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Assessing the effect of quinoa and moringa on low gluten vermicelli formulation

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Abstract
The grain Quinoa is declared as a highly nutritious grain which possesses no gluten, which is why its demand is rising worldwide. It has now become an appreciable tradition to switch consumption to the grains which are rich in nutrients rather than the ones which have been traditionally used; additionally leaves of Moringa have been recognized as prophylactic and as source of various medicinal and nutritional benefits. This paper elaborates on the physical, cooking properties and storage analysis of 'low gluten vermicelli' fortified with quinoa and moringa leaf powder. Summarizing the results of all the experiments conducted, the quinoa floor addition was suitable up to 60% for preparation of palatable, nutritional and low gluten vermicelli. Addition of 1g powdered moringa leaves in every 100g of flour mixture led to nutritional enhancement of prepared vermicelli. Addition of tragacanth gum led to better binding of dough while vermicelli formulation. It provides a better, healthy and convenient alternative to the consumers especially celiac patients as gluten content decreased from 7.21% (in 100% refined wheat flour combination) to 2.8% in combination which contained 60% quinoa and 40% refined wheat flour.

Keywords: Assessing, quinoa, moringa, vermicelli, formulation

Introduction
Quinoa (*Chenopodium quinoa*) is a pseudo-cereal whose popularity is steadily growing across the world. It has exceptional nutritional characteristics and is regarded as a superfood since it includes a significant quantity of protein, vitamins (particularly Vitamin E), and heart-healthy fats such as MUFA, omega-3 fatty acid, and - linolenic acid (Bhargava *et al*., 2006) [2].
It is also suitable for celiac patients because it is gluten-free. Moringa oleifera is a plant that has a wide range of uses, including nutritional and therapeutic ones. It comprises essential amino acids, carotenoids, important antioxidants, antibiotics, vitamins, minerals and nutraceutical components that encourage the concept of using this plant as a dietary supplement or as a food preparation part (Razis *et al*., 2014) [10]. Gluten is a protein present in grains such as wheat, rye, and barley that gives them their chewiness, softness, and other textural qualities. In certain gluten-sensitive persons, the gluten protein causes an immune response. Gluten-free and low-gluten diets are becoming increasingly popular, owing to increased knowledge of gluten sensitivity. Several non-gluten cereals and starches (rice, maize, quinoa, sorghum, millets, and potato/pea starch) as well as gluten replacers (xanthan and guar gum) have been employed to maintain the physical-sensory features of gluten-free cereal-based goods.
Cold extrusion is a process of mixing and shaping foods such as pasta and other shaped food items in which the food temperature stays ambient. Extrusion at low temperatures (below 100 °C) is commonly used to make pasta and vermicelli (Wang *et al*., 1994) [12]. Its advantages include low cost, long life, and adaptability in the processing of a wide range of foods. Bioactive compounds are added to basic mixes for the production of functional meals, with cereals, legumes, and other nutrient-rich foods being the primary suppliers (Martha *et al*., 2017) [6]. The word "extrude" comes from the Latin words "ex" meaning "out" and "trude" meaning "to push." (Kehinde Adedeji Adekola, 2016) [5].

Materials and Methods
Preparation of raw materials
Quinoa was turned into flour by grinding in a hammer mill. Moringa leaves were cleaned, shade dried, and milled into a fine powder to minimize color and nutritional losses. Table 1 shows how to make samples of various formulas by adding the pre-calculated amount of flour.

Utensils and accessories made of food-grade stainless steel (SS 304) were used to make the vermicelli (Sharma *et al.*, 2023) [11].

Preparation of vermicelli

Under pre-set operating parameters, the dough was fed to the single-screw extruder feeder. The vermicelli were gathered in the trays once they came out of the extruder. Vermicelli was collected, dried, wrapped, and packed in a variety of materials. Extrudates that had been prepared were investigated further in accordance with the study's requirements.

