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Optimization of process variables for multigrain extruded product for celiac disease

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Abstract
A ready-to-eat nutritious snack mix was developed by blending the flour from broken rice, corn kernel and splitted chickpea and other ingredients in the optimized proportion of 70:10:10:10. The nutrient composition, functional properties, sensory qualities and storage characteristics of the product were analysed. The product obtained was pellet type of extruded product, since there is no any longitudinal and axial expansion takes place. Optimize product was obtained with the combination of Maize Flour-86.56gm and Rice Flour-6.18gm with other ingredients i.e. (Gram Flour-10gm, Baking Powder. – 3.0gm, Salt-4.5 gm, Sugar – 5gm, Citric Acid – 0.6gm, Refined vegetable oil- 10 gm, Seasoning – 2gm, Chilli powder- 1gm) Optimized product protein content was. 7.73%. Sensory Evaluation of optimized product was better on Hedonic scale (0-9 scale). As the increase in rice flour the gritty texture properties increase and also the colour of the product should be lighten when frying time and temperature was fix.

Keywords: popping, high temperature short time treatment, physicochemical characteristics, functional properties, sensory qualities, shelf life studies

Introduction
The overall growing demand for novel, tasty, and healthy foods, together with the increasing number of people suffering from celiac disease, has given birth to a new market consisting of cereal products made from grains other than wheat and rye. In this challenging market pearl millet has gained a special position (Angioloni and Collar, 2012). Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. It is one of the most common lifelong disorders worldwide. In the past, celiac disease was considered a rare disorder, mostly affecting children of European origin. Recently, a huge number of studies have shown that celiac disease is one of the commonest lifelong disorders affecting humans in many areas of the world (Catassi *et al*., 2007). A gluten-free diet primarily affects food consumption from the grain food group. In place of wheat, barley, and rye-based foods, persons adhering to a gluten-free diet must consume foods made from gluten-free grains, including pearl millet, rice, corn, sorghum, amaranth, buckwheat, quinoa, wild rice, and oats (Tripathi, 2010). In the developed countries, there is a growing demand for gluten-free foods and beverages from people with celiac disease and other intolerances to wheat, barley, or rye. However, since millets are gluten-free, they have considerable potential in foods and beverages that can be suitable for individuals suffering from celiac disease (Chandrasekara and Shahidi 2012).

Compared to the availability of ready-to-eat products from rice, wheat and corn, the products based on minor cereals such as sorghum and millets are still scanty. Sorghum and millets possess unique nutritional characteristics, specifically, they are gluten-free, represent good source of carbohydrates, rich in dietary fibre, phenolic compounds and also minerals (Saturni *et al*. 2010). These grains, apart from the macro nutrients, also form a good source of micronutrients and photochemical and complement well with lysine-rich vegetable (leguminous) and animal proteins to prepare nutritionally balanced composites of high biological value (Gorinstein *et al*. 2002). Sorghum and millets are used in many traditional foods namely roti, dumpling and porridges and some of the novel food uses include preparation of bakery products (Taylor *et al*. 2006).

Bakery products are the most popular food consumed by all age groups in all over the world. In India bakery products are increasingly becoming popular as indicated by over 2.5 fold increase in their production during last two decades (Puranik *et al*., 2003). The production of bakery product in India is 3 million tons (Samanath et. al. 2002). Among all bakery products, cookies are predominant, with vast combinations of texture and taste giving them a universal appeal. Biscuits in India is accounting for more than 30% of total bakery products production. The per capita consumption of biscuit in India is 8 Kg per annum in comparison to 15 Kg per

annum in developing countries (*Shukla et al. 2000*). Cookies are considered as the lowest cost processed foods in the country, when compared to Indian sweet meats, salted snacks, wafers and savoury items. Apart from offering nutrition and taste, they can be packed in a variety of sizes.

