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Development and quality evaluation of rice-based meal replacer with chocolate flavour for adults

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ABSTRACT: Overweight and obesity rates are increasing across all age groups due to factors such as dietary changes, sedentary lifestyles,urbanisation, and economic development. Skipping meals, particularly breakfast, worsens this problem by reducing nutrient intake, increasing the risk of abdominal weight gain, and contributing to insulin resistance and cardiovascular issues. In response, meal replacement products are becoming more popular as a health management strategy.This study aimed to develop wholesome meal replacers for adults that provide adequate nutrients in a well-balanced manner. Rice and ragi, along with other functional ingredients, were used in various combinations to develop a meal replacer powder. The combination containing jackfruit flour was found to be the most acceptable one organoleptically. The developed meal replacer contained 65.173g of carbohydrates, 22.88g of protein, 2.323g of fat, 4.137g of fibre and 2.39g of total ash, providing 371.92 kcal of energy per 100g. The product demonstrated high shelf stability for more than six months. Nutritious meal replacers made from locally available ingredients can be promoted as a healthy and convenient alternative to maintain a balanced diet for adults amidst busy lifestyles.

Key words: Meal replacer, nutritional qualities, rice, sensory qualities

The adult population in developing countries are facing significant health challenges due to the presence of underweight individuals and the increasing prevalence of overweight and obesity. Factors such as dietary changes, urbanisation, sedentary lifestyle, and improved economic conditions are contributing to the steady rise in overweight and obesity rates. In India, urban areas have three times higher rates of overweight and obesity compared to rural areas, with women being more commonly affected. Additionally, undernutrition and micronutrient deficiencies continue to be persistent issues alongside overweight and obesity.

Many adults frequently skip meals, with breakfast being the most commonly skipped. This habit is linked to a lower intake of essential nutrients, increased risk of weight gain around the abdomen, insulin resistance, and other heart health issues. Studies show that between 24 and 87 per cent of young adults regularly skip meals, with higher rates compared to other age groups (Silliman *et al*., 2004).

The rise towards healthier lifestyles is growing among people of all ages, leading to a desire to switch to nutritious, easy-to-prepare meals that are low in fat and high in nutrients. This has resulted in an increased demand for ready-to-use mixes. These products can serve as a replacement for traditional meals and are becoming more popular due to the increasing rates of diabetes, obesity, and cardiovascular diseases. The awareness of the importance of weight loss and management is growing, driving the market for meal replacers. These products are effective in curbing hunger and providing essential nutrients like fibre, vitamins, minerals, and proteins.

Meal replacers come in various forms such as shakes, meal/snack bars, or frozen entrees, and can help individuals avoid the negative effects of unhealthy, high-calorie meals. They can also support the immune system, aid in weight management, and ensure the body receives necessary nutrients.However, the high price of meal replacement products on the market, as well as

concerns about the presence of sugar and additives, are causing hesitation among consumers. Therefore, there is a need for innovation in convenient food options to offer a variety of healthier alternatives. Meal replacers are a good option for meal skippers, working population and for all who wish to follow a healthy lifestyle. Hence, this study aimed to develop wholesome rice based meal replacers which can provide adequate nutrients in a well balanced manner for adults.

MATERIALSANDMETHODS

Collection of materials

This study was carried out in2023 at Department of Community Science, College of Agriculture, Kerala Agricultural University, Thrissur, Kerala. Rice was the major ingredient for developing meal replacers. The *Ponmani* variety of rice was collected from farmers of Palakkad district. All the other ingredients were collected from local market.

Preparation of flours

The flours of different ingredients were prepared using standard procedures as follows:

Preparation of rice flour

Rice flour was prepared by the method of Bangoura and Zhou (2007).After washing the rice, it was soaked in water for four hours, which helps to reduce the hardness of the rice kernel and makes grinding easier. After draining the excess water the rice was placed in a cabinet dryer at 30°C for one hour and a half hours. Once dried, it was milled and sifted through 90-micron mesh to get the rice flour.

Preparation of ragi flour

Ragi flour was prepared by the method of Azeez *et al*. (2022). Cleaned finger millet grains were washed, drained, and dried in cabinet dryer at 40°C for 24 hours. The dried finger millet grains were ground into a fine powder using a pulveriser and sieved through 90 µm mesh to produce the flour.

