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Development and Evaluation of Ready to Cook Extruded Food from Mushroom and Fruit Flours

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Abstract

Convenient foods are defined as fully prepared or partially prepared food items where some or all of the preparation time, culinary skills or energy inputs are provided by food processor than a home maker. The study proposed to find the suitability of fruit flours namely jackfruit and breadfruit flour in the production of extruded products. The study tried different combinations of oyster mushroom and fruit flours and the best treatment was selected using organoleptic evaluation. Incorporation level of 90 per cent of fruit flours and 10 per cent of mushroom flour was found suitable than other combinations. In the selected treatments from each fruit flour based pasta, nutritional evaluation of proximate values and minerals, shelf life studies and cost of production was carried out. When comparing the sensory aspects of the two pastas, jackfruit-based pasta was preferred, whereas breadfruit-based pasta was superior in terms of nutritional value. The study thus demonstrates that both underutilised fruits can be effectively utilized in the manufacturing of low cost gluten-free pasta with additional research on industrial production and modification.

Keywords : Extruded food, Pasta, Jackfruit, Breadfruit, Mushroom, Composite flours, Convenience foods

Convenient foods are defined as fully prepared or partially prepared food items where some or all of the preparation time, culinary skills or energy inputs are provided by food processor than a home maker (Kim *et al.,* 2019). Many convenience foods are made employing the extrusion method in developed nations, since it allows for the incorporation of a variety of desirable qualities. In Asian culture, noodles and pasta, among many convenience foods prepared using extrusion technology, have come to symbolise long life and good fortune (Contini *et al.,* 2020).

Extruded products have enormous potential, since they offer value, are practical for manufacturers and the community of working women, give consumers more variety and can also be eaten as a savoury dish. Apart from them, more people are becoming health-conscious and choose to experiment with coarse grains instead of fine grains like rice and wheat. Thus, development of healthy foods is needed in order to satisfy the market demand for healthier food products (Choton *et al.,* 2020).

To improve the health benefits, composite flour technology can be prepared using of Composite flour technology which refers to the method of combining different flours to create high-quality dishes. The formulation of composite flour is an essential factor for the good functioning of value added products development (Rehman *et al.,* 2007). This technology is considered as advantageous in developing areas as it reduces the importation of wheat and uplift the use of locally grown crops as flour. The value added products developed from composite flour had not only improved quality, but also it provides essential attributes to consumer preference. Development of

the products by incorporation of blends of different levels of flour in a product helps to meet the daily nutritional requirement. Composite flours can be prepared using cassava, maize, rice, sorghum, millets, potato, barley, sweet potato and yam (Chandra *et al.,* 2014).

To improve the nutritional and textural qualities, various sources of starch, fibre, protein from other agricultural products rich in nutrients can be incorporated with mushroom flour (Thomas *et al.,* 2022).

Nutritionally, mushrooms are low in energy and fat but high in protein, carbohydrate and dietary fibre. They also contain a variety of minerals and trace elements such as potassium, copper and vitamins such as riboflavin, niacin and folate. Besides this, it has pharmacological effects such as anti-tumour, antioxidant, antiviral, hypocholesterolemic and hypoglycemic effects (Bustos *et al.,* 2015).

The addition of fruit flours to mushroom flour can again enhance its nutritional qualities. The use of locally available fruit can also reduce the loss of these fruits and also improve the taste and nutritional qualities of extruded products. Jackfruit and breadfruit are fruits which are seen in abundance and are common in Kerala. The post harvest losses of these fruits are also highest in the state. Jackfruit is a rich source of phytochemicals, including phenolic compounds and offers opportunities for the development of value added products, such as nutraceuticals and food application to enhance health benefits (Swami *et al.,* 2012).

The desire for gluten-free foods has driven efforts to employ breadfruit in value-added goods such as chips, fries, dips, baked goods, sweets and beverages over the past decade. Additionally, it has increased the interest in milling breadfruit into flour. Products made from breadfruit flour will increase and supplement current and potential markets for the fresh or processed fruit. Breadfruit flour has a high starch content of 80.9 & 4.2 per cent crude fibre, 1.6 per cent ash content and 4.5 per cent protein (Liu *et al.,* 2015).