Table 1: Formulation of vermicelli fortified with quinoa and powdered moringa leaves

Samples	Quinoa (g)	Refined wheat flour (g)
V1(control)	0	100
V2	20	80
V3	40	60
V4	60	40
V5	80	20
V6	100	0
Other ingredients used in combinations (other than control): Moringa leaf powder: 1g, Edible oil: 2ml, Tragacanth gum: 1g		

Physical analysis

Physical properties were estimated such as dimensions which were taken manually by Vernier calliper, water absorption capacity and oil absorption capacity by centrifugation method; bulk density using Ranganna (1986) [9] method, true density using toluene displacement method, porosity by difference, 1000 Kernel weight and 1000 Kernel volume according to Williams *et al*., 1983 [13]; hydration index as hydration capacity per seed divided by the weight of 1 seed in grams; were estimated accordingly for whole grains (quinoa and wheat), powdered material (quinoa flour, refined wheat flour and moringa leaf powder) and prepared samples.

Cooking characteristics

Cooking characteristics were estimated such as total gruel loss by IS 1485:1993 method, cooked weight according to AACC (2000) [1] method, cooking time according to method of Ding *et al.*, (2013) and swelling index by method proposed by (Mestres *et al*., 1988) [7].

Storage studies

Storage study for 120 days was conducted for the best made extrudates. The packaging material used for the storage was PVC boxes, aluminum foil and paper laminated aluminum foil. During the storage period, proximate and sensory evaluation was done every week to check the nutritional properties, acceptability and shelf stability of the produced extrudates.

Statistical analysis

Entire analysis was performed in triplicate. The analytical data obtained for low gluten quinoa vermicelli was subjected to analysis using complete randomized design (Panse and Sukhatme, 1984) [8].

Results and Discussion

The physical properties (table 2,3,4) of raw materials and formulated vermicelli are summarized. The results showed that the length of the vermicelli decreased with increasing quinoa content from 0 to 100%. The diameter of the vermicelli strands was found to be constant at 0.14 cm as all the combinations were extruded through the same die. The water absorption capacity (WAC) values of the samples were higher than the control due to the addition of tragacanth gum to all samples. On the other hand, the oil absorption capacity (OAC) values of the samples were lower than the control due to the addition of 2 ml edible oil before extrusion. The bulk density and true density of the samples were found to be significantly lower than the control due to the addition of moringa leaf powder and quinoa flour. The porosity of the vermicelli samples was greater than the control, which was attributed to the addition of quinoa and moringa leaf powder that resulted in higher water absorption during kneading and later evaporated during drying, leaving voids behind. The 1000 kernel weight and volume values were found to be consistent with previous studies, while the hydration index showed that the hydration capacity of wheat was higher than that of quinoa. These results provide useful information for understanding the physical properties of formulated vermicelli and can guide future research and product development.

Table 2: Physical properties of grains used in various vermicelli combination

Grains	BD (g/ml)	TD (g/ml)	Porosity (%)	1000 KW (g)	1000KV (ml)	Hydration index (g/100seeds)
Quinoa grains	0.60	1.03	41.74	4.2	5.4	1.07
Wheat grains	0.761	1.14	34.51	22.91	29.16	3.91

Table 3: Physical properties of raw materials used in various vermicelli combinations

Raw materials	BD (g/ml)	TD (g/ml)	Porosity (%)	WAC (%)	OAC (%)
Quinoa flour	0.541	1.745	70.29	107.4	113.6
Refined wheat flour	0.648	1.711	62.12	136	142
Moringa leaf powder	0.69	1.26	45.23	102.76	113.2

Table 4: Physical properties of vermicelli fortified with quinoa and moringa

Samples	Length (cm)	Diameter (cm)	WAC (%)	OAC (%)	BD (g/ml)	TD (g/ml)	Porosity (%)
V1	27.5	0.14	142.27	141.62	0.52	0.67	22.38
V2	24.1	0.14	157.30	125.42	0.39	0.51	25.49
V3	20.5	0.14	154.54	121.37	0.4	0.55	27.27
V4	14.12	0.14	152.66	117.94	0.42	0.59	28.81
V5	11.83	0.14	150.41	114.35	0.44	0.62	29.03
V6	4.5	0.14	147.23	109.05	0.44	0.64	31.25
SEM	0.229	0.102	0.021	0.031	0.072	0.105	0.012
CD @ 5%	0.088	0.013	0.067	0.065	0.103	0.158	0.035

The cooking properties of vermicelli samples were analyzed to determine the quality characteristics of the product as depicted in Fig 1 and Table 5. The total gruel loss was found to be in the range of 2-7%, which meets AGMARK specifications. The addition of gum helped to reduce cooking loss and increase firmness and cohesiveness. The cooked weight of the vermicelli samples did not vary much, but it was different compared to the control due to the presence of gum.