Preparationof jackfruit flour

Raw jackfruit was collected from the households and the flour was prepared by modifying procedure suggested by Pandeay (2004). The raw jackfruit was washed and the bulbs and seeds were separated. After slicing the bulbs into 2.5 cm x 1 cm, blanched in boiling water for 1 minute, cooled and immersed in 0.2 per cent KMS solution for 10 minutes. After draining, the slices were dried in a cabinet dryer at 60^0C for 12 hours. The resulting dried chips were then ground into flour and sifted through a 90 mm mesh.

Preparation of banana flour

The raw banana was peeled and sliced into circular shape of 4 mm thickness using dicer. The slices were immersed in water (1: 3 ratio) containing 0.05% potassium meta bisulphite ($K_2S_2O_5$) and 0.1 per cent citric acid for 10 minutes to arrest the enzymatic browning as suggested by Kumar *et al.* (2018). The banana slices were then dehydrated at a temperature of 55 ± 2 °C using laboratory scale hot air forced electrical convection drier, till the slices turned brittle. The dehydrated slices were ground in a commercial pulveriser for 2 minutes and then sieved using 90 micronmesh to get the flour.

Standardisation of meal replacers

Meal replacers were prepared using rice as main ingredient and ragi along with other ingredients in different combinations.

The ingredients used were rice, ragi, jackfruit flour, banana flour, skimmed milk powder and soya protein isolate. Peanut flour and rice bran flour were used as the functional ingredients. The amount of ingredients used in the treatments follows; rice 40 to 60 percent, ragi 0 to 20 per cent, and banana and jackfruit flour from 0 to 15 per cent. Skimmed milk powder 15 per cent, soya protein isolate andother ingredients (peanut flour and rice branflour) at 5 per cent were used in all treatments at a fixed rate. The meal replacer was developed by combining the different flours in the above mentioned ratios, roasted for 5 minutes, pulverised, and sifted through a 90 micron mesh as detailed in figure 1. Later it was flavoured with chocolateat the rate of 4 per cent. The details of treatments used to standardise the meal replacers are given in Table 1.

Table 1:Standardisationof meal replacers with chocolate flavour

Treatments	Combinations	Chocolate flavour
T_1	40% R + 20% MR + 15% SMP + 5% SPI + 15% BF + 5% OI	4 % chocolate powder
T_2	40% R + 20% MR + 15 % SMP + 5% SPI + 15% JF + 5% OI	
T_3	40% R + 20% MR + 15 % SMP + 5% SPI + 15% (BF+JF) + 5% OI	
T_4	50% R + 10% MR + 15 % SMP + 5% SPI + 15% BF + 5% OI	
T_5	50% R + 10% MR + 15 % SMP + 5% SPI + 15% JF + 5% OI	
T_6	50% R + 10% MR + 15 % SMP + 5% SPI + 15% (BF+JF) + 5% OI	
T_7	60% R + 15 % SMP + 5% SPI + 15% BF + 5% OI	
T_8	60% R + 15 % SMP + 5% SPI + 15% JF + 5% OI	
T_9	60% R + 15 % SMP + 5% SPI + 15% (BF+JF) + 5% OI	
T_{10}	60% R + 15% MR + 15 % SMP + 5% SPI + 5% OI	

(R- rice, MR- millet ragi, SMP- skimmed milk powder, SPI-soy protein isolate, OI-other ingredients)

Organoleptic evaluation

The developed meal replacer powder, 100 g was mixed with 300 ml of luke warm water for carrying out the organoleptic evaluation.

The sensory evaluation was carried out using score card on nine point hedonic scale by a panel of 20 judges for qualities like appearance, colour, flavour, consistency, taste and overall acceptability. The panel of twenty judges between age group of 18 to 35 years was selected by conducting a series of organoleptic trial susing simple triangle test at laboratory level as suggested by Jellinek (1985).

Based on the organoleptic scores the best combination of meal replacer was selected and were packed in laminated aluminium pouches and kept for three months under ambient conditions for conducting storage studies.

Nutritional composition

The nutritional qualities like moisture (A.O.A.C., 1980), carbohydrate, protein, fat and fibre (Sadasivam and Manickam,1997)contents and energy value of the selected meal replacer were determined initially and after three and six months of storage.

