

## DEVELOPMENT AND EVALUATION OF EXTRUDED PRODUCTS FROM AMARANTHUS INCORPORATED NUTRITIOUS MIX

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### Introduction

India is one of the major contributors of agricultural produce to the world. Though the country has attained food security at the national level, hunger and malnutrition continue to haunt India despite Green, White and IT revolutions and economic reforms. Thus it is found that the country has to attain food security at household level. The main reason behind the lack in household food security is due to post harvest losses. Food processing is an important element to prevent post harvest losses and provide a better shelf life and nutrient quality. Processed foods include convenient foods like instant mixes, extruded foods, canned foods and dehydrated foods. Among the processed foods, extruded products and nutrient mixes have better shelf life and are easily acceptable by all age groups.

Green leafy vegetables are rich in micronutrients and could be used to prepare nutritious mixes to enhance their nutrient content. There are many studies available on the development, evaluation and supplementation of various health mixes utilizing whole and sprouted cereals and oil

seeds. Yet studies related to incorporation of fruits and vegetables with special interest to greens are limited. Amaranthus species are tender annuals, which are less expensive compared to other vegetables and are available throughout the year. Since they are micronutrient rich and also contain a variety of phyto-chemicals, it was thought of interest to select *Amaranthus spinosus* for incorporation in nutritious mix preparation. Hence, the present study was undertaken with the broad objective of developing nutritious mix based on locally available cereals, pulses and oil seeds incorporating amaranthus and evolve extruded products from these mixes.

### Materials and Methods

#### Preparation of nutritious mix

The selection of ingredients for the development of nutritious mix and extruded products were based on the availability, nutrient content and their cost. The ingredients were selected from all the basic five food groups containing whole wheat flour (45%) as base. The other ingredients included legumes like red gram dhal (10%) and green gram dhal (5%), groundnut (10%) wheat bran (2.5%), corn flour (12.5%), rice flakes (5%), oats (5%) and skim milk powder (5%).

Wheat flour and corn flour were sifted thrice; wheat bran, rice flakes and oats were powdered. red gram dhal and green gram dhal were dry roasted to golden brown colour for a period of 3 to 5 minutes and powdered. The skin and spoilt roasted groundnut were removed and powdered.

The drying of *Amaranthus spinosus* included sorting, washing, blanching for two minutes in boiling water and sun drying<sup>1</sup>. The increase in weight after blanching was +20/100g, sun drying time was 50 to 60 minutes and the dried form of greens obtained was 14.5g/100g.

The basic ingredients after pre processing as stated above were blended, powdered and developed in the form of a nutritious mix. The mix without the addition of amaranthus powder was termed as standard nutritious mix. Dried and processed amaranthus powder was incorporated at a level of 2.5 to 10 per cent and termed as amaranthus incorporated nutritious mix.

#### **Development of extruded products**

From the formulated nutritious mix, products like noodles (2.5 to 10 %) were prepared manually by steaming the nutritious mix and extruded into noodles and sun dried. After the organoleptic evaluation of manually extruded product based recipes, the best accepted products were developed in the shape of swirl and vermicelli using pasta making equipment.

#### **Preparation of recipes**

The recipes included for the organoleptic analysis of nutritious mix were

adai, idli, missiroti, porridge and pittu. The incorporation of nutritious mix in the recipes ameliorates the vitamin and mineral deficiency of the recipes. The best accepted incorporation of manual noodles was extruded using pasta machine to develop vermicelli and swirl pasta and the recipes like payasam, soup, vegetable vermicelli, pakoda and tomato bhath were prepared. The prepared recipes were organoleptically evaluated by a trained panel of 25 judges using the five point rating scale. The best accepted incorporations were analysed for their quality characteristics, nutrient content and microbial load.

#### **Analysis of quality characteristics**

The accepted extruded products were analyzed for the quality characteristics namely wettability, cooking time, cooked weight, rehydration ratio and percentage water in rehydrated material. These characteristics were analysed before and after dry roasting without any addition of fat for a period of three to five minutes till a slight colour change in the product was observed.

