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Nutritional and physical properties of pseudo-cereal based geriatric food mix supplemented with moringa leaves

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Abstract
The cornerstone of geriatric nutrition is a well-balanced diet. In this study, an attempt has been made to formulate a geriatric food gruel mix with higher nutritive value. All geriatric food mixes prepared from quinova, amaranth, moringa and other ingredients were nutritionally superior in terms of protein, fat, fibre, ash, iron, zinc and ascorbic acid but carbohydrate content was estimated as lower than control sample in all modified formulations. Thus in the light of the scientific data it may be concluded that quinoa, amaranth (pseudo-cereal) and moringa are good source of macro and micro nutrients hence open the way of introducing these materials to daily food items to prevent health problems.

Keywords: Geriatric nutrition, Geriatric food, Quinoa, Amaranth and Moringa.

1. Introduction

During the aging process, certain inevitable degenerative changes that occur result in functional decline. These are influenced by genetics, nutrition, socio-economic, psychological conditions, illness and availability of health care facilities. Hence proper nutrition and health care are necessary for them to lead a normal life. In this connection, it is important to consider inter related aspects such as ageing process and need for good nutrition [1].

Several gluten-free grains exist, such as the pseudo-cereals amaranth and quinoa which are characterized by an excellent nutrient profile. Thus, an increasing trend in research is focusing on their use in the formulation of high quality, healthy gluten-free products such as bread and pasta. However, commercialization of these products is still quite limited. The availability of palatable pseudo- cereal containing gluten-free products would represent a significant advance towards ensuring an adequate intake of nutrients.

Moringa oleifera belonging to the family of Moringaceae is an effective remedy for malnutrition. Moringa is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods and seeds. The leaves of *M. Oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper [2]. Vitamins like beta-carotene, vitamin-B such as folic acid, pyridoxine and nicotinic acid, vitamin-C, D and E also present in *M. Oleifera* [3]. Phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar present along with anti-cancerous agents like glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate [4]. A good dietary intake of zinc is essential for proper growth of sperm cells and is also necessary for the synthesis of DNA and RNA. *M. Oleifera* leaves show around 25.5–31.03 mg of zinc/kg, which is the daily requirement of zinc in the diet [5].

Hence, elongation of a healthy life expectancy in an ageing society is a significant social issue globally as well as in India. Diet, nutrition and lifestyle have a direct influence on health and well-being of ageing population. Development of therapeutic functional food from wholesome grains such as quinoa, amaranth along with moringa leaves can be an ideal vehicle for not only specific nutrients but also functional for geriatric population.

Thus the present study was undertaken to evaluate the pseudo-cereal based functional foods for geriatric population.

2. Materials and Methods

Raw commodities

Moringa leaves (variety PKM1) have been procured from JNKVV, Jabalpur. Quinoa grain, amaranth, green gram dahl, garlic, onion, tomato and fennel were collected from local market of Jabalpur. Good quality of moringa leaves were collected and cleaned properly by removing the insect damaged parts for drying. The cleaned leaves were steam blanched for 2-3 minutes then shade dried in room temperature [6]. The fresh spices (onion and garlic) were cleaned, chopped into small pieces and dried in hot air oven at 65 ˚C for 8-10 hours. Tomatoes were immersed in hot water (60 °C) for 1 min followed by peeling, cutting and drying at 55 °C for 48 hrs and powdered [7].

Treatment combinations

Table 1: Different formulations of geriatric food mix

Formulations (%)	T1	T2	T3	T4	T5
Wheat grits	70	-	-	-	-
Quinoa	-	55	50	50	45
MLP*	-	10	15	20	25
Amaranth powder	-	15	20	20	20
Greengram powder	30	20	15	10	10
Spice mix	20	20	20	20	20

*MLP – Moringa Leaf Powder

The spice mix was developed using 40% tomato powder and 20% each of onion, garlic and fennel powder.

Physical properties

Hunter Color Measurement

Color measurement of different cooked geriatric mix was done by using a Hunter color measuring system and expressed in terms of L*, a*, b*, according to the [8]. L* represents the brightness from white (100) to black (0). Red to green color component was indicated by the a* values and yellow to blue color components were indicated by the b* values.