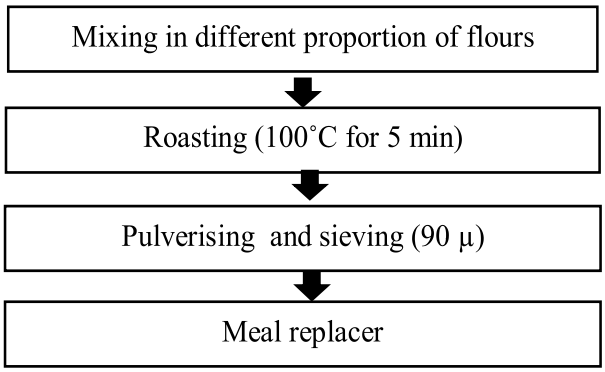

Fig 1: Preparation of meal replacers by roasting

Moisture

To determine moisture content 10 g of the sample was dried in a hot air oven at 60^0C to70^0C, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight on drying.

Carbohydrates

A dried sample of 100mg was hydrolysed with 5ml of 2.5 NHCl for 3 hours by boiling in water bath and cooled to room temperature. The residue was neutralized with sodium carbonate until effervescence ceases. The volume was made upto 100 ml and centrifuged. Analiquot of 0.2ml from the supernatant was pipetted out and made upto 1ml and then 4ml of anthrone reagent was added. Heated for 8 minutes in a boiling water bath, cooled rapidly and the intensity of green to dark colour was read at 630 nm(OD) in spectrophotometer. A standard graph was prepared using standard glucose by applying the serial dilutions. From the standardgraph, the amount of total carbohydrate present in the sample was estimated and expressed in gram per100g of sample.

Protein

A sample of 500 mg was extracted using 5 to 10 ml

of buffer (Trisbuffer GR–trishydroxymethyl amino methane) and centrifuged. An aliquot of 0.1ml from the supernatant wastaken in a test tube, 5ml alkaline copper solution was mixed well and allowed to stand for 10minutes. Folin-Ciocalteau reagent of 0.5 ml was added and incubated at room temperature in the dark for 30 minutes and the developed blue colour was read at 660 nm (OD) in spectrophoto meter. A standard graph was prepared using alkaline copper solution and Folin-Ciocalteau reagent by applying serial dilutions. From the standard graph, the amount of totalproteinpresent insamplewasestimated and expressed ingram per100g of sample.

Fat

Five gram of sample was taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for six hours without interruption by gentle heating in a Soxhlet apparatus. Extraction flask was then cooled and ether was removed by heating and the weight was taken. The fat content was expressed in gram per 100g of the sample.

Fibre

The sample (2g) was boiled with 200 ml of 1.25 percent sulphuric acid for 30 minutes. It was then filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200 ml of 1.25 percent of sodium hydroxide for 30 minutes.

Repeated the filtration through muslin cloth and residue was washed with 25 ml of boiling 1.25 per cent of sulphuric acid, 50 ml portion of water and three times 25 ml of alcohol. The obtained residue was taken in an ashing dish (W1) and dried at 130^0C for 2 hours. Cooled the dish in a desiccator and reweighed (W2). The amount of fibre present in the sample was calculated as g/ 100g.

Statistical analysis

The statistical analysis was carried out for the mean score obtained from sensory evaluation.The data on organoleptic evaluation was statistically interpreted using Kendall Coefficient on concordance. One way anova was carried out for nutritional analysis.

Cost of production of meal replacement powder

The cost of production of the most acceptable meal replacement powder was computed based on the market price of ingredients used for its preparation. Labour charge, fuel charge, electricity charge and packaging cost incurred was also taken into consideration while computing the cost. The cost was calculated for100g of the product and compared with similar products available in the market.

RESULTS AND DISCUSSION

Organoleptic qualities of rice-based meal replacers with chocolate flavour

The mean score and the mean rank scores obtained for different sensory attributes of meal replacers prepared with different combination of ingredients are presented in Table 2.