Wettability of the accepted samples was evaluated by difference between known weight of dried sample and drained weight of the wet sample<sup>2</sup>. The rehydration ratio and percentage water in rehydrated sample were analyzed according to specifications<sup>1</sup>. Rehydration ratio is defined as the ratio between the drained weights of the rehydrated sample to the weight of dehydrated sample.

The formula to find out the percentage water in rehydrated sample was

$$\text{Percentage water in rehydrated sample} = \frac{\text{Drained weight of the sample} - \text{Dry matter content in the sample taken for rehydration}}{\text{Drained weight of rehydrated sample}} \times 100$$

### **Nutrient analysis**

The standards and best accepted incorporations of nutritious mix (5% amaranthus) and extruded products (2.5% amaranthus) were analysed for their moisture, ash, protein, fat, calcium, phosphorus, iron,  $\beta$ -carotene, thiamine and riboflavin content. The estimation of fat was done by soxhlet method. The carbohydrate analysis was done by anthrone method. The proximate principles were analyzed using the AOAC<sup>3</sup> methods. Thiamine and riboflavin content of the samples were analyzed by the fluorimetric methods. HPLC method was adopted for the analysis of  $\beta$ -carotene. Microbial analysis and cost comparison of the developed products were also carried out.

### **Results and Discussion**

#### **Organoleptic evaluation**

The sensory attributes of the recipes prepared with the addition of developed nutritious mix showed that idli, missiroti and porridge were accepted at the level of 5 per cent amaranthus incorporation; adai at 7.5 per cent incorporation; and pittu at 2.5 per cent amaranthus incorporation. The organoleptic evaluation of recipes prepared with manual noodles showed that soup, pakoda and tomato bhath were accepted

at 2.5 per cent amaranthus incorporation; payasam and vegetable vermicelli at 5 per cent amaranthus incorporation. Thus it was arrived as the standard that 5 per cent of amaranthus incorporation was best accepted for nutritious mix and 2.5 per cent for manual noodles. The machine made extruded products was prepared at the level of 2.5 per cent amaranthus incorporation.

#### **Quality characteristics**

Table I presents the results on the quality characteristics of the extruded products. The rehydration ratio was more for standard noodles (1:2.54) after roasting and the least was observed as 1:1.08 for the amaranthus incorporation before roasting. The percentage water in the rehydrated material was 53 for the standard after roasting whereas it was found to be 45 for standard before roasting. For all the types of vermicelli, the cooking time decreased and cooked weight increased after the process of roasting. Sudha *et al*<sup>4</sup> reported that the cooked weight of vermicelli was increased by blending finger millet with whole wheat flour. The cooked weight was found to be increased more than 3.8 times. The addition of pigeon pea increased the cooked weight of the pasta product.

The percentage water in the rehydrated materials before and after roasting was 38.27, 33.33 and 50.00, 42.53 for standard and amaranthus incorporations respectively. It was found that the net cooking time of the product decreased almost for two minutes after roasting of the product. The rehydration ratio of the products before and

TABLE I  
Quality Characteristics of Best Accepted Manual Noodles,  
Extruded Vermicelli and Swirl Shaped Pasta

Criteria	Cooking time (mts)	Cooked weight (g)	Rehydration ratio (1:x)	Percentage water in rehydrated material	Wettability (g)
<b>Manual noodles</b>					
<b>Before Roasting</b>					
Standard	7.0	+82	1:1.85	45.05	+30.0
Amaranthus	7.0	+28	1:1.08	21.88	+36.4
<b>After Roasting</b>					
Standard	5.0	+114	1:2.54	53.27	+64.6
Amaranthus	5.0	+48	1:1.84	46.81	+95.0
<b>Extruded vermicelli</b>					
<b>Before Roasting</b>					
Standard	4.5	+62	1:1.62	38.27	+34.2
Amaranthus	4.5	+50	1:1.50	33.33	+46.6
<b>After Roasting</b>					
Standard	3.0	+100	1:2.00	50.00	+71.2
Amaranthus	3.0	+74	1:1.74	42.53	+102.8
<b>Extruded swirl shaped pasta</b>					
<b>Before Roasting</b>					
Standard	7.5	+92	1:1.62	47.92	+14.4
Amaranthus	7.5	+86	1:1.50	46.24	+31.4
<b>After Roasting</b>					
Standard	5.0	+118	1:2.00	54.13	+21.6
Amaranthus	5.0	+110	1:1.74	52.38	+50.8