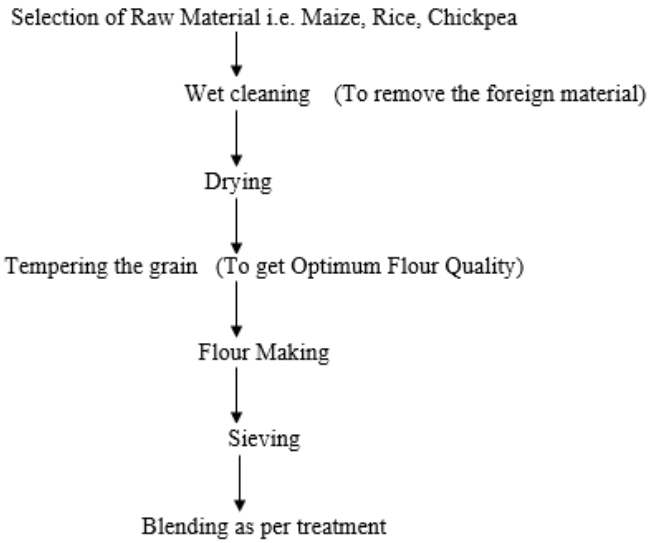
Gluten is an essential structure-building protein used through white wheat flour in bakery products, which affect the appearance, mouthfeel, colour and texture final products. In contrast to bread, in cookies the gluten network is restricted to develop for the dough to be cohesive without being too elastic (*Contamine et. al. 1995*). Cohesive dough with low elasticity can also be formed from gluten-free composite flours.

Celiac disease is an important disease, which is associated with the allergic reactions and intolerances to gluten consumption. The chronic inflammation of mucosa in the proximal small intestine causing the progressive disappearance of the villi, which leads to the malabsorption of several important nutrients including iron, folic acid, calcium and fat-soluble vitamins. The only effective treatment for celiac disease is a strict adherence to a gluten-free diet throughout the patient's lifetime which, in time, results in clinical and mucosal recovery (*Gallagher et. al. 2004*).

Materials and Methods

Maize, Rice, Chickpea and other ingredients such as sugar, vegetable oil, baking powder and seasoning and chilli were procured from local market. The grains were cleaned to remove dust and other extraneous materials and stored at room temperature in plastic containers.

Prepare Gluten-Free Multigrain Flour Blend Mix



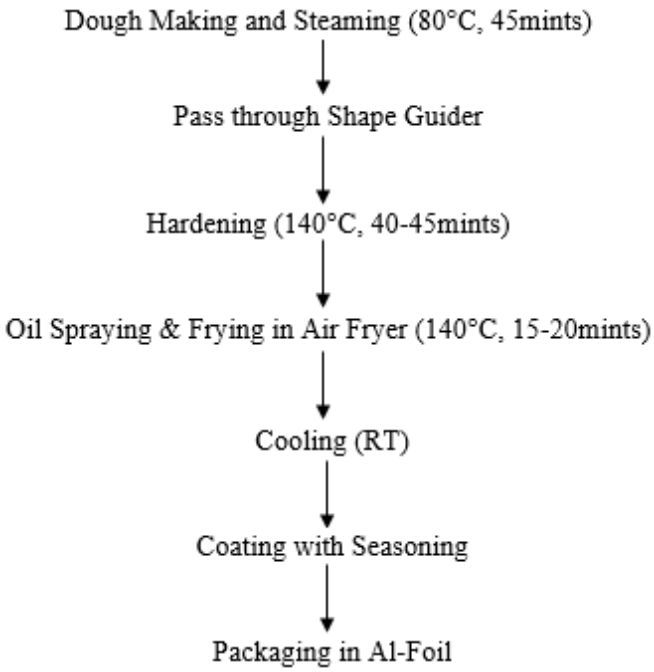
Treatment for process standardization

T_1- Maize – 100gm
T_2- Maize – 80gm, Rice Flour – 10gm, Gram – 10gm
T_4- Maize – 70 gm, Rice Flour – 20gm, Gram – 10gm,
T_3- Maize – 60gm, Rice Flour – 30gm, Gram – 10gm
T_5- Maize – 50gm, Rice Flour – 40gm, Gram – 10gm,
T_6- Maize – 40gm, Rice Flour – 50gm, Gram – 10gm

Other Ingredient

Baking Powder – 3.0gm, Salt-4.5 gm, Sugar – 5gm, Citric Acid – 0.6gm,
Refined vegetable oil – 10gm, Seasoning – 2gm, Chilli Powder- 1gm

