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Development and evaluation sorghum fortified pasta using response surface technology

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Abstract
Sorghum is a nutrient-rich grain because high in soluble fibre and antioxidants and a gluten-free replacement for wheat. Pasta is very popular now a days and an adequate vehicle for food supplementation with minerals, proteins and many other valuable healthy components. Therefore the present study was carried out to optimize the levels of different ingredients required for development of Pasta from composite flour blends of sorghum and wheat and to study the effect of different ingredients on physical properties, chemical composition and sensory quality attributes of developed pasta. The reported mean value of moisture content (%), protein content (%), fat content (%) and ash content (%) was 10.02, 9.74, 4.37 and 0.95, respectively. In the sensory evaluation, the average score for the appearance, colour, texture, crispness, taste, flavour and overall acceptability were 6.46, 6.57, 6.47, 6.50, 6.60, 6.28 and 7.78, respectively. Among physical properties, chemical composition and sensory quality attributes of pasta developed from the blends of sorghum flour and refined wheat flour (30:70 Sorghum RWF, Oil 21, Gum 9 and salt 7.5) was found to be best among all the combinations.

Keywords: Fortified, sorghum, pasta

Introduction
Millets are nutritious, climate resilient, hardy and dryland crops hence tagged as Nutri-cereals, contribute substantially for food and nutritional security. Sorghum is the major millet crops grown, constituting above 65% of total millets. Based on its use, sorghum is classified as grain sorghum, forage sorghums (for pasture and hey), sweet sorghum (for syrup and biofuel), and Broomcorn. Due to sorghum's vital uses and adaption "sorghum is one of the really indispensable crop" required for the survival of humankind. In developing countries the commercial processing of these locally grown grains into value-added food and beverage products is very important driver for economic development. Previously sorghum is employed for bio-fuel and animal feed than for human consumption, but this percentage is quickly rising with the interest in sorghum as a gluten-free replacement for wheat. It is a nutrient-rich grain because high in soluble fibre and antioxidants and should reduce the chance of diseases like type 2 diabetes (Margaret and James, 2020) [24].

In the current era of globalization, industrialization, rapid urbanization, hectic lifestyles and western influences, there is a worldwide shift in the structure of diet and lifestyle. Consumer's expectation now days is becoming very high for nutritional and ready to eat food products, and to satisfy this requirement, the improvement of staple foods like pasta with nutritional as well as functional properties with good consumer acceptability is need of the hour and important target for the food technologist. Indeed, World Health Organization (WHO) and U.S. Food and Drug Administration (USFDA) have considered the staple food like pasta as good carrier of nutrients to enhance the human health status. So it is considered as an adequate vehicle for food supplementation with minerals, proteins and many other valuable healthy components (Borneo and Aguirre 2008) [12]. Increasing demand of nutritionally rich pasta products is indicative of pasta as potential vehicle for incorporation of nutraceuticals like vitamins or polyunsaturated fatty acids.

Pasta is an important staple food and Durum Wheat Semolina (DWS) is preferred for the production of different kinds of pasta however, it is not nutritionally balanced, due to the low biological value of its protein. Pasta is made from semolina (durum wheat), which is rich in gluten, as protein responsible for elastic property of dough. Gluten present in wheat causes celiac disease which damaging the small intestine and leads to indigestion leads to unbalanced nutrients in the diet (Vijayakumar and Boopathy, 2014; Prema *et al*., 2018) [34, 28].

The deficiencies of essential micronutrient ions are major concern in wheat (Abecassis *et al*. 2000, Jalgaonkar *et al*., 2019) [2, 20]. Therefore, supplementation of wheat flour with inexpensive staples, other cereals, helps improve the nutritional quality of wheat products (Sharma *et al*., 1999) [32]. Processing and utilization of millets specially Sorghum in value added convenience food products are the current areas of research in last couple of years as they are nutritionally superior to rice and wheat; provide protein, dietary fibre, minerals and vitamins. It has calming benefits like to control the diabetic heart disease, migraine, asthma, atherosclerosis, blood pressure and heart attack. With the changing scenario of utilization of millets in processed products and awareness of consumer regarding health benefits a tremendous potential exists for its utilization in cold extruded products like pasta.