Hence, the present study was proposed to standardise nutri-rich ready to cook extruded foods from mushroom and fruit flours and to evaluate its organolepticand nutritional qualities.

Material and Methods

Collection of Raw Materials

Oyster mushroom (*Pleurotus florida*) was collected from KVK Thrissur, Kerala Agricultural University. Breadfruit and jackfruit were collected from households and local market. All the other ingredients required for the study were purchased from the local market.

Preparation of Fruit Flours and Mushroom Flour

For the preparation of composite flours, jackfruit flour, breadfruit flour and mushroom flour were prepared using standard procedures.

Standardization of Fruit Flour and Mushroom Flour Based Ready to Cook Extruded Product

Flours were prepared from mature jackfruit (koozha type) and breadfruit. Pastas were prepared using combinations of jackfruit flour with oyster mushroom flour and breadfruit flour with oyster mushroom flour. The pasta was prepared with different proportion of fruit flours and mushroom flour (Table 1).

Organoleptic Evaluation of Pasta

The organoleptic qualities of the ready to cook extruded products were conducted by score card method using nine-point hedonic scale by a panel of fifteen selected judges. Triangle test suggested by Jellinek (1985) was carried out in the laboratory. Based on the results of triangle test, a panel of fifteen judges (between 18 - 35 years) were selected. The acceptability trials of pastas were done by this panel. The best treatment was selected through sensory parameters by applying Kendall's coefficient of concordance.

Nutritional Properties of the Pasta

The nutritional qualities of pasta were carried out in three replications and the methods used are discussed

TABLE 1

Proportion of ingredients in fruit flour and oyster mushroom flour incorporated pastas

Combinations	Treatments				
	T_0 (Control)	T_1	T_2	T_3	T_4
JFF + OMF	100% JFF	90% + 10%	80% + 20%	70% + 30%	60% + 40%
BFF + OMF	100% BFF	90% + 10%	80% + 20%	70% + 30%	60% + 40%

(JFF - jackfruit flour, BFF - breadfruit flour, OMF - oyster mushroom flour)

below. Nutritional qualities such as moisture, protein (A.O.A.C, 1980), energy (Gopalan *et al.,* 1989), total carbohydrate, fat, fibre, starch (Sadasivam and Manickam, 1992), minerals such as calcium, iron, sodium, magnesium (Perkin and Elmer, 1982) were analysed using standard procedures.

Shelf Life Studies

The selected treatments were packed in HDPE covers. The standardized spice mix will be packed in laminated aluminium pouches (250 gauge) and was kept for the period of three months. The microbial quality, insect infestation and sensory qualities were studied in the selected samples during storage at monthly intervals.

Cost of Production of Selected Products

Cost analysis of the products was done to assess the extent of expenses for the preparation of products. The cost of production was worked out based on the market rates of different ingredients used for the preparation of the products. The cost was calculated for 100g of the product and compared with the price of similar product available in the market.

Statistical Analysis

The observations were tabulated and analysed statistically as Completely Randomised Design (CRD). The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance and other data were analysed using suitable statistical tools.

RESULTS AND DISCUSSION

Standardization of Fruit Flour and Mushroom Flour based Ready to Cook Extruded Product

Fruits selected for the study were jackfruit and breadfruit. Fruit flours and mushroom flour was mixed using various combinations and the dough was prepared to produce the extruded food (pasta). This was then passed on to the pasta machine and kneaded for 1 minute which is then extruded using single crew and was dried for 2 hours at 60 °C. Dried pasta was cooked and mixed with the spice mix.

Organoleptic Evaluation of Ready to Cook Extruded Products

Pastas prepared using combinations of jackfruit with oyster mushroom flour and breadfruit with oyster mushroom flour were subjected to organoleptic evaluation and the scores are tabulated in Table 2.