Bulk Density (BD)

Known weight (5 gm) of sample was placed in a 10 ml measuring cylinder. The volume of mix was measured in a measuring cylinder after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed. Based on the weight and volume, the apparent (bulk) density was calculated and expressed in g/ml [9].

Reconstitution Index (RI)

The reconstitution index of the samples was determined according to method described by Onwuka 2005 [10].

$$\text{RI (g/ml)} = \frac{\text{Volume of sediment}}{\text{Weight of sample}}$$

Water absorption capacity (WAC)

Absorption capacity is expressed in grams of water absorbed per gram of sample [10].

Swelling index (SI)

The method as described by Ukpabi and Ndimele (1990) [11] was used in the determination of the swelling index.

$$\text{Swelling Index} = \frac{\text{Change in volume of sample}}{\text{Original weight of sample}}$$

Proximate composition

The nutritional evaluation of geriatric food mix with respect to various constituents was carried out by the standard procedures. Moisture was analyzed using the digital moisture analyzer at 100 °C for 10 minutes. The protein content in sample was determined by using conventional Micro-Kjeldhal digestion and distillation procedure as given in AOAC (2000) [12] using Pelican's Kel Plus digestion and distillation assembly. The fat content of the sample was determined by the procedure as described in AOAC (2000) [12] using Pelican's Sox plus automatic fat analysis system. The ash content present in the sample was determined according to the procedure given in AOAC (2000) [12] using Muffle furnace. Crude fibre was estimated by subtracting the sum of moisture, protein, fat, ash and carbohydrate from 100. Carbohydrate is determined by the method of Sadasivam and Manickame, 1992 [13].

Ascorbic acid

Ascorbic acid was determined according to the method described by Ranganna, 2002 [14].

Minerals

Estimation of minerals (Iron & Zinc) was done by diacid digestion method. 1 g of powdered sample was taken in a 100 ml conical flask and 15 ml of diacid mixture consisting of nitric acid and perchloric acid (5:2) was added. After digestion, the volume of aliquot was made to 100 ml. This acid digest was used for the determination of the minerals. The micronutrients *viz*., iron and zinc were determined by atomic absorption spectroscopy.

In-vitro Protein Digestibility

IVPD was determined by the method given by Singh et al, 1989 [15].

3. Results and Discussion

Physical attributes of geriatric food mix

The results of physical characteristics of all geriatric food mix i.e., reconstitution index, water absorption capacity, bulk density, swelling index and hunter color analysis (cooked) compared to control are given in the Table 2-3.

Table 2: Physical attributes of geriatric food mix

Formulations	Reconstitution Index (g/ml)	WAC (g/100g)	Bulk Density (g/ml)	Swelling Index
T1	6.8	135	0.85	1.70
T2	6.2	170	0.73	0.73
T3	5.2	177	0.71	0.83
T4	3.8	204	0.68	0.90

Reconstitution index

The data depicted in table-2 showed that reconstitution index with different formulations of geriatric food mix supplemented with moringa leaf powder varied from 3.6-6.8g/ml.

The reconstitution index of the prepared product was different from the wheat and green gram based formulation. It was evident that RI was decreased with modification (quinoa 45-55%, moringa 10-25% and amaranth 10-20%).This may be due to the use of different raw materials i.e. quinoa grain, amaranth flour, green gram flour and moringa leaves powder in different proportions.

Water absorption capacity

The water absorption capacity of geriatric food mix ranged from 135-204 g/100g which was observed to be high in all the quinoa and moringa leaves based products in comparison to wheat based control. It may be due to the increase the supplementation of the amaranth flour and decrease in the quinoa content in all formulations. Similar observations have been recorded by Stikic *et al.* (2012) [16] with regards to lower quinoa concentration in doughs. Similarly in case of amaranth substitution as reported by Tomoskozi *et al.* (2011) [17] showed an increase in the water absorption of the composite flours when amaranth substitution increased which is in line with the present findings. The increase in WAC may also be due to incorporation of MLP in geriatrics gruel mix.