Gluten is responsible for the visco-elastic properties of wheat dough. Removal of gluten protein significantly decreases bread flavour, loaf volume, and yields a crumbling crumb (Arendt *et al*., 2002; Gallagher *et al*., 2004; Sabanis and Tzia 2011b; Ylimaki *et al*., 1991) [8, 19, 29, 35]. Because there is no standard gluten free baking method available, RSM was applied to identify optimal conditions for producing gluten free pasta with sorghum flour addition. RSM is a collection of mathematical and statistical techniques that are useful for modelling and analysing of problems in which a response of interest is influenced by several variables and the objective is to optimize this response (Nawakolar, 2020) [26]. The little change in extrusion variables such as feed compositions, feed moisture content, screw speed, screw geometry, dies configuration; feed rate, processing temperature could greatly affect finished product quality (Ding *et al*., 2005) [15]. This therefore has placed a critical need on food scientists to properly and effectively optimize production variables if extrusion technology is to be adopted. Response surface methodology (RSM) provides an ideal tool for investigating and optimizing process and product parameters in food processing. Keeping all in view, the present study was carried out to optimize the levels of different ingredients required for development of Pasta from composite flour blends of sorghum and wheat and to study the effect of different ingredients on physical properties, chemical composition and sensory quality attributes of developed pasta.

Material and Methods

Raw Material

The raw material is used for the experiments were refined wheat flour (RWF), Sorghum flour, Gaur Gum, Edible oil and oil were purchased from local market in appropriate quantity.

Experimental Details

The Raw material /Ingredients combinations for making pasta was presented in table 1

Table 1: Raw material /Ingredients combinations for making pasta Sorghum, Water-350 ml, Semolina (10%) - Fixed level

(Sorghum)	(-2)	(-1)	(0)	(+1)	(+2)
(Sorghum)X_1	20	30	40	50	60
(Oil)X_2	12	15	18	21	24
(Gum)X_3	8	9	10	11	12
(Salt)X_4	5	7.5	10	12.5	15

Development of Pasta Samples

The pasta extruder machine (Make: K. K. LIFE SCIENCES, 21/41, Flat No.3, Sunkuvar Street, Triplicanve, Chennai-600005) located at the Department of Food Science and Technology, JNKVV, Jabalpur was used. Products were prepared at room temperature approx. 27±2 ºC. Pasta samples were prepared by using steps of weighing, sieving, mixing, kneading, and extrusion process in a pasta extruder machine. The preparation of control and fortified pasta sample starts with mixing of different raw ingredients (refined wheat flour and Sorghum flour) and addition of oil & water in pasta extruder machine followed by kneading in to a form of dough. Subsequently, the required amount of water was added to keep the moisture content around 32-34% in mixture. Mixing and kneading were carried out for an optimum time of 12-15 minute till it produces homogeneous dough. A sharp blade cutter was then fixed in front of the die in extrusion machine and the speed of the sharp blade cutter was adjusted as per the requirement which cuts the dough in the desired shape and size of pasta samples. Finally, the control and fortified pasta samples were steamed for 9 minutes, and then dried in a cabinet drier at around 60 °C for 6-8 hours followed by cooling at ambient room temperature for 30 min and then packed in commercially available air tight LDPE poly bags/ pouches.

Physical Properties Evaluation

The physical properties of the different composition of flour were analyzed for the such as Bulk density (Badwaik *et al*. 2014 with slight modification) [10], water absorption capacity (WAC) (Anderson, 1993) [4], oil absorption capacity, color analysis (Hunter colour scanning machine).

Nutritional Properties Evaluation

The different composition of flour were assessed for the chemical properties such as Moisture content (AOAC, 1995) [5], protein content (AOAC, 1980) [6], fat content, total ash content, calcium, phosphorus, crude fiber, total carbohydrate, total solid loss and energy (AOAC, 1995) [5].

Cooking and Sensory Evaluation

Cooking properties of pasta were assessed such as Optimum Cooking time (OCT), cooked weight (AACC, 2000) [1], swelling index (Tudorica *et al*. 2002) [33] and rehydration. Extrudates (Pasta) were evaluated for various sensory attributes like colour, appearance, flavour, taste and overall acceptability on 9 points hedonic scale.

Statistical Analysis

The data obtained during the present investigation were suitably analyzed by employing response surface methodology (RSM) was used to optimize the various parameters. ANOVA was performed to validate the RSM optimization.

Result and Discussion

Assessment of Physical Properties

The physical properties of different composition of sorghum flour were assessed to determine the quality value and presented in table 2-3. The bulk density is one of the important characteristics of a pasta product which significantly impacts its acceptance. Bulk density is an indication of porosity of a product which influences package and could be used to determine the type of packaging material required (Gebnyi *et al*. 2016) [18]. The bulk density (%) ranged

from 0.45 to 0.58 with the mean value of 0.48. The higher bulk density may be due to the presence of high fiber in the blends (Dayakar Rao *et al*. 2015) [14]. More crude fiber in the composite blend sample resulted in higher bulk density (Sawant *et al*. 2013) [31]

The water absorption index is a measure the amount of water absorbed by starch and can be used as an index of gelatinization. In present study, water absorption capacity (%) ranged from 255 to 313 with the average value of 289.03. While, the oil absorption capacity were (%) ranged from 121 to 166 with the mean value of 140.93. The water absorption capacity could be attributed to the alterations in the water absorption qualities during the fortification, making of pasta and cooking process. The enrichment of pasta with dietary fibre has been shown to affect the water absorption properties of pasta blend (Lucisano *et al*. 2008; Foschia *et al*. 2015) [23, 17].