Organoleptic evaluation was conducted in all the treatments and the scores were recorded in the table. T_1 scored highest in most of the quality attributes. T_1 was having highest scores for appearance among the treatments followed by T_0. In case of flavour, the highest score was observed in the control followed by T_1. Based on Kendall's value (W) significant agreement among judges was noticed in the evaluation of different quality attributes of ready to cook extruded foods.

Treatment T_1 attained higher total score 44.65 for organoleptic attributes compared to other treatments. The lowest total score was observed in T_4. Hence, T_1 was selected as the best treatment in this set with a

TABLE 2

Organoleptic scores of Jackfruit and mushroom based extruded food

Parameters	T_0	T_1	T_2	T_3	T_4	W
Appearance	7.42 (3.63)	8.15 (4.37)	6.57 (2.67)	6.36 (2.30)	5.91 (2.03)	0.507 **
Colour	7.28 (3.40)	7.71 (3.90)	6.93 (3.33)	5.75 (2.13)	5.88 (2.23)	0.308 **
Flavour	7.42 (3.93)	7.28 (3.67)	6.75 (3.43)	5.57 (2.43)	4.62 (1.53)	0.438 **
Texture	6.85 (3.23)	7.14 (3.43)	6.21 (2.97)	5.78 (2.53)	5.00 (2.83)	0.061 *
Taste	6.55 (3.57)	7.02 (4.10)	6.31 (3.13)	5.93 (2.63)	6.11 (1.57)	0.400 **
Overall acceptability	6.82 (3.47)	7.35 (3.97)	6.60 (3.30)	5.91 (2.57)	5.35 (1.70)	0.345 **
Total	42.34	44.65	39.37	35.30	32.87	

Values in parentheses are mean rank score based on Kendall's W which was significant (** significant at 1% level)

combination of 90 per cent jackfruit flour and 10 per cent mushroom flour.

Lakmali (2021) developed pasta from jackfruit bulb flour, jackfruit seed flour, semolina, cassava flour, corn flour with varying proportions. The best treatment selected was pasta produced by using the formulation of T_3 (40:40:10:5:5, JFS: JFB: semolina: CF: corn flour), which scored the highest mean score among all the sensory attributes. Das and Prakash (2011) prepared pasta from jackfruit along with wheat flour and green gram flour. The jackfruit incorporated pasta was highly acceptable for the sensory score of 4.8, 4.7, 4.8 and 5.0 for appearance, flavour, colour and overall acceptability based on 5 point hedonic scale.

The sameset of treatments was repeated by incorporating breadfruit flour instead of jackfruit flour and was subjected to organoleptic evaluation. The scores of organoleptic evaluation is tabulated in Table 3.

In these set of treatments, control recorded highest scores in all the sensory qualities. In the treatments, T_1 recorded highest scores in all the parameters. The mean scores for the appearance of breadfruit and mushroom flour incorporated ready to cook extruded food ranged from 7.13 (T_1) to 6.80 (T_2) with mean rank score from 2.90 to 1.80. The highest score for appearance was recorded for T_1 (7.13) followed by T_2 (6.80). Based on Kendall's value (W) significant

TABLE 3

Organoleptic scores of breadfruit and mushroom based extruded food

Parameters	T_0	T_1	T_2	T_3	T_4	W
Appearance	7.80 (4.90)	7.13 (2.90)	7.20 (3.40)	7.08 (2.00)	6.80(1.80)	0.628 **
Colour	7.60 (3.50)	7.13 (2.10)	7.28 (3.40)	7.16 (3.20)	7.06(2.80)	0.137 **
Flavour	7.46 (3.60)	7.46 (3.20)	7.35 (3.60)	7.31 (3.20)	7.13(1.40)	0.350 **
Texture	6.93 (2.70)	7.13 (2.80)	7.02 (3.00)	7.05 (3.60)	7.00(2.90)	0.052 *
Taste	7.20 (3.00)	7.46 (3.40)	7.28 (3.00)	7.31 (3.00)	7.20(2.60)	0.035 *
Overall Acceptability	7.40 (3.20)	7.20 (3.20)	7.20 (3.20)	7.16 (2.40)	7.06(3.00)	0.049 *
Total	44.39	43.51	43.33	43.07	42.25	

Values in parentheses are mean rank score based on Kendall's W which was significant (** significant at 1% level)

agreement among judges was noticed in the evaluation of different quality attributes of ready to cook extruded foods.

