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Research Article

Utilization of Moringa Oleiferaleaves to Fortifyrice: Effect Onrda of Adult and Pregnant Women

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Abstract

The present study aims to utilize the staple food of over half of the world population, that is rice, which is a brilliant source of energy and good for Celiac, and fortifying it with Moringa oleifera caries potential to enhance and improve overall nutrient availability. Products like Ready- to- Cook (RTC) Idli & Dhokla mix were fortified with 5 and 10 % moringa leaves powder respectively were analyzed. The proximate and nutrient composition like moisture, ash, fibre, protein, fat and carbohydrate of rice, moringa leaves and fortified mixes were analyzed. The micronutrients like calcium, phosphorus, iron and vitamin C were analyzed and compared with RDA of adult and pregnant women as per % Daily Value (DV). The elevation of % DV by 1.5% & 3% in calcium, 2.5% & 3% in potassium, 5.2% & 10.4% in vitamin C and 4.2% & 9.5% (adult), 2.9% & 6.6% (pregnant women) with respect to standard sample was observed respectively with elevation of 5% and 10% fortification moringa leaves powder. The products were packed in different packaging materials like Glass, LDPE, HDPE, aluminum laminated HDPE and storage life was analyzed for the period of 60 days. For storage life parameters like weight, moisture content, water absorption capacity and overall acceptability were taken into consideration.

Keywords: Rice flour; Moringa leaves; Recommended Dietary Allowance (RDA); Daily Value (DV); Fortification; Proximate analysis; Nutritional composition

Introduction

For over half of the world's population, rice is a staple food (FAO, 2004), accounting 20% of global calorie intake from rice only [1]. In India rice is grown in 43.86 million ha, the productivity is approx. 2390 kg/ha and the production level is 104.80 million tons (Agricultural Statistics at a glance, 2015) (NSFM, 2016). It provides instant energy as its most important component is carbohydrate (starch) [12]. Rice is consumed majorly as whole grain, thus during milling, rice cracks and breaks into smaller fragments, which are utilized by grinding into rice flour. Rice flour is rich in starch and is used for making various food materials in India like Idli, Dosa, Chapati, etc [4]. Rice flour possesses several health benefits. It is an excellent choice for those suffering from gluten intolerance as it is gluten-free. It contains a sufficiently high amount of insoluble fibers, which keeps good health of the digestive tract [5].

The leaves of *Moringa oleifera* are very nutritious. In 100 g dry matter; they contain 1,924 ± 288 mg calcium, 29 ± 6 g protein, 28 ± 6 mg iron, 15,620 ± 6,475 IU vitamin A and 773 ± 91 mg vitamin C [6] which is 17 times the calcium of milk, 15 times the potassium of bananas, 25 times the iron of spinach, 10 times vitamin A of carrot and nine times the protein of yogurt [7]. Evidence reports that these leaves potentially contain arginine and histidine two amino acids especially important for infants, who require enough protein for their growth and development. Carries potential to alleviate malnutrition among children and women (FAO 2014) [8].

The study presents utilization of locally available staple grain into nutritious and value-added products by fortifying it with *Moringa oleifera* leaves powder.

Dhokla is of Gujrat origin [9] and Idli is a south Indian delicacy [10], prepared commonly with cereal along with a combination of legumes. These are favorite breakfast food snack because of it spongy texture and distinct flavor [11]. As these products require a long preparation time thus precooked dehydrated ready-to-Cook products are developed with having short cooking time [12].

Objective

1. Nutritional analysis of Moringa leaves fortified Rice flour mix and comparison with RDA.

2. Shelf-life study of developed Ready- to-Cook instant mix (Dhokla, Idli) in different packaging materials.

Material and Methods

Ingredients

The raw materials sona masori white rice, dehulled black gram were procured from the local market of Lucknow, Uttar Pradesh, and Moringa leaves were plucked fresh from the tree growing in the premises of Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh.

Preparation of Fortified Dhokla & Idli mix

A common procedure (Figure 1) was used in the preparation of fortified mix for both dhokla and idli but with different formulations and cooking preparation. The blends were made as per formulations (Table 1).

