and 46.20 mg/100 g respectively while phosphorus content stood at 176.12, 204.14 and 252.8 mg/100 g, magnesium at 52.6, 70.5 and 107.6 mg/100 g, potassium at 212.7, 273.4 and 395.5 mg/100 g, iron at 2.6, 3.4 and 5.1 mg/100 g and zinc at 1.65, 1.94 and 2.46 mg/100 g correspondingly. The increase in mineral content across all samples could be attributed to the incorporation of quinoa flour. This augmentation aligns with the inherent high mineral content of quinoa as noted by (Maldonado-Alvarado *et al*., 2023) [9].

According to Varli and Sanlier (2016) [27] the mineral content of the samples showed a rise corresponding to the increase in quinoa quantity. Quinoa demonstrated higher calcium and iron content compared to other frequently utilized grains and incorporating these grains alongside moringa leaves powder notably boosted the mineral content of the resulting vermicelli.

In their study, Renu and Seema (2013) [17] formulated vermicelli using a blend of malted wheat flour, green gram dal, spinach and sago flour referred to as vermicelli-MGS. They discovered that this vermicelli exhibited the highest

mineral content across various elements including calcium, phosphorus, sodium, potassium, zinc and copper.

The mineral composition of vermicelli varied noticeably between the sample with quinoa added and the control. Consequently the study concluded that quinoa had a substantial impact on enhancing the mineral content of vermicelli. These findings regarding the mineral composition of vermicelli closely align with those reported by (Lande *et al*., 2017). [8]

Dietary fiber content of vermicelli incorporated with quinoa flour

Dietary fiber refers to the portion of plant matter in our diet that remains undigested by enzymes. This includes cellulose, noncellulosic polysaccharides like hemicellulose, pectic substances, gums, mucilages and lignin is a non-carbohydrate component. Diets abundant in fiber, found in foods like cereals, nuts, fruits and vegetables are associated with improved health outcomes and a reduced risk of various diseases. The data pertaining to dietary fiber content of vermicelli has been depicted in Table 6.

Table 6: Dietary fiber content of vermicelli incorporated with quinoa flour

Treatments	Parameters		
	Insoluble dietary fiber (%)	Soluble dietary fiber (%)	Total dietary fiber (%)
V_0	3.14	1.02	4.16
V_1	5.20	1.08	6.28
V_2	6.19	1.12	7.31
V_3	7.24	1.16	8.40
V_4	8.32	1.25	9.97
SE ±	0.032	0.010	0.016
CD at 5%	0.098	0.031	0.048

*Each value is average of three determinations

The dietary fiber content in prepared vermicelli was found to be increasing in order with increase in quinoa flour. The lowest dietary fiber was reported in control sample of vermicelli prepared from wheat semolina. The IDF and SDF values for control vermicelli were 3.14% and 1.02% respectively. Whereas the dietary fiber was found to be increased in each sample with addition of quinoa flour highest for sample V_4 had 8.32 IDF and 1.25% SDF while sample V_3 had 7.24 IDF and 1.16% SDF respectively. Sample V_1 had 5.2% IDF and 1.08% SDF whereas sample V_2 had 6.19% IDF and 1.12% SDF respectively. The results are in close agreement with (Pedrali *et al*., 2023) [14].

The dietary fiber content in the prepared vermicelli showed a consistent increase corresponding to the addition of quinoa flour. The vermicelli made from wheat semolina serving as the control sample exhibited the lowest dietary fiber content with IDF and SDF values of 3.14% and 1.02% respectively. Conversely each sample containing quinoa flour demonstrated elevated levels of dietary fiber with the highest values recorded in sample V_4 reaching 8.32% IDF and 1.25% SDF. Sample V_3 displayed 7.24% IDF and 1.16% SDF while sample V_1 and V_2 had IDF values of 5.2% and 6.19% respectively with corresponding SDF values of 1.08% and 1.12%. These findings closely resemble those reported by (Pedrali *et al*., 2023) [14].

Azkia *et al*., (2021) [2] observed similar trends of increasing dietary fiber in sorghum noodles. They found that noodles made with a combination of 20% sorghum flour, 30% moong bean flour and 50% sago flour had the highest dietary fiber content at 13.16% with 4.2% soluble dietary fiber (SDF) and 9.48% insoluble dietary fiber (IDF). Lambo *et al*., (2005) [7] noted that cereals constitute a significant source of dietary fiber contributing approximately 50% of fiber intake in western diets. In the prepared vermicelli insoluble dietary fiber content was higher compared to soluble dietary fiber.

Conclusion

The use of quinoa flour improved the nutritional status of vermicelli in different formulations. The proximate composition, mineral content and dietary fiber content of all vermicelli samples were seen increasing which may be attributed to the addition of quinoa flour. Traditional extrusion product like vermicelli could be prepared by incorporating with 50% quinoa flour was found to be highly acceptable in terms of nutritional qualities. The nutritional quality of quinoa based vermicelli was superior in terms of proximate composition, mineral content and dietary fiber content.

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