after roasting were found to be 1:1.62, 1:1.50 and 1:2.00, 1:1.74 for standard and amaranthus incorporations respectively. Raina *et al*<sup>5</sup> found that the raw material and cooking conditions were responsible for pasta quality. They reported that rehydration ratio was 3.11 for pasta products incorporated with rice brokens. 75 per cent

of increase in wettability was observed in standard and amaranthus incorporated pasta after roasting.

In general, the wettability, cooked weight, rehydration ratio and percentage water in rehydrated material increased after dry roasting of the material. The cooking time

**TABLE II**  
**Nutrient Analysis of Best Accepted Nutritious Mix and Manual Noodles (g/100g)**

Criteria	Nutritious mix		Manual noodles	
	STD <sup>1</sup>	5 G <sup>2</sup>	STD <sup>1</sup>	2.5 G <sup>3</sup>
<b>Proximate composition</b>				
Moisture	9.50	7.20	9.00	7.70
Protein	15.80	13.20	16.3	14.20
Fat	7.50	8.40	6.85	5.30
Ash	3.20	2.40	3.60	2.90
Carbohydrate	70.00	68.18	72.00	68.61
Crude fibre	2.35	1.29	2.42	1.29
<b>Vitamin and mineral composition</b>				
β-carotene (mcg)	405.09	186705	207.02	1393.05
Thiamine (mg)	0.31	0.32	0.28	0.29
Riboflavin (mg)	0.23	0.36	0.14	0.20
Calcium (mg)	151.92	195.00	136.88	281.00
Phosphorus (mg)	305.00	354.00	410.00	341.00
Iron (mg)	2.00	7.81	4.00	6.42

1- Standard; 2- 5 per cent amaranthus incorporation; 3-2.5 per cent amaranthus incorporation

was found to be inversely proportional to the roasted material, that is, cooking time decreased after roasting. Cooking time was the same for standard and no impact on cooking time for incorporations was noted.

#### **Nutrient content**

Table II presents the nutrient content of best accepted nutritious mix and manual noodles. The analysis of proximate composition revealed that the moisture content of the products was well below the BIS specifications of 11g/100g. The moisture content ranged from 7.00 to 10.00 g/100g with the highest moisture content of 9.5 g/100g for standard nutritious mix. The

standard recipe also possessed more protein and fiber, that is, 15.8 and 2.35 g/100g respectively. Addition of pigeon pea flour enhanced nutritional content in the proximate principles and levels of thiamine, riboflavin and vitamin-E than the control made from 100 per cent durum wheat flour<sup>6</sup>. The crude fiber content of best accepted amaranthus (5%) nutritious mix were 1.29g per 100g whereas those of standard manual noodles and amaranthus (2.5%) incorporated were 2.42 and 1.29 g/100g respectively. The protein content analysed by Khetarpaul and Goyal<sup>7</sup> in processed noodles supplemented with whole wheat flour, soy and sorghum resulted in 14.2 per cent. β-carotene values

TABLE III  
Nutrient Analysis of Extruded Vermicelli and Swirl Pasta (g/100g)

Criteria	Vermicelli		Swirl pasta	
	STD <sup>1</sup>	2.5G <sup>3</sup>	STD <sup>1</sup>	2.5G <sup>3</sup>
<b>Proximate composition</b>				
Moisture	8.95	8.70	8.25	8.10
Protein	12.42	12.80	11.05	12.10
Fat	4.70	6.05	4.00	6.05
Ash	3.20	3.60	3.20	3.50
Carbohydrate	52.00	53.00	55.00	50.00
Crude Fibre	2.12	3.00	2.02	3.00
<b>Vitamin and mineral composition</b>				
β-Carotene (Mcg)	289.35	1427.47	288.03	1425.93
Thiamine (Mcg)	0.33	0.29	0.29	0.290
Riboflavin (Mg)	0.19	0.19	0.18	0.190
Calcium (Mg)	223.20	266.40	223.20	266.40
Phosphorous (Mg)	310.00	395.00	310.00	366.40
Iron (Mg)	3.00	6.00	3.00	6.00