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Table 1: Formulation of blends for Idli& Dhokla mix.

Blends	Ingredients (%)				
	Rice Flour	Black gram	MLP	Sodium bicarbonate	Citric acid
C	60	37	0	1.8	1.2
I	60	32	5	1.8	1.2
D	60	27	10	1.8	1.2

*MLP: Moringa leaves powder
*C: Standard Idli& Dhokla mix, I: Fortified idli mix, D: Fortified dhokla mix

Table 2: Nutritional composition of Raw materials and Idli, Dhokla blends.

Parameters	Raw material		Blends		
	Rice Flour	MLP	C	I	D
Moisture content %	12.33	6.10	6.00	9.67	9.95
Ash content %	0.80	11.20	3.00	2.18	2.65
Crude Fat %	1.02	4.01	1.80	1.39	1.40
Crude Protein %	10.40	27.3	15.03	15.93	16.11
Crude Fibre %	2.52	12.9	3.90	2.62	4.01
Carbohydrate %	72.93	38.49	70.27	68.21	61.88
Calcium (mg/100g)	27.62	442.01	71.77	86.97	102.17
Potassium (mg/100g)	312.01	1320.01	470	590	612
Iron (mg/100g)	0.8	7.23 26	3.4	4.20	5.20
Vitamin C (mg/100g)	Nd*	83	0.00	4.15	8.30

*Nd = Not detected, *MLP: Moringa leaves powder

Table 3: Recommended dietary allowance of various nutrients.

Nutrient component supplied	Recommended dietary allowance (mg/d)		Daily Value (DV) %		
	Adult	Pregnant women	C/100g	I/100g	D/100g
Calcium	1000 mg/d	1000 mg/d	7.2	8.7	10.2
Potassium	4700 mg/d	4700 mg/d	10	12.5	13.0
Iron	19 mg/d	27 mg/d	17.9 (adult) 12.6 (pregnancy)	22.1 (adult) 15.5(pregnancy)	27.4 (adult) 19.2(pregnancy)
Vitamin C	80 mg/d	80 mg/d	0.0	5.2	10.4

*C: Standard Idli& Dhokla mix, I: Fortified idli mix, D: Fortified dhokla mix
* RDA (ICMR NIN 2020

Cooking of RTC Idli & Dhokla mix

To make idli, the blend was transformed to a batter by adding curd, salt and water as per required consistency and steamed in anidli maker until cooked completely. In dhokla making, curd, salt, asafoetida, green- chilli &ginger paste and water was added to make the batter and steamed in a pre-greased square mould until completely cooked.

Determination of Moisture Content

Moisture content was determined by drying in hot air oven [14]. 5g of sample was weighed in a empty Petri dish, note it as initial weight (W_1). Dry the sample in pre heated oven to 100^{0}C. Dried sample in oven at 105^{0}C ± 2^{0}C for 4 to 5 hrs. Take out and place the dried sample in the desiccator to cool down, then weight and note it as final weight (W_2).

$$\text{Moisture content (\%)} = \frac{W1 - W2}{W1} X\ 100$$

Determination of Ash Content

Ash content was determined by using procedure given by AOAC, 2000. Finely ground sample was weighed (W_1) in pre-weighed silica crucible (W_2) Z. Organic matter was completely oxidised in a muffle furnace at 550^{0}C for 4 hrs and produced ash was weighed (W_3).

$$\text{Ash content (\%)} = \frac{W3 - W2}{W1} X\ 100$$

Determination of Fat Content

The crude fat was determined using Soxhlet apparatus and procedure as per AOAC, 2000. The moisture-free powdered sample weighed in a thimble and noted as A, empty flask before extraction was weighed and noted as C. At 60-80^{0}C the fat was extracted for 6-8 hrs and on completion of extraction and removal of solvent, flask was weighed and noted as C and further calculation as per formula was done.

$$Fat\ content\ (\%) = \frac{B - C}{A} X\ 100$$

Determination of Protein Content

Protein content was determined by using Kjeldhal apparatus. The sample was boiled with conc. H_2SO_4 to digest nitrogenous material in sample material into ammonium sulphate. It is subsequently treated with excess alkali to decompose and liberate ammonia into a boric acid solution. Ammonia forms ammonium borate with boric acid

which is titrated directly against std. HCl [13].