Bulk Density

Bulk density is the measure of heaviness of material. Nutritionally lower bulk density promotes the digestibility of the product. Bulk density was decreased as compared to control sample with modification. This may be due to the increase in the content of the moringa and amaranth and continue decrease in quinoa seed content. The lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be derivable from such diets [18]. This low density values of the food samples implies that more of the samples could be prepared using a small amount of water yet giving the desired energy nutrient density and semi-solid consistency which can easily be fed to geriatrics. Similar finding was reported by Mosha and Lorri (1987) [19].

Swelling index

Swelling index is an important factor used to determine the amount of water that food sample would absorb and degree of swelling within a given time. Lower swelling capacity is an advantageous in geriatric feeding as it increases the nutrient density. Swelling index of all formulated samples was decreased from the control. Similar findings were reported by Olatain *et al*. (2014) [20] in the product formulated from pearl millet flour and moringa leaf powder. High value of control sample could be due to the water binding properties of the legume protein as control samples contains more green gram as compare to modified samples. The significant decrease in SI may be due to the lower concentration of pulse in the modified combinations. Similar findings were reported by Nelson and Cox, (2000) [21] with regards to use of soy flour in complementary foods. However geriatric foods do not require high swelling index as the food would absorb more water and have less solids resulting in low nutrients density for the elder.

Hunter colour analysis

Table 3: Hunter color analysis of cooked geriatric food mix

Formulations	L*	a*	b*
T1	55.22	1.32	17.91
T2	31.72	2.53	21.60
T3	32.87	2.97	22.65
T4	36.07	2.24	20.44
T5	33.14	3.67	22.57

L* - Lightness, a* - Red to green and b* - Yellow to blue

Geriatric food mix prepared with quinoa and moringa leaf showed significant differences in color values which may be due to incorporation of different type of ingredients in different concentration in the mix.

The wide range in lightness values observed for the samples may also be due to the ingredients color. In the product lightness values decreased more because leaf powder suppress the lightness. The a* value increased in all the modified formulations. Similarly for b* values of formulations, it increased. Jayathunge *et al.* (2012) [7] recommended that pre-treatment condition of blanching, affected the color of the dehydrated product. Hot water blanching at 60°C for 1 min. was found to be the most effective pre-treatment in preservation of red color of the dehydrated product.

Proximate composition of formulated geriatric food mix

There was increase in protein, ash, fat and crude fibre whereas the carbohydrate content was gradually decreased. This is due to increased proportion of moringa which has higher protein, ash and fibre content with lower carbohydrate content. Similarly quinoa and amaranth also increase the fat and fibre content in the prepared food mixes.

Arise *et al.* (2014) [22] and Olorode *et al.* (2013) [23] found that the addition of moringa leaf powder to ogi substantially improve the nutritional value of maize or millet gruel. The ogi sample with 15% moringa leaf substitution had the highest value of protein (17.63%) as reported by Abioye (2015)[24]. Stikic*et al.* (2012) [16] reported the similar finding with regards to protein enhancement through quinoa supplementation. Similar results were reported by Gonzalez *et al.* (2014) [25], Fardet (2010) [26], Lamothe *et al.* (2015) [27] as quinoa is an excellent source of dietary fibre, comprising about 2.6%-10% of the total weight of the grain, about 78% of its fibre content is insoluble and 22% soluble.

According to Ruales and Nair (1994) [28] the insoluble fraction of fibre does not differ by cooking but the soluble fibre can be decreased. Similarly Rita and Dietrich (2006) [29] reported that amaranth has twice as much fibre as corn and oats, and three times as much as wheat.

Table 4: Proximate composition of geriatric food mix

Formulations	Proximate composition (%)					
	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
T1	10.91	15.04	2.20	2.68	2.85	65.12
T2	10.50	16.60	4.22	6.68	3.66	57.88
T3	9.65	16.72	4.40	7.25	3.80	57.04
T4	10.36	16.02	4.60	7.68	3.90	55.44
T5	10.40	17.78	4.56	8.43	4.08	54.20
SEM	0.171	0.119	0.107	0.133	0.138	0.544
CD @ 5%	0.545	0.380	0.340	0.424	0.440	1.736

Alvarez *et al.* (2010) [30] and Schoenlencher *et al.* (2008) [31] also observed similarly that the lipid content of quinoa and amaranth is between 2 and 3 times higher than in other cereals such as maize and wheat.