Table 2: Mean score for organoleptic qualities of meal replacers with chocolate flavour

Treatments	Sensory parameters						
	Appearance	Colour	Flavour	Consistency	Taste	Overall Acceptability	Total mean score
T_1	8.41(5.35)	8.41(5.35)	7.77(3.83)	7.83(2.86)	7.31(2.18)	7.76(3.30)	7.91
T_2	8.43(5.68)	8.45(5.95)	7.9(4.18)	7.91(3.76)	7.78(3.85)	7.9(4.35)	8.06
T_3	8.4(5.08)	8.43(5.80)	7.82(3.55)	7.86(3.26)	7.51(2.88)	7.83(3.38)	7.97
T_4	8.42(5.65)	8.42(5.70)	8.42(7.08)	8.43(7.19)	8.38(6.53)	8.36(6.75)	8.40
T_5	8.48(6.45)	8.46(6.05)	8.46(7.70)	8.49(7.48)	8.45(7.13)	8.46(7.58)	8.46
T_6	8.46(6.28)	8.43(5.80)	8.44(7.38)	8.45(7.45)	8.41(6.63)	8.43(7.25)	8.43
T_7	8.42(5.65)	8.4(5.30)	8.19(4.48)	8.01(5.52)	8.18(5.43)	8.06(5.35)	8.21
T_8	8.44(5.93)	8.41(5.35)	8.30(5.83)	8.23(6.21)	8.23(8.30)	8.28(6.75)	8.31
T_9	8.42(5.65)	8.4(5.30)	8.23(5.68)	8.21(5.83)	8.21(6.25)	8.16(5.68)	8.27
T_{10}	8.44(5.93)	8.41(5.35)	8.14(5.33)	8.08(5.43)	8.06(5.85)	7.91(4.63)	8.17
Kendall"s W	0.061*	0.017*	0.278**	0.352*8	0.448**	0.306**	

Value in parantheses are mean rank score based on Kendall's W**Significant at 1 % level, *significance at 5 % level

The mean score for appearance of meal replacers prepared in different combinations (T_1 to T_{10}) ranged from 8.41 to 8.48. For colour and flavour, the mean score varied from 8.41to 8.46 and 7.77 to 8.46 respectively. As the product was flavoured with 4 per cent of 100 per cent cocoa powder, all treatments had almost similar appearance and colour.

Considerable difference in flavour was noticed with change in ingredients and treatments added with banana flour had lowest scores for flavour. Mean score forconsistency of different treatments was between 7.83 to 8.49. The mean scores for taste varied from 7.31 to 8.45 and maximum mean score for taste was noticed for treatments added with jackfruit flour.For overall acceptability the scores ranged from 7.91 to 8.46. Among the meal replacers, the highest mean score of 8.48, 8.46, 8.46, 8.49, 8.45 and 8.46 for appearance, colour, flavour, consistency, taste and overall acceptability respectively was noticed for treatment T_5 (50 per cent rice, 10 per cent ragi, 15 per cent jackfruit flour, 15 per cent skimmed milk powder, 5 per cent soy protein isolate and 5 per cent other ingredients like peanut and rice bran flour)and it was selected for further studies.Based on Kendall's coefficient of concordance, significant agreement among judges was observed while determining the organoleptic qualities.

Meal replacers prepared in different combinations was acceptable in terms of organoleptic qualities. Comparatively, combination with ragi flour and banana flour received least acceptance especially for parameters like flavour, texture and taste. Addition of ragi more than 10% affected the colour and taste of the products. Similar findings were given by Bansal and Kaur (2018), in milk beverage with malted ragi supplementation ranging from 5 to 15 per cent, with less acceptance for beverages containing 15 per cent ragi. Addition of ragi flour at a higher concentration imparted slightly bitter taste (Taynath *et al.,* 2018) and use of banana flour imparted a slight astringent taste due to the presence of tannins and polyphenols (Sruthy, 2020). Meal replacer combinations containing jackfruit flour had the highest acceptability,as the addition of jackfruit flour could impart a delicate sweetness and slightly dense texture, potentially improving its overall taste as reported by Soumya and Divakar (2021).

Nutritional qualities of rice based meal replacer

The prepared meal replacer powder was evaluated for nutritional qualities like moisture, energy, carbohydrate, protein, fat, and fibre. initially, three month and six month after storage (Table 4).