$$\% N = \frac{(ml\ of\ sample - ml\ of\ blank)\ X\ normality\ of\ H2SO4\ X\ 0.014\ X\ 100}{ml\ of\ aliquot\ taken\ for\ distillation\ X\ weight\ of\ sample\ (g)}$$

Crude Protein (%) = N x 6.25

Determination of Crude Fibre

Boil 2 gm defatted sample in digestion flask with attached condenser in 200 ml sulphuric acid and 0.5 gm asbestos for 30 min. Filter and wash with boiling water to remove acid. Wash the residue with hot 10% potassium sulphate solution. Return the residue into digestion flask by washing all the residue from the filter cloth with hot water. Filter into Gooch crucible using 15ml alcohol. Dry the content at 110^{0}C, cool in desiccator and ignite in muffle furnace. Cool again in desiccator and the loss in weight represent crude fibre [13].

$$\%\ Crude\ fibre = \frac{Loss\ in\ weight\ noted}{Wt.\ of\ sample\ taken}\ X\ 100$$

Determination of Carbohydrate

Carbohydrate comes in simple forms such as sugars and complex form such as fibre and starches. It was determined using a difference method.

Carbohydrate (%) = 100 - (% Moisture + % Ash + % Fat + % Protein + % Fibre)

Determination of Calcium

Calcium was determined as per procedure by [13]. In a 250 ml beaker, take 20-100ml of ash solution obtained from dry ashing. Add 10 ml of saturated ammonium oxalate along with 25-50ml water and 2 drops of methyl red indicator. Add dil. ammonia and few drops of acetic acid until colour changes to faint pink. Boil the solution and allow it to stand overnight. Filter using What man No. 42. Wash the filtrate with dil. H_2SO_4 and hot water. Titrate against 0.01N $KMnO_4$ to permanent pink colour. Use the formula to calculate Calcium mg/100g [13].

Determination of Potassium

Potassium was determined using Flame photometric method. Dry ash aliquot was diluted which contains potassium less than 150 ppm. 5 ml HCl is added. Diluted sample was atomized in a calibrated flame photometer at 768 mm wavelength and 100% transmittance for the top standard solution of potassium. Note the concentration from the standard curve [13].

Determination of Iron

Iron was measured calorimetrically at 480 nm. Iron was converted to ferric form using oxidising agents like potassium persulphate and treating thereafter with potassium thiocynate to form red ferric thiocyanate. Calibration curve is formed by plotting absorbance against the concentration [13].

Determination of Vitamin C

Vitamin C was determined using the Direct Colorimetric method [13]. It is based on the measurement of the extent to which 2, 6- dichlorophenol indophenol solution is decolourized by ascorbic acid in standard and sample solution. Standard curve was made to determine concentration against absorbance of red colour at 518 nm wavelength [13].

Storage Study of Ready- to-Cook Fortified Dhokla & Idli Mix

In this study, both the sample variants were kept at room temperature in different packaging materials including, Glass, LDPE, aluminium laminated HDPE pouch and HDPE standing pouch. The study was done for 60 days with 15 days interval on different parameters weight, moisture content, water absorption capacity and overall acceptability [15].

Result and Discussion

Nutritional Analysis

The nutritional analysis showed that rice is rich in carbohydrate (72.93%) and moringa is rich in protein (27.3%), fibre (12.9) and micronutrients. The (Table 2) presents the nutritional composition of standard RTC Idli- Dhokla mix (C) and fortified RTC Idli- Dhokla mix (I & D). The elevation in nutrient properties was observed except carbohydrate and fat with increase in quantity of moringa leaves powder from 0% to 5% to 10%. The carbohydrate was maximum in standard sample (70.27%) followed by fortified Idli (68.21%) and Dhokla sample (61.88%). The fat is observed maximum in standard sample C (1.80%) followed by fortified dhokla D (1.40%) and idli mix I (1.39%). The vitamin C content was not detected in standard sample C may be because of presence of the negligible amount of vitamin C in rice and dehulled black gram flour.