Cooking time was reduced due to the increased porosity of the vermicelli, which led to quicker water uptake. The swelling index was higher in the formulated vermicelli samples compared to the control, due to the addition of gum. Overall, the functional properties of vermicelli, such as cooking loss, firmness, and cohesiveness, determine the quality of the product. Superior quality vermicelli has low cooking loss, is firm and does not stick, and does not release excessive organic matter into the cooking water. The results of this analysis indicate that the cooking properties of vermicelli are influenced by the presence of gum and the formulation of the product.

Table 5: Cooking characteristics of vermicelli fortified with quinoa and moringa

Samples	Total gruel loss (%)	Cooked weight(g)	Cooking time(min)	Swelling index
V1	**2.76**	60	~7	2.42
V2	4.67	65.25	~6	2.61
V3	5.27	65.44	~6	2.62
V4	5.70	65.68	~6	2.62
V5	6.21	64.93	~6	2.63
V6	6.84	65.75	~6	2.62
SEM	0.026	0.058	0.031	0.042
CD @ 5%	0.073	0.148	0.125	0.141

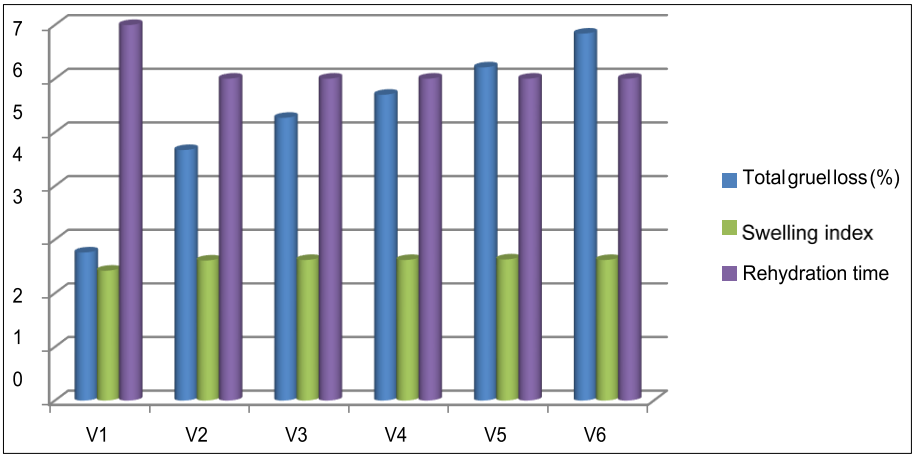

Fig 1: Cooking characteristics of vermicelli fortified with quinoa and Moringa

Storage studies

The storage study assessed the 120-day shelf life of sample V4 and control V1 at a temperature of 35 ± 5°C and relative humidity of 75 ± 10% using three distinct packaging materials. Literature review, such as Ganga *et al*. (2014) and Devika and Tahira (2016), showed similar results in the extended storage of food products, such as moringa noodles and multigrain vermicelli, without significant degradation. The data collected at 30-day intervals indicated minimal changes in the moisture content and sensory attributes of the products packaged in the various materials. Among the three packaging materials, the PVC box exhibited the lowest moisture barrier performance, while the paper laminated aluminum foil provided the best results with comparatively lower moisture uptake. This superior performance of the plastic laminated aluminum foil can be attributed to its dual-layer structure, wherein the aluminum foil outer layer acts as a barrier to moisture entry and any ingress is absorbed by the inner butter paper layer, thus preventing the packaged product from exposure to moisture.

Table 6: Moisture content of stored vermicelli fortified with quinoa and moringa

Formulations	0 days	30 days	60 days	90 days	120 days
PVC V1	8.89	8.97	9.08	9.21	9.42
PVC V4	8.77	8.86	8.98	9.19	9.39
AF V1	8.89	8.91	8.95	8.98	9.05
AF V4	8.77	8.8	8.84	8.94	8.99
PLAF V1	8.89	8.91	8.93	8.95	8.96
PLAF V4	8.77	8.8	8.82	8.86	8.91

PVC- Poly vinyl chloride rigid container, AF- Aluminum foil, PLAF- paper laminated aluminum foil

Table 7: Sensory evaluation of vermicelli fortified with quinoa and moringa during storage

