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RESEARCH ARTICLE

DEVELOPMENT AND EVALUATION OF GLYCEMIC INDEX OF BROWN RICE BASED TRADITIONAL INDIAN BREAKFAST ITEM – *ADAI*

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ABSTRACT

Traditional Indian breakfast items are based on different cereal or grains and are popular for their unique taste and flavour. Indian breakfast or popularly known as 'nashta' and has its own diversity. Amongst the breakfast items, South Indian Breakfast is considered to be the most nutritious and wholesome. *Idli, dosai, upma, adai, aapam* accompanied with steaming sambhar and different chutneys rule the South Indian breakfast menu. The cereal portion used in these items mainly comprises of polished white rice or polished parboiled rice. Polished white rice contains only carbohydrates and devoid of vitamins, minerals and fiber due to polishing. This renders a high glycemic index and low satiety value to the product. Brown rice is whole grain, produced by removing only the husk or hull using pestle and mortar, retaining the bran layer. This causes the grain to remain intact and retain its soluble fibre and antioxidant content. Consumption of whole grains has associated to lower the risks of Cardio Vascular Diseases (CVD), Type II Diabetes, Cancers and other chronic degenerative diseases. In this study an attempt has been made to develop brown rice based Ready- To- Eat breakfast item *Adai* and evaluate its acceptability and Glycemic Index.

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INTRODUCTION

South Indian breakfast items include *Idli, Dosai, Aapam, Upma* complimented with different chutneys and steaming hot sambhar. These food items have been consumed for centuries together. According to K.T. Achaya, an eminent Indian food scientist and food historian, foods like *Aapam, Idiyappam, Dosai and Adai* were already known in ancient Tamil country and around 1st century A.D., as per references in Tamil Sangam Literature. The common ingredients involved in preparation of these breakfast items are rice as the cereal base combined with pulse(s) (whole/split) along with spices. The cereal portion consists of polished white rice or polished parboiled rice. Polished rice is rich in carbohydrates but deficient in vitamins minerals and soluble fibre. Traditionally these meals were prepared using whole grain carbohydrates like amaranthus, brown rice, barley, millets and other ancient grains that have grown on the Indian subcontinent for the past millennia. But the transition in nutrition has led to replacement of these whole grain ingredients with polished form. According to Sen (2004), the Green Revolution in 1951 has resulted in increasing the consumption of refined rice and wheat to three fold. This has lead to a nutrition transition from whole grains to refined grain intake. A typical Asian Indian diet is high in carbohydrates (70–80% of total daily caloric intake and low in protein (9–10% of total daily caloric intake (Gopalan *et al.*, 2009). Refined grain consumption coupled low physical activity and sedentary lifestyle has put India on the top list amongst the countries suffering from degenerative diseases. Brown rice is unpolished whole grain rice that is produced by removing the hull or husk using a mortar and pestle or rubber rolls. It may be distinctly brownish or purplish red. It has a mild nutty flavour, is chewier than white rice and becomes rancid more quickly but it is very nutritious. In many parts of Asia, Brown rice is associated with poverty and wartime shortages and in the past was rarely eaten except by the sick, the elderly and a cure for constipation. This traditionally denigrated kind of rice is now more expensive than the common white rice partly due to relative low supply and difficulty of storage and transport (Anonymous, 2000).The health benefits of brown rice are immeasurable. Brown rice has high dietary fibre (a gentle laxative, prevents Gastrointestinal

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diseases and good for diabetes, rich in B vitamins and minerals (prevents beriberi) and high in fat (energy source). Also brown rice contains high phytic acid (antioxidant, anti-cancer); it decreases serum cholesterol (prevents cardiovascular diseases) and is considered a low glycemic index food (GI Value 55) decreasing the risk to type 2 diabetes. There is another benefit of brown rice –economics as 50-60% fuel is saved in milling due to elimination of polishing and whitening steps. Hence an attempt has been done to revive the usage of ancient nutrient dense grains by developing brown rice based conventional South Indian breakfast items. Carbohydrates are and are going to be an integral part of our cuisine and so reintroduction of these wholesome nutritious whole grains into the conventional items would be a better alternative as well as an initiative towards reducing the disease burden in our population.

MATERIALS AND METHODS

The major raw materials used in the preparation of product include brown rice flour, barley flour, whole black gram flour and lentil flour. Green leafy vegetables were used for variation purpose. These include amaranthus leaves, curry leaves, drumstick leaves, mint leaves and coriander leaves. Other vegetables like onions and carrot and chillies were also added.