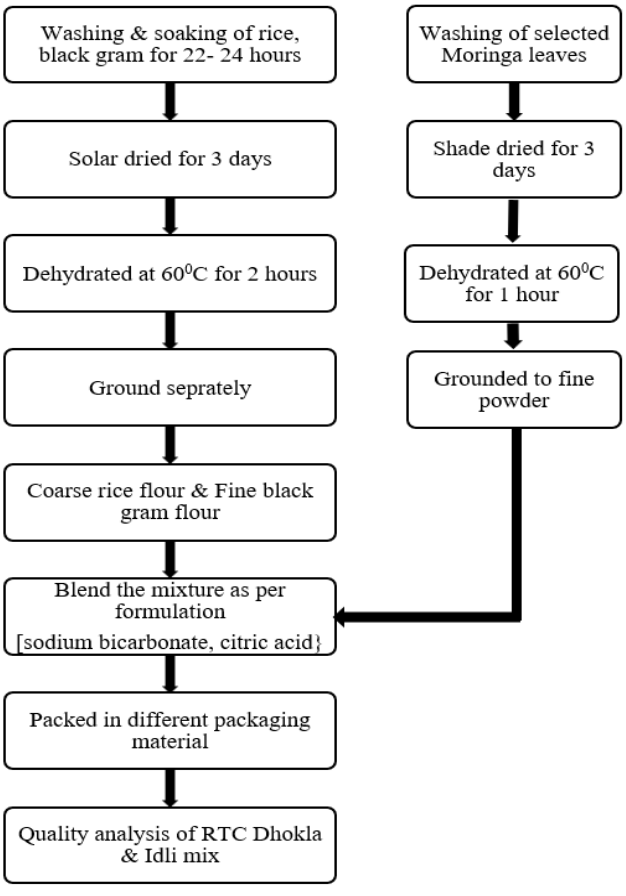

Figure 1: Flow chart for fortified Idli& Dhokla mix preparation.

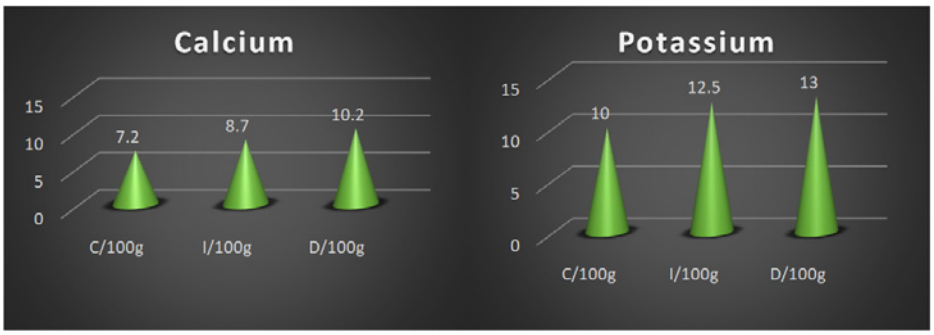

Figure 2 & 3: % Daily value of Calcium and Potassium in C: Standard Idli & Dhokla mix, I: Fortified idli mix, D: Fortified dhokla mix for both adult and pregnant women.

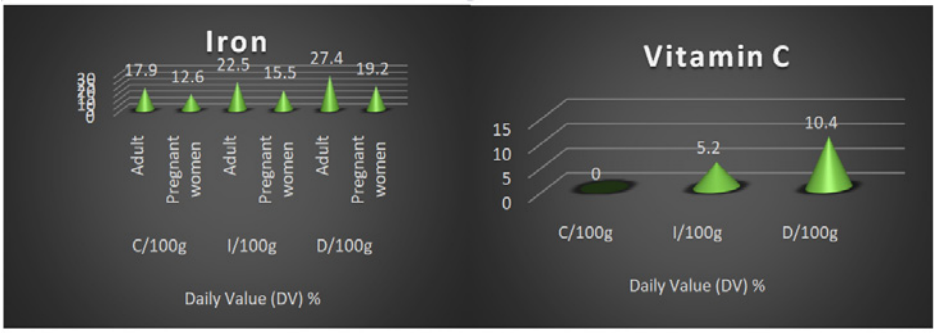

Figure 4 & 5: % Daily value of iron& vitamin Cin C: Standard Idli & Dhokla mix, I: Fortified idli mix, D: Fortified dhokla mix for both adult and pregnant women.