Moisture is an important parameter determining the shelf-life quality of any food products. The moisture content of meal replacer powder was 3.30 per cent initially, which was found to be lower than the moisture contentof 4.2 per cent reported by Ghandivel and Prakash (2010) in composite weaning mixes developed with roasted rice flour, green gram flour and skim milk powder. Gradual increase in moisture content was observed during 6 months of storage. The initial moisture content of the meal replacer was 3.30 per cent which is increased to 4.62 per cent and 5.73 per cent after third and sixth month of storage respectively. The product was found to be slightly hygroscopic even with the packaging of laminated aluminium pouches. Similar findings were also reported by Ali *et al.* (2017) in the storage studies of maize-pulses based weaning mixes, they observed an increase in moisture content from 3.78 to 5.56 per cent at the end of six month. The relative humidity and temperature of the storage environment may have also influenced the moisture gain during the storage period. The moisture content of meal replacer was still found to be lower than the FSSAI standard of 14 percent in powdered products after six months of storage.

The rice based meal replacer had 65.17g $100g^{-1}$ of carbohydrate, 22.88g $100g^{-1}$ of protein, 2.32g $100g^{-1}$ of fat, 4.13 g$100g^{-1}$ of fibre, 2.39g $100g^{-1}$ of total ash and energy value of 371.92 Kcal $100g^{-1}$. These values are comparable with germinated wheat and mung bean based weaning food mixes, having moisture 3.30 to 3.70 per cent, carbohydrate 52.80 to 61.20, protein 20.80 to 27.70 g, fibre 3.10 to 3.50 g, ash 2.08 to 2.36 g and energy 411.40 to 419.30 Kcal per 100 g reported by Jahan *et al*. (2021). The present findings are in agreement with those by Bana

Table 3: Nutrient analysis of meal replacement powder

Nutrients (100 g^{-1})	Initial	3 MAS	6 MAS	CD value
Moisture (%)	3.30 [c]	4.62 [b]	5.73 [a]	0.30*
Energy (Kcal)	371.92 [a]	364.33 [b]	355.93 [c]	0.09*
Carbohydrate (g)	65.17 [a]	64.98 [b]	64.18 [b]	0.14*
Protein (g)	22.88 [a]	21.67 [b]	21.45 [c]	0.06*
Fat (g)	2.32 [a]	2.01 [b]	1.54 [c]	0.17*
Crude fibre (%)	4.13 [a]	3.99 [b]	3.81 [c]	0.06*
Total ash	2.39 [a]	2.27 [b]	2.21 [c]	0.03*

Duncan's Multiple Range Test (DMRT) column wise comparison (*significance at 5% level)
Different letters (a, b, c) in the column are significantly different by DMRT

and Gupta (2015), who reported that the developed ready to mix infant food using gorgon nut, samak rice and banana flour contained 374.44 Kcal energy, 64.12 g carbohydrate, 2.04 g fat, and 9.18 g protein per 100 g. Bharathi and Rajamani (2015) formulated nutritious mixes from wheat, ragi, green gram and soya bean. They reported that the nutrimix contains moisture, energy, protein, carbohydrate and fat in the rage of 6.40-7.56 per cent, 372-374.97 Kcal, 14.24-16.19 g, 59.18-62.56 g, 7.16-7.85 g respectively.

A meal replacement product should provide 200 to 400 kcal per serving as it used for replacing major meals (codex standards). The developed meal replacer could meet the specified requirements for such a product providing a balanced ratio of different nutrients.

The nutrients significantly decreased with advancements in days of storage and the decrease in carbohydrate, protein and fat content during storage could be attributed to the degradation of polysaccharides, dissociation of protein, into amino acids, lipolytic activities of the enzyme lipase and lipoxidase and decomposition of complex molecules into simple sugars (Murugkar and Jha, 2011).

Cost of production of meal replacement powder

The cost of production of meal replacement powder was Rs. 200/kg and was found to be much lower in price compared to such products available in the market that ranges from Rs. 1000/kg. So, the developed meal replacement powder offers affordability without sacrificing nutritional quality for consumers.

CONCLUSION

Meal replacer powder made from rice, ragi, jackfruit flour, skimmed milk powder, soy protein isolate, peanut flour, and rice bran flour has proven to be highly acceptable with a strong nutritional profile. Promoting the development of nutrient-dense products using locally available, cost-effective ingredients can help address poor dietary habits. These meal replacers are convenient, nutritionally balanced options for adults who often skip meals due to busy schedules. They are also a healthy choice for weight management and dietary control, offering a practical solution for maintaining proper nutrition when traditional meals are impractical or unavailable.

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