Treatment T_1 attained higher total score 43.51 for organoleptic attributes compared to other treatments. The lowest total score was observed in T_2. Accordingly T_1, in which 90 per cent bread fruit flour and 10 per cent mushroom flour incorporated pasta was selected as the best treatment.

From the two sets of treatments with fruit flours and mushroom flour, one from each set was selected for the further studies.

Many studies have been carried out on using breadfruit to create extruded food products. According to studies, breadfruit is a non-glutenous fruit, making pasta made with this fruit flour and free of wheat a gluten-free dish (Nochera & Ragone, 2016). In a study on wheat and breadfruit instant noodles, Akeem *et al.* (2017) found that as breadfruit flour substitution increases, the likeness of the noodles sample drops.

Selection of Ready to Cook Extruded Food

Based on the organoleptic qualities, the most acceptable treatment from each set was selected. The selected ready to cook extruded food and their combinations are summarised in Table 4.

TABLE 4

Combinations of selected ready to cook extruded food

Ready to cook extruded food	Combination
Jackfruit and mushroom pasta (MP. 1)	T_1 (90% JF + 10% OMF)
Breadfruit and mushroom pasta (MP. 2)	T_1 (90% BF + 10% OMF)

The above selected combinations of ready to cook extruded food from set 1 and 2 were specified as Jackfruit and mushroom pasta (MP. 1) and Breadfruit and mushroom pasta (MP. 2).

Analysing the organoleptic scores of the selected ready to cook extruded foods (Table 5), it was understood that the jackfruit flour incorporated pasta was having the highest scores for appearance, colour and overall acceptability while bread fruit pasta scored highest for flavour and taste.

TABLE 5

Organoleptic scores of the selected extruded foods from two sets

	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
MP. 1	8.15	7.71	7.28	7.14	7.02	7.35
MP. 2	7.13	7.13	7.46	7.13	7.46	7.20

The nutritional properties such as moisture, energy, protein, carbohydrate, fat, fibre were estimated in the selected pastas and are tabulated in the Table 6. While comparing the nutritional properties, carbohydrate, fibre, fat and starch content were found higher in the breadfruit and mushroom based pasta than that of jackfruit and mushroom based pasta. In case of protein, jackfruit and mushroom based pasta is having 9.48 g per 100g which was higher than that of breadfruit and mushroom based pasta which was only 5.40 g per 100g. In line with the findings of the current study, Hettiarchi *et al.,* (2011) found that jackfruit bulb flour contains a substantial amount of protein and that the noodles made from this flour have good stiffness qualities as a result of the high protein content. Adebowale *et al.,* (2017) found that the protein level of breadfruit-based noodles was

TABLE 6

Nutritional composition of the selected pastas

Nutrients (per 100g)	MP. 1	MP. 2	t value
Moisture (%)	6.67	6.03	31.47 *
Energy (Kcal)	355.95	320.69	1004.31 *
Total Carbohydrate (g)	78.63	73.49	1363.09 *
Protein (g)	9.48	5.40	326.59 *
Total fat (g)	0.39	0.57	11.30 *
Fibre (g)	3.60	7.52	218.37 *
Starch (g)	73.39	69.64	1210.88 *
Reducing sugar (%)	0.37	2.12	11.30 *
In vitro digestibility of starch (%)	61.10	52.56	12.69 *
In vitro digestibility of protein (%)	57.76	69.23	101.90 *

as low as 2.80 g/100 g of sample, supporting the fact that the inclusion of mushroom flour had increased the protein content of the pasta developed in the study.