Table 4: Storage study of fortified RTC mix in different packaging material.

Days	Parameters								
	Packaging Material	Weight (g)		Moisture content (%)		WAC (%)		OAA	
		I	D	I	D	I	D	I	D
0	Glass	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	LDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	HDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	Aluminium laminated HDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
15	Glass	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	LDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	HDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	Aluminium laminated HDPE	20	20	6.10	6.10	124.16	124.32	8.5	8.6
30	Glass	20	20	6.10	6.10	124.16	124.32	8.5	8.6
	LDPE	20.09	20.10	6.13	6.14	124.50	124.60	8.4	8.5
	HDPE	20.08	20.09	6.11	6.12	124.20	124.40	8.4	8.5
	Aluminium laminated HDPE	20.04	20.06	6.10	6.11	124.16	124.32	8.5	8.6
45	Glass	20.02	20.02	6.10	6.11	124.16	124.32	8.5	8.6
	LDPE	20.15	20.17	6.18	6.19	125.50	126	8	8
	HDPE	20.12	20.12	6.14	6.14	125.00	125.40	8.2	8.2
	Aluminium laminated HDPE	20.04	20.06	6.10	6.11	124.20	124.40	8.5	8.6
60	Glass	20.04	20.05	6.12	6.12	124.20	124.60	8.3	8.4
	LDPE	20.17	20.21	6.21	6.23	126.04	126.09	7.8	7.8
	HDPE	20.15	20.18	6.17	6.18	125.20	125.90	8	8
	Aluminium laminated HDPE	20.04	20.07	6.12	6.14	124.22	124.70	8.2	8.3

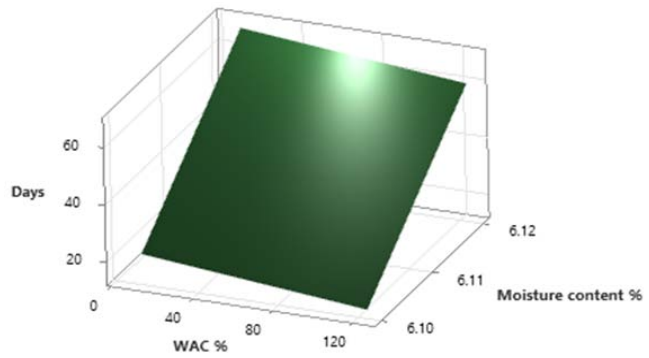

Figure 6: Effect of time on moisture content and water absorption capacity in Glass jar.

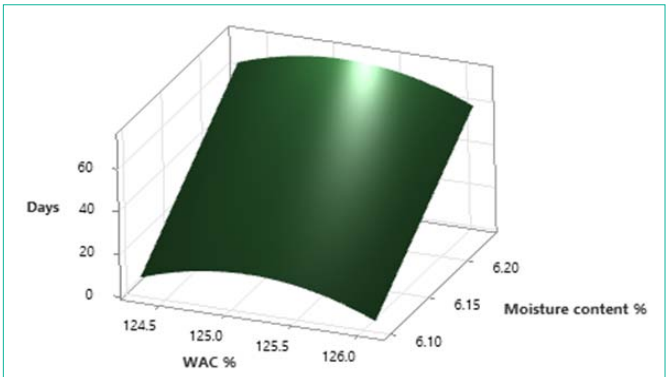

Figure 7: Effect of time on moisture content and water absorption capacity in LDPE pouch.