The colour is most important parameters for accepting any staple food products in terms of appearance has significant role in its sensory and consumer acceptance. The incorporation of different ingredients in the variation of colour in differentially fortified pasta samples. In present investigation, Hunter colour value of L* (indication of lightness) ranged from 44.10 to 48.10 with the average value of 44.85, while a* value (indication of redness) ranged from 6.10 to 7.10 with the mean value of 6.34. The Hunter colour value of b* (indication of yellowness) ranged from 17.10 to 18.88 with the mean value of 17.67.

Among all the physical properties, pasta developed from the blends of sorghum flour and refined wheat flour (30:70 Sorghum RWF, Oil 21, Gum 9 and salt 7.5) was found to be best among all the combinations.

Table 2: ANOVA for Physical properties of pasta developed from the blends of sorghum flour and refined wheat flour

Source	Bulk Density (%)	Water absorption capacity (%)	Oil absorption capacity (%)	Hunter Color values			Optimum cooking time (%)	Total solid loss (%)	Cooked weight (g)	Swelling index	Rehydration %
				L	a	b					
Model SS	0.012	3402.88	536.45	13.26	0.89	5.92	0.37	0.50	0.65	0.20	62.50
Model MS	0.0008	243.06	38.32	0.95	0.064	0.42	0.027	0.036	0.047	0.015	4.46
Model DF	14	14	14	14	14	14	14	14	14	14	14
Error SS	0.014	5250.08	2163.42	6.96	0.51	2.17	0.14	0.17	0.22	0.097	21.43
Error MS	0.0009	350.01	144.23	0.46	0.034	0.14	0.0009	0.012	0.015	0.0006	1.43
Error DF	15	15	15	15	15	15	15	15	15	15	15
F Ratio	0.96	0.69	0.27	2.04	1.89	2.92	2.83	3.09	3.20	2.25	3.13
F Table	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
R Square %	47	39	19	65	63	73	72	74	74	67	74
Std. Dev.	0.030	18.71	12.01	0.68	0.18	0.38	0.097	0.11	0.12	0.081	1.20
Mean	0.48	289.03	140.93	44.85	6.34	17.67	5.33	2.39	22.34	2.82	109.44
C.V.%	6.31	6.47	8.52	1.52	2.89	2.15	1.82	4.50	0.54	2.86	1.09

Table 3: ANOVA for chemical composition of pasta developed from the blends of sorghum flour and refined wheat flour

Source	Moisture	Protein	Fat	Carbohydrate	Crude Fibre	Ash	Calcium	Phosphorous
ModelSS	0.40	5.34	2.27	6.35	0.092	0.042	348.89	6813.25
Model MS	0.028	0.38	0.16	0.45	0.0006	0.0002	24.92	486.66
Model DF	14	14	14	14	14	14	14	14
Error SS	0.48	1.61	0.0005	2.35	0.0003	0.0005	1.78	0.38
Error MS	0.032	0.11	0.0003	0.16	0.0002	0.0003	0.12	0.026
Error DF	15	15	15	15	15	15	15	15
F Ratio	0.89	3.55	461.99	2.89	25.87	8.81	210.12	19013.89
F Table	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
R Square %	45	76	99	72	96	89	99	99
Std. Dev.	0.18	0.33	0.019	0.40	0.016	0.018	0.34	0.16
Mean	10.02	9.74	4.37	73.85	0.95	1.07	30.09	186.54
C.V.%	1.78	3.37	0.43	0.54	1.68	1.73	1.14	0.086

Table 4: ANOVA for Sensory quality of pasta developed from the blends of sorghum flour and refined wheat flour

Source	Colour	Appearance	Texture	Crispness	Taste	Flavour	Over All Acceptability
Model SS	0.79	0.84	0.44	0.46	1.77	0.24	0.42
Model MS	0.056	0.060	0.031	0.033	0.13	0.017	0.030
Model DF	14	14	14	14	14	14	14
Error SS	0.88	0.83	0.24	0.97	0.65	0.23	0.18
Error MS	0.058	0.055	0.016	0.065	0.044	0.016	0.012
Error DF	15	15	15	15	15	15	15
F Ratio	0.96	1.08	1.93	0.50	2.90	1.10	2.47
F Table	2.46	2.46	2.46	2.46	2.46	2.46	2.46
R Square %	47	50	64	31	73	50	69
Std. Dev.	0.24	0.24	0.13	0.25	0.21	0.12	0.11
Mean	6.57	6.46	6.47	6.50	6.60	6.28	7.78
C.V.%	3.68	3.65	1.97	3.92	3.16	1.99	1.42