1- Standard; 3-2.5 per cent amaranthus incorporation

were more for amaranthus incorporated preparations. Reddy<sup>8</sup> assures that among the green leafy vegetables, drumstick leaves, agathi, amaranth, curry leaves and coriander contain very high amount of β carotene (6000-9000 μg/100g). Also, thiamine, riboflavin, calcium and iron values were better than the rest of the preparations. The iron content of noodles fortified with curry leaves was 8 mg<sup>9</sup>. The iron content of nutritious mix and manual noodles incorporated with amaranthus are 7.81 and 6.42 mg/100g respectively. From Table III it is noted that the moisture content of all the extruded products was between 8 and 9 per cent. The USDA recommended

nutrient content of pasta as 13g protein, 10g moisture and 75g carbohydrate. The protein

TABLE IV  
Total Microbial Count for the Best Accepted  
Nutritious Mix and Manual Noodles

Best Accepted Products	Microbial count (cfu/g)	
	Initial	Final
<b>Nutritious mix</b>		
Standard	6000	7000
5% amaranthus	5800	8000
<b>Manual noodles</b>		
Standard	7000	9000
2.5% amaranthus	5600	8500

TABLE V  
Cost Comparison of the Nutritious Mix and Extruded Products with the Commercial Formulae (per Kg)

Criteria	Developed products			Commercial formulae		
	NM	MN	EP	NM	N	EP
Standard	50.00	60.00	80.00	140.00	200.00	200.00
Amaranthus Incorporation (%)						
2.5	60.00	65.00	85.00	--	--	--
5.0	65.00	72.50	92.50			
7.5	70.00	80.00	100.00			
10.0	80.00	145.00	165.00			

NM-Nutritious Mix MN-Manual Noodles, EP- Extruded Products, N-Noodles

content of vermicelli incorporated with amaranthus was 12.80 per cent and it was more than the rest of the prepared products.  $\beta$ -carotene values of standards were 289.35 and 288.03  $\mu\text{g}/100\text{g}$  for vermicelli and swirl pasta respectively. The thiamine values of standard vermicelli were highest (0.33 mg/dl).

#### Microbial load and cost analysis

Table IV shows that the microbial load of the best accepted nutritious mix and extruded products ranged from 7,000 to 9,000cfu initially and after two months. The specified limit for the colony forming units in pasta products is 50,000 cfu/g (IS-1485, 1993). Thus it was observed that the microbial load was less than the specified limit. The initial standard nutritious mix and manual noodles showed 6,000 cfu/g and 7,000 cfu/g and the final analysis showed 7,000 and 9,000cfu/g.

Also microbial analysis revealed that the best nutritious mix and extruded products did not possess any food borne illness causing bacterial species namely *Salmonella sp.*, *Vibrio sp.*, *Campylobacter sp.*, *E.coli* and *Aeromonas sp.*

Table V depicts that the developed products were economically feasible to all categories of people and included ingredients from the basic five food groups. The commercially available extruded product did not possess any pulses and value added with amaranthus. The incorporations thus proved that they are not only economical but also rich in nutrient content and much safe for consumption.

#### Summary and Conclusion

The findings of the study revealed that the formulated nutritious mix could be

developed into extruded products. The developed products with amaranthus incorporations were highly acceptable from the organoleptic evaluation of commonly consumed recipes. The nutrient content and the quality characteristics were highly satisfactory. The incorporations did not affect the cooking time of the products. The bacterial loads were within the limit of BIS

specifications and no pathogenic bacteria were found. The cost of the developed nutritious mix and extruded products were compared to the commercial formulae. The present investigations proved the feasibility of developing nutritious rice incorporating low cost micronutrient rich foods like green leafy vegetables and develop extruded products from them.

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