Attributes	0 days		30 days		60 days		90 days		120 days	
	V1	V4	V1	V4	V1	V4	V1	V4	V1	V4
PVC rigid containers										
Color and appearance	8.89	8.23	8.81	8.14	8.78	8.01	8.65	7.82	7.54	7.36
Taste	8.64	8.58	8.2	8.46	8.37	8.32	7.87	7.9	7.32	7.39
Texture	8.82	8.03	8.7	7.94	8.76	7.82	8.56	7.62	8.32	7.56
Flavor	8.2	8.56	7.98	8.48	7.73	8.28	7.46	8.14	7.4	7.71
Overall acceptability	8.63	8.35	8.42	8.27	8.41	8.11	8.14	7.87	7.65	7.51
Al foil										
Color and appearance	8.89	8.23	8.86	8.18	8.82	8.07	8.65	7.91	7.54	7.45

Taste	8.64	8.58	8.6	8.52	8.41	8.39	8.2	8.1	7.51	7.41
Texture	8.82	8.03	8.79	8	8.8	7.86	8.61	7.79	8.32	7.72
Flavor	8.2	8.56	8.1	8.53	7.81	8.32	7.55	8.16	7.4	7.78
Overall acceptability	8.63	8.35	8.59	8.31	8.46	8.16	8.25	7.99	7.69	7.59
Paper laminated aluminum foil										
Color and appearance	8.89	8.23	8.88	8.21	8.84	8.14	8.66	8.01	7.59	7.48
Taste	8.64	8.58	8.63	8.54	8.46	8.42	8.23	8.14	7.57	7.48
Texture	8.82	8.03	8.82	8.01	8.82	7.93	8.67	7.82	8.36	7.74
Flavor	8.2	8.56	8.2	8.54	7.87	8.36	7.61	8.21	7.49	7.89
Overall acceptability	8.63	8.35	8.63	8.33	8.50	8.21	8.29	8.05	7.75	7.65

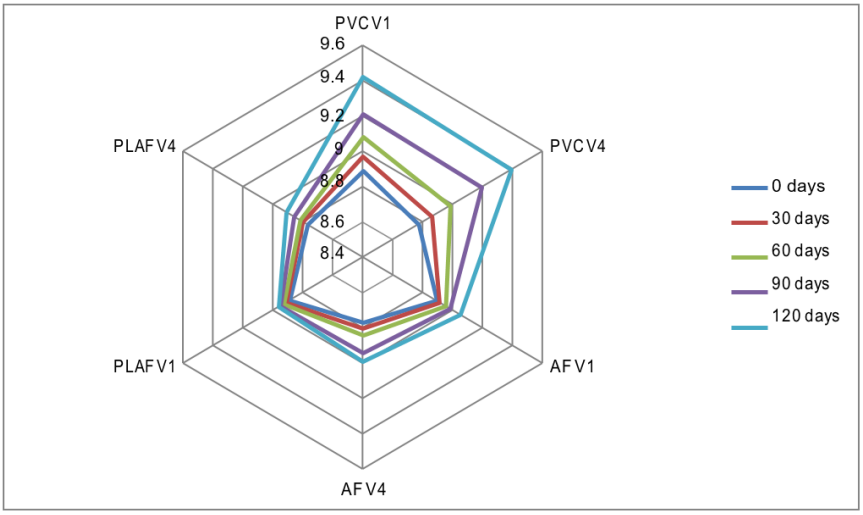

Fig 2: Sensory evaluation of vermicelli fortified with quinoa and moringa during storage

Conclusion

In conclusion, the study aimed to formulate and evaluate low gluten vermicelli using a combination of quinoa and powdered moringa leaves. The results showed that up to 60% of quinoa usage was sufficient for producing a nutritious and palatable product, and the addition of 1 gram of moringa powder per 100 g of quinoa-wheat flour mixture helped to improve the nutritional content and color of the vermicelli. The physical characteristics, such as length, diameter, water absorption capacity, bulk density, and texture, were found to vary among the different formulations. During cooking, the control sample (V1) had the least gruel loss and cooking time, while the sample with the highest quinoa usage (V6) had the most significant gruel loss and the shortest cooking time. The results of the storage analysis, conducted over 120 days using different packaging materials, showed that paper laminated aluminum foil was the best in retaining the moisture content and overall acceptability of the product. Overall, the results of this study suggest that the combination of quinoa and moringa can be used to produce a low gluten, nutritious, and palatable vermicelli product.

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