Assessment of Nutritional Properties

The moisture content (%) of different combination of sorghum flour and ingredients was ranging from 9.76 to 10.29 with the mean value of 10.02. The observations from the protein content (%) analysis indicated that the crude protein (%) ranges from 8.50 to 10.75 with the average value of 9.74. As expected the pasta fortified with sorghum found to have creased level of protein content as compared to control pasta. The fat content (%) exhibits the mean value 4.37 and ranged from 3.78 to 4.98. The observations from ash content (%) range from 0.98 to 1.17 with the average value of 1.07.

The crude fiber content analysis indicated that the fiber content (%) ranges from 0.85 to 1.09 with the mean value of 0.95. Foods are rich in fiber slows down the absorption of sugar, which results in lowering of bad cholesterol and improving blood sugar level in diabetes and may also protect against cancer (Augustin *et al*. 2001; Satya *et al*. 2011) [9, 30]. The carbohydrate % ranges from 72.58 to 75.22 with the mean value of 73.85. While, the total solid loss (%) was ranged from 2.10 to 2.88 with the mean value of 2.39.

In the present investigation, the value of calcium content (mg/ 100 g) of different combination of sorghum flour and ingredients was ranging from 22.74 to 37.58 with the mean value of 30.09. Whereas, phosphorus content (mg/ 100 g) ranged from 153.16 to 220.18 with the average value of 186.54. There was increasing pattern observed in all fortified combination as compared to the control pasta. The addition of natural resource of proteins and fibers caused a significantly increase the levels of minerals in the pasta products (Bepary *et al*. 2012) [11]. Among all the nutritional properties pasta developed from the blends of pasta developed from the blends of sorghum flour and refined wheat flour (30:70 Sorghum RWF, Oil 21, Gum 9 and salt 7.5) was found to be best among all the combinations.

Assessment of Cooking Properties

The optimal cooking time of pasta plays a very significant role in its consumer acceptance as well as in retaining the nutritional properties of raw pasta. In present investigation, the optimal cooking time ranged from 5.05 to 5.50 with the mean value of 5.33. Optimal cooking time (OCT) depends primarily on the rates of water penetration and starch gelatinization. However, there are reports, which suggest that the optimal cooking time found to decreases as well with the increasing amount of fiber content (Bustos *et al*. 2009; Martinez *et al*. 2007) [13, 25] possibly due to the dilution of gluten content and the formation of weaker network, and also the lower amount of fibre enrichment has also been linked with no effect on the optimal cooking time (Kaur *et al*. 2013; Aravind *et al*. 2012; Piwinska *et al*. 2016) [22, 7, 27]. Due to lesser quantity which is not sufficient enough to either facilitate or affect the cooking process & cooking time (Bepary *et al*. 2012; Foschia *et al*. 2015; Jayasena and Nasar-Abbas, 2012) [11, 17, 21].

The increase in cooked weight of pasta, known as cooking volume as well, has been implicated as an indirect index of cooking quality of pasta. The increase in cooked weight (9 g) of pasta was ranging from 22.05 to 22.65 with the mean value of 22.34. Swelling index of any food material is an important indicator of amount of water absorbed by the starch and protein present in the raw flour material or ingredients during its preparation and cooking process. The swelling index of ranged from 2.64 to 2.98 with the mean value of 2.82. A food sample with the minimum swelling index is expected to have relatively higher nutrient density (Emmanual *et al*. 2009) [16], and it has also been reported that the low amylase content results in a higher swelling capacity (Lucisano *et al*. 2008; Adebowale *et al*. 2005) [23, 3]. The swelling capacity, water absorption and the cooking loss have direct influence on the net weight of cooked pasta, and also these parameters are dependent on the nature and the type of ingredients present in the pasta blend flour.

Assessment of Cooking and Sensory Properties

Sensory evaluation of the maize fortified pasta was done by the panelists. They are asked to score products based on colour, appearance, texture, crispness, taste, flavour and overall acceptability. The average score for the colour, appearance, texture, crispness, taste and flavour were 6.57, 6.46, 6.47, 6.50, 6.60 and 6.28, respectively. This indicates that the product averaged 'like' (score 6). The mean score for the overall acceptability was 7.78. This indicates that the product averaged 'like slightly' (score 7).

Among all the cooking quality and sensory evaluation of pasta developed from the blends of Sorghum flour and refined wheat flour (20:80 Sorghum RWF, Oil 16, Gum 8 and salt 7.5) was found to be best among all the combinations.

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