A product's starch and protein in vitro digestibility is influenced by a number of variables, including milling, cooking, germination, and so on (Kaur *et al.,* 2015). *In vitro* digestibility of starch was higher in jackfruit mushroom pasta while *In vitro* digestibility of protein was higher in breadfruit mushroom pasta. When statistically analyzing the data, it was understood that there is a significant difference in the nutritional contents of both pastas. Since amylose-rich starches are difficult to swell or gelatinize, their amylose content has a significant impact on their *in vitro* digestibility. In addition, a number of other parameters, including the amount of amylopectin, the cooking temperature, the manner of processing and the phosphorus content, have an impact on the digestibility (Rincon and Padilla, 2004). Thus, it can be assumed that the changes in the invitro digestibility of both the pastas may be because of the differences in the amylose content in these fruits.

TABLE 7

Mineral content of the selected extruded food

Minerals	MP. 1	MP. 2	t value
Calcium	26.10	37.80	61.08 *
Iron	1.64	0.10	51.46 *
Sodium	6.85	12.03	83.85 *
Magnesium	56.02	19.72	414.36 *

Mineral contents of the both the pasta were also estimated and was found that minerals such as calcium, sodium, magnesium and iron were higher in breadfruit mushroom pasta while jackfruit mushroom pasta had higher iron content. On statistically analyzing, each mineral content were significantly different from one another.

Kumari and Divakar (2016) studied the mineral content in the jackfruit based noodles. The study revealed that JFB flour contained magnesium (0.13 mg), sodium (35.06) and calcium (30 mg). Sobha *et al.,* 2019 observed the mineral content in the multipurpose flour roti. The study shows that the multipurpose flour contained calcium (250mg), iron (6.75mg) and magnesium (10.46mg).

The method of processing may be the reason for the changes in the mineral values of pasta in the present study.

Appiah *et al.,* (2011) have reported that the predominant minerals in the breadfruit flour was calcium, iron, potassium, sodium and phosphorus, which was proved in the present study also.

4.3.3. Shelf Life Studies

Pasta made with fruit flour and mushroom flour were packed in HDPE covers and were kept for three months storage at room temperature.

The sensory values of both the pastas decreased during storage. The reason may be because of the oxidation process and also the absorption of moisture content during storage. The results of the study had been supported by Sharon (2003) that the breadfruit flour had significant reduction in the sensory qualities during storage.

Insect Infestation of the Selected Extruded Food during Storage

The insect infestation of the selected pasta were assessed at monthly intervals for a period of three months. Throughout the storage period, there were no visible insect infestations. Packaged food products are susceptible to infestation along the entire marketing and supply chain channels, especially if the packaging is permeable to food odours. Use of proper packaging material can ensure that the product may not be infested during storage (Brodnjak *et al.,* 2020). Therefore, no visible insect infestation may be attributed to the use of HDPE, a suitable packing material.

Microbial Enumeration of the Selected Extruded Food during Storage

The microbial population of the pasta was assessed at monthly intervals for a period of three months

JF - Jackfruit pasta, BF - Breadfruit pasta, OMF - Oyster mushroom flour & ND - Not detected

TABLE 8

Mean scores for organoleptic evaluation of fruit flour and mushroom based pastas at monthly intervals

Parameters	M. P. 1 (T_1 – 90% JF + 10% OMF)				M. P. 2 (T_1 – 90% BF + 10% OMF)			
	Initial	1 MAS	2 MAS	Final	Initial	1 MAS	2 MAS	Final
Appearance	8.15	8.14	8.02	8.00	6.80	6.74	6.40	6.16
Colour	7.71	7.54	7.20	7.08	7.06	6.89	6.70	6.18
Flavour	7.28	7.01	6.70	6.01	7.13	6.70	6.25	6.00
Texture	7.14	7.10	7.02	6.77	7.00	6.75	6.67	6.51
Taste	7.02	6.60	6.15	6.00	7.20	7.04	6.87	6.52
Overall acceptability	7.35	7.05	6.24	6.18	7.06	6.50	6.10	6.00
Total	44.65	43.44	41.33	40.04	42.25	40.62	38.99	37.37