Design of Raw Material



Results and Discussions

Table 1: Chemical composition of Raw Materials

Sr. No.	Parameters	Broken Rice	Corn Kernel	Splited Chickpea
1	Moisture (%, w.b)	11.06	11.54	10.92
2	Protein (%)	6.81	8.13	23.49
3	Fat (%)	0.27	1.15	2.64
4	Carbohydrate (%)	81.10	77.83	60.24
5	Starch (%)	78.92	75.17	57.86
6	Mineral (%)	0.76	1.35	2.71

Table 2: Ingredients combination detail for the preparation of Gluten free multigrain extruded product based on central composite rotatable design (CCRD)

Treatment No.	Variable Ingredients			Fixed Ingredients						
	Corn Flour	Rice Flour	Chickpea Flour	Baking Powder	Salt	Sugar	Citric Acid	Refined Veg. Oil	Seasoning	Chilli Powder
	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm
1	72.93	2.93	10	3	4.5	5	0.7	10	2	1
2	87.07	2.93	10	3	4.5	5	0.7	10	2	1
3	72.93	17.07	10	3	4.5	5	0.7	10	2	1
4	87.07	17.07	10	3	4.5	5	0.7	10	2	1
5	70	10	10	3	4.5	5	0.7	10	2	1
6	90	10	10	3	4.5	5	0.7	10	2	1
7	80	0	10	3	4.5	5	0.7	10	2	1
8	80	20	10	3	4.5	5	0.7	10	2	1

9	80	10	10	3	4.5	5	0.7	10	2	1
10	80	10	10	3	4.5	5	0.7	10	2	1
11	80	10	10	3	4.5	5	0.7	10	2	1
12	80	10	10	3	4.5	5	0.7	10	2	1
13	80	10	10	3	4.5	5	0.7	10	2	1

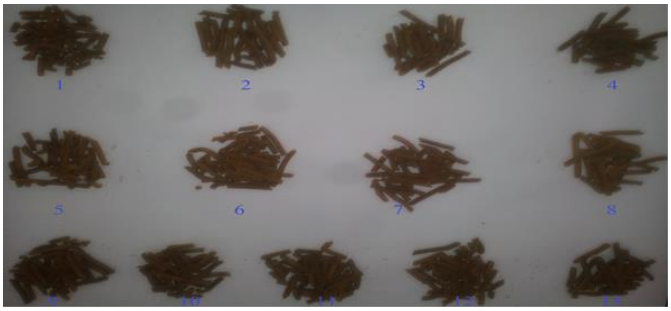


Fig 1: Gluten free multigrain extruded products (1 -13 treatments)

Table 3: Chemical composition of the product (1-13 treatment)

Treatment No.	Protein %	Fat %	Carbohydrate %	Mineral %	Moisture %
1	7.64	5.43	81.48	1.69	3.76
2	7.71	5.51	81.17	1.63	3.98
3	7.54	5.54	81.37	1.62	3.93
4	7.60	5.79	80.91	1.59	4.10
5	7.57	5.43	81.56	1.65	3.79
6	7.66	6.05	80.67	1.60	4.02
7	7.69	5.51	81.14	1.66	4.01
8	7.56	5.57	81.28	1.60	3.99
9	7.62	5.40	81.52	1.62	3.84
10	7.62	5.40	81.52	1.62	3.84
11	7.62	5.40	81.52	1.62	3.84
12	7.62	5.40	81.52	1.62	3.84
13	7.62	5.40	81.52	1.62	3.84
R^2 Value	98.99 %	86.61 %	91.08 %	95.65 %	89.79 %
CV %	0.067	1.67	0.13	0.38	1.12

Surface plot for Gluten free multigrain extruded products Protein, Fat, Carbohydrate, Mineral, Moisture as a function of corn starch and rice flour