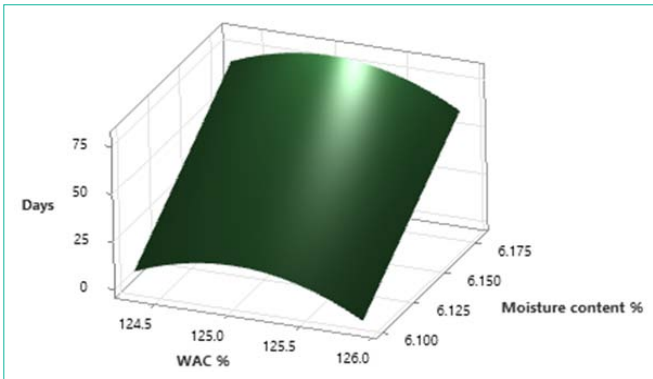

Figure 8: Effect of time on moisture content and water absorption capacity in HDPE standing pouch.

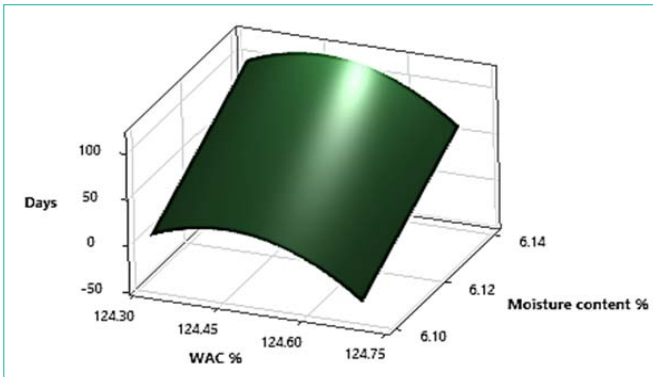

Figure 9: Effect of time on moisture content and water absorption capacity in aluminium laminated HDPE.

% Daily value (DV) of various micronutrients for different blends are presented in (Table 3). With an increase in quantity of moringa powder, all the micronutrients increased. The % DV of calcium increased by1.5% in idli & 3% in dhokla with respect to % DV of a standard sample for both adult and pregnant women. Similarly, 2.5% & 3% in potassium, 5.2 & 10.4% in vitamin C and 4.2 & 9.5% (adult), 2.9 & 6.6% (pregnant women) with respect to standard sample was observed respectively with elevation of 5 and 10% moringa leaves fortification. The iron content in fortified Idli& Dhokla mix were 4.20 mg/100g and 5.20 mg/100g respectively were fulfilling 22.5 to 27.4 % daily value of an adult diet. As calcium is necessary in pregnancy, maximum 10.2 % daily value can be fulfilled by 100 gm of fortified Dhokla mix. Vitamin C act as natural anti-oxidant which was found in negligible quantity in standard RTC mix was enriched by fortification and was found to fulfil maximum 10.4 % daily value.

Storage Study of fortified RTC mix

torage study of fortified RTC Idli and Dhokla mix for 60 days in different packaging materials is presented in (Table 4). The storage life of developed RTC mix appeared best in glass material. Least changes were observed in glass storage evaluated on different parameters like weight, moisture content, water absorption capacity and overall acceptability. Followed by glass, aluminium laminated HDPE appeared to have least changes compared to HDPE and LDPE.

The effect on moisture content and water absorption capacity (WAC) with time under the storage of different packaging material is presented in the form of surface plot using Research surface methodology in different figures (Figure 6,7,8 & 9). With time, the sample in LDPE gained maximum weight, its moisture content increased as it absorbed water and its water absorption capacity increased because of denaturation of protein.

From the study, it is concluded that widely available highly valuable *Moringa oleifera* can be utilized to elevate nutritive properties of rice flour. *Moringa oleifera* carries the potential to enhance the macro and micro nutrition availability in Dhokla and Idli. When comparing the fortified idli & dhokla mix with simple idli & dhokla mix, the moringa leaves powder itself has highly enhanced the protein, calcium, phosphorus, iron and vitamin C (natural antioxidant). It can be consumed by all ages as it carries potential of therapeutic diet. It is also concluded that packaging material glass and aluminum laminated HDPE has high barrier property, thus suitable for storage of RTC idli & dhokla mix. It is also inferred that the study needs further research with different formulations to fulfil major portion of recommended dietary allowance (RDA) in one serving.

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Conflict of Interest

The authors report that there is no conflict of interest.

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