OMF - Oyster mushroom pasta, BF - Breadfruit flour pasta

TABLE 9

Total microbial count of fruit flour and mushroom flour pastas at monthly intervals

Microbial population (cfu g-1)	M. P. 1 (T1- 90% JF + 10% OMF)				M. P. 2 (T1- 90% BF + 10% OMF)			
	Initial	1 MAS	2 MAS	Final	Initial	1 MAS	2 MAS	Final
Bacteria (x103)	1.00	1.23	2.18	2.53	1.00	1.20	1.40	2.15
Fungi (x103)	ND	ND	1.00	1.13	ND	ND	ND	1.20
Yeast (x105)	ND	ND	ND	ND	ND	ND	ND	ND

JF - Jackfruit pasta, BF - Breadfruit pasta, OMF - Oyster mushroom flour ND - Not detected

According to Sarah (2017), the variables that directly affect microbial development include temperature, relative humidity and moisture content. The bacterial count in the jackfruit and mushroom based pasta was enumerated. The initial bacterial count was found to be 1.00 x 10^3 cfu g^{-1}, which increased gradually to 2.53 x 10^3 cfu g^{-1} during the end of third month. The first and second month had 1.23 x 10^3 cfu g^{-1} and 2.18 x 10^3 cfu g^{-1} respectively.

In case of breadfruit and mushroom based pasta, the initial bacterial count was found to be 1.00 x 10^3 cfu g^{-1}, which increased gradually to 2.15 x 10^3 cfu g^{-1} during the end of third month. The first and second month the product had 1.20 x 10^3 cfu g^{-1} and 1.40 x 10^3 cfu g^{-1} respectively.

The fungal growth was not detected in the initial days first month and second month of storage in the jackfruit and mushroom based pasta. During third month, a fungal growth of 1.13 x 10^3 cfu g^{-1} was detected in the pasta.

A fungal growth of 1.20 x 10^3 cfu g^{-1} was detected at the end of the storage period of three months, in pasta prepared with breadfruit flour and mushroom flour.

Yeast growth was not detected throughout the storage period in the pasta prepared using fruit flours.

An important indicator of stability during storage is the moisture content. Natural, processed and manufactured food's moisture content determine their

legal standards for identity, texture, palatability, consumer acceptability and shelflife (Rafed, 2017).

According to research by Ajisha (2018), the bacterial count increased after the fourth month of storage (1.74 x 106 cfu/g to 1.89 x 106 cfu/g) in jackfruit-based vermicelli. The fungal count wasn't noticed at first, but in the second and fourth months, it was found to be between 0.30 and 0.45 x 103 cfu/g and 0.49 and 0.67 x 103 cfu/g, respectively.

Cost of Production

The cost of production of the selected pasta was calculated based on cost of raw ingredients, fuel charges and electricity charges. The cost of pasta prepared was Rs.50.50, Rs.52.00 for jackfruit flour + mushroom flour, breadfruit flour + mushroom flour pastas, respectively. Compared to the commercially available multigram gluten free pasta (costs Rs.100-Rs.130/ 100g), the pasta prepared in the present study is cheaper.

TABLE 10

Cost of production of the selected extruded foods

Products	Cost (Rs/100g)
Jackfruit and mushroom pasta	50.50
Breadfruit and mushroom pasta	52.00

The present study had been formulated in developing extruded product known as pasta using fruit flours and mushroom flour. The fruit flours used in the study were jackfruit and breadfruit and it was found that both flours are suitable for pasta production. From various treatments tried, the incorporation of 90 per cent of fruit flour and 10 per cent mushroom flour was found to be more acceptable. While comparing the sensory qualities of both the selected pastas, jackfruit based pasta was more acceptable while in the nutritional qualities breadfruit based pasta excelled. This study proves that , both the fruits which are underutilized can be effectively used in the production of low cost gluten free pasta.

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