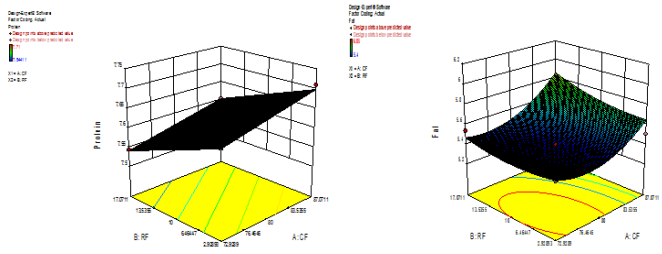


Fig 2: Surface plot for Gluten free multigrain extruded products Protein and Fat

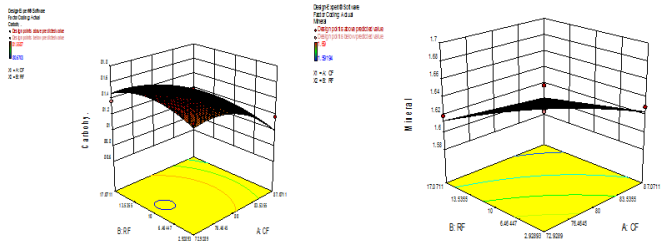


Fig 3: Surface plot for Gluten free multigrain extruded products carbohydrate and Minerals

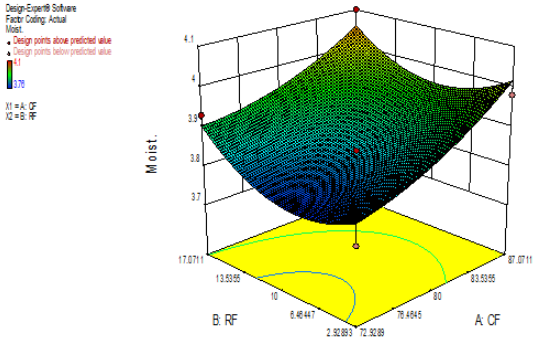


Fig 4: Surface plot for Gluten free multigrain extruded products Moisture

Table 4: Sensory Evaluation of the product (1-13 treatments)

Treatment No.	Colour	Smell	Flavour	Texture	Mouthfeel	Appearance	OAA
1	7.56	7.28	7.28	6.17	6.67	7.12	7.56
2	7.29	6.69	6.89	6.17	6.26	6.29	7.29
3	7.86	7.78	7.67	6.89	7.56	7.67	7.86
4	7.48	6.28	6.28	5.89	6.07	5.97	7.48
5	8.06	7.89	7.73	6.93	8.56	7.87	8.06
6	7.28	7.36	6.57	6.17	6.17	6.17	7.28
7	7.07	6.54	6.38	5.88	6.86	5.97	7.07
8	6.98	6.49	6.89	5.89	7.12	6.29	6.98
9	7.16	7.29	7.16	6.41	7.86	7.02	7.16
10	7.16	7.29	7.16	6.41	7.86	7.02	7.16
11	7.16	7.29	7.16	6.41	7.86	7.02	7.16
12	7.16	7.29	7.16	6.41	7.86	7.02	7.16
13	7.16	7.29	7.16	6.41	7.86	7.02	7.16

Table 5: Ingredients combination at optimized level

Corn Flour	Rice Flour	Chickpea Flour	Baking Powder	Salt	Sugar	Citric Acid	Refined Veg. Oil	Seasoning	Chilli Powder	Desirability
gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	
86.56	6.179	10	3	4.5	5	0.7	10	2	1	0.809

Table 6: Chemical composition results at optimised level

Optimise combination treatment	Protein	Fat	Carbohydrate	Mineral	Moisture
	%	%	%	%	% (w.b)
	7.73	5.52	81.19	1.63	3.93

Fig 5: Extruded product at optimized level

Conclusions

A ready-to-eat nutritious snack mix was developed by blending the flour from broken rice, corn kernel and splitted chickpea and other ingredients in the optimized proportion of 70:10:10:10. The nutrient composition, functional properties, sensory qualities and storage characteristics of the product were analysed. The product obtained was pellet type of extruded product, since there is no any longitudinal and axial expansion takes place. Optimize product was obtained with the combination of Maize Flour-86.56gm and Rice Flour-6.18gm with other ingredients i.e. (Gram Flour-10gm, Baking Powder. – 3.0gm, Salt-4.5 gm, Sugar – 5gm, Citric Acid – 0.6gm, Refined vegetable oil- 10 gm, Seasoning – 2gm, Chilli powder- 1gm) Optimized product protein content was. 7.73%. Sensory Evaluation of optimized product was better on Hedonic scale (0-9 scale). As the increase in rice flour the gritty texture properties increase and also the colour of the product should be lighten when frying time and temperature was fix.

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