Quinoa fat content (5.2 to 9.7%) is higher than maize (4.7%) and lower than soy (18.9%). Amaranth grain has higher lipid content than quinoa and most other cereal grains, and it is present between 5.7% and 10.9% (average 8.81%). Valencia *et al.* a & b (2010) [32, 33] and Shimelish and Martha (2012) [34] also reported that amaranth and quinoa has a considerably higher ash content (2.39%) than wheat flour and rice. Carbohydrate of all the formulated food mix decreased because the quinoa and moringa have lower percentage of carbohydrate in comparison to wheat.

Iron& Zinc

Table 5: Mineral content, ascorbic acid and IVPD of geriatric food mix

Formulations	Minerals mg/100g		Ascorbic acid mg/100g	IVPD (%)
	Iron (Fe)	Zinc (Zn)		
T1	08.95	2.66	49.05	83.24
T2	12.01	4.04	50.55	80.48
T3	13.13	4.21	51.22	78.42
T4	14.14	4.40	51.70	78.07
T5	15.69	4.60	52.38	77.78

Both, Iron and Zinc observed to be higher in modified formulations and this is due to the moringa leaves, quinoa and amaranth supplementation that have high content of iron and zinc than wheat. Similar finding was reported by Saini *et al.* (2014a) [35] and kasolo *et al.* (2010) [2] with regards to moringa mineral contents. The findings of Shimelis and Martha (2012) [34] are in line with the present findings that zinc, calcium and iron contents of bread increased as amount of amaranth substitution increased. Bressani *et al.* (1987) [36], Rathod and Udipi (1991) [37] reported that amaranth is an excellent source of calcium, iron, and magnesium. Zinc content was observed higher in the formulation because moringa leaf contains higher amount of zinc.The zinc content in quinoa and amaranth is not much higher than wheat but slightly more content of the zinc in the quinoa and amaranth than wheat as reported by Yamani and Silva Lannes (2012) [38].

Ascorbic Acid Content

Ascorbic acid is an important element of the food for seniors and all the formulated geriatric food mixes shown as good source of the ascorbic acid in comparison to wheat based gruel mix. In the modified formulations ascorbic acid content gradually increased with the increase in supplementation of moringa leaves and amaranth. This increment in the ascorbic acid content may be due to supplementation of moringa leaves which have good amount of ascorbic acid. Yamani and Silva Lannes (2012) [38] reported that amaranth is also a good source of ascorbic acid (4.50%). Vega-Galvez *et al.* (2010) [39] reported that quinoa contains more vitamin-c as compared to wheat.

***In-Vitro* Protein Digestibility**

The in-vitro protein digestibility of the food mix shows the availability of protein fraction out of total protein content. As per table 5, IVPD of the formulated geriatric food mix decrease from the control sample due to the increase in the leaf content. The IVPD of quinoa and amaranth is slightly less in comparison with the wheat and green gram. Maradini-Filho (2017) [40], James LAE (2009) [41], Comai (2007) [42] and Alves (2008) [43] stated that the protein digestibility or the bioavailability (true digestibility) of amino acids in quinoa varies according to the variety and treatment that the grains receive, increasing considerably with cooking. The findings of present study are in line with the results of Carrasco-Valencia and Serna (2011) [44] as they reported the IVPD of quinoa varied between 76.3% and 80%. Similarly the IVPD in moringa leaf flour was investigated by the Mune *et al.* (2016) [45] as 57.22%. Similarly Estelamar *et al.* (2014) [46] reported lower value for IVPD of *M. oleifera* leaf flour.

Conclusion

Thus in the light of the scientific data it may be concluded that quinoa and moringa are good source of macro and micro nutrients hence open the way of introducing these materials to daily food items to prevent health problems. The incorporation of these ingredients in the geriatric food could help to alleviate the deficit in protein, fibre, minerals in the elder population.

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