Preparation of Flour

i. Brown Rice Flour

Brown rice was procured from the local market cleaned to remove stones, and other extraneous matter, washed to make it dirt and filth - free and sun dried. The grains were ground in a food processor to a granular size similar to that of *sooji.*

ii. Barley Flour

Barley a very good source of fibre and selenium, it is also a good source of phosphorus, copper and manganese. Barley's dietary fibre also provides food for the "friendly" bacteria in the large intestine. Barley was procured from the local market. It was cleaned, washed to remove dirt and filth, and sundried. The dried grains were ground into flour in a flour mill. The flour was then slightly roasted to reduce the raw flavour.

iii. Whole Black Gram Flour

Whole black gram contains about 26% protein which is almost 3 times of that of cereals. Black Gram lipids have shown to have cholesterol – reducing effects in both humans and experimental animals (Devi and Kurup, 1972). Whole black gram was procured from the local marked. It was cleaned manually to remove stones and other foreign particles. The cleaned pulse was then soaked overnight to destroy the anti - nutrients, sundried for (2-3 days) and ground into flour in food processor. (Panasonic Super- Mixer Grinder, Model No AC 220) The flour was sieved and then stored in an air tight container. Care was taken to retain the fiber content to the maximum extent.

iv. Lentil Flour

Lentils are the unsung heroes of the nutrition world. Inexpensive and versatile, lentils are rich in protein and fibre but low in fat. They are relatively low in calories and a good source of vitamins and minerals. Lentils were procured from the local market, cleaned to remove foreign particles, soaked overnight to increase the nutrient availability and digestibility, sundried (2-3 days) and ground into flour in a food processor (Panasonic Super- Mixer Grinder, Model No AC 220). The flour was sieved and stored in air – tight container.

v. Green Leafy Vegetables

Fresh, tender leafy vegetables were procured form the local vegetable market. The leaves were separated from stalks, unwanted leaves, wilted and ripe leaves. They were then washed thoroughly in water, drained completely, and chopped finely. The chopped vegetable was then weighed, sautéed in little oil prior to addition in the product.

vi. Carrots

Fresh and firm carrots were purchased from the local vegetable market. They were cleaned for soil particle, blemishes and decayed portions were removed, thoroughly washed, separated from the heads, deskinned and grated prior to addition in the product.

vii. Onions

Small Onions were procured from the local market, peeled, washed thoroughly, chopped finely and sautéed in little quantity of oil. It was then used in the preparation of products.
The cereal and pulse were combined in three different proportions in the preparation of *Adai*. These have been represented in the below given table.

Development of Food products

Adai

To the blend of cereal-pulse flour (50g) , 25 g of cleaned , washed, chopped green leafy vegetable, 15 g onions, 5g grated carrots, 1g green chillies, chilli powder-0.5g, salt- 1.0 g, and curry leaves – 5 nos. was added. About 80 ml of water was added to obtain a batter like consistency. The batter was covered and held at room temperature for 30 minutes. On a pre- heated tawa, the batter was spread as a layer to form a pancake of 4mm thickness. It was cooked till golden brown on both sides with addition of 5 ml of oil.

Product Analysis

The organoleptic evaluation of the products was carried out by a panel of 20 semi- trained panelists using a numerical scoring method. The sensory parameters included colour, flavour, texture, taste and overall acceptability. The scores were then subjected to statistical analysis like mean score, 2 way ANOVA and coefficient of variation using MATLAB software 2007.The best variation was further evaluated for nutrient and shelf life analysis.

Evaluation of Glycemic Index

The most accepted product was taken for determination of glycemic index.

Table I. Formulation of cereal pulse mix

Product Code	Cereal: Pulse Proportion	Combination (100g)	Amount (75g)	Variations				
				ML	AL	DL	CL	FL
BRBG	1:1	Brown Rice Flour +Whole Black Gram Flour +Other Vegetables	25g+25g+25g	25g	25g	25g	25g	25g
BRL	1:1	Brown Rice Flour +Lentil Flour +Other Vegetables	25g+25g+25g	25g	25g	25g	25g	25g
BRBL	2:1	Brown Rice Flour +Barley flour+ Lentil Flour +Other Vegetables	15g+15g+ +20g+25g	25g	25g	25g	25g	25g
LBGBR	1:2	Brown Rice Flour+ Lentil flour +Black Gram Flour +Other Vegetables	20g+15g+15g +25g	25g	25g	25g	25g	25g

Table II. Mean scores of organoleptic evaluation of *Adai*

Variations	Colour (5)	Flavour (5)	Texture (5)	Taste (5)	Overall Acceptability (5)
LBGBR					
I	3.08±0.37	**4.1±0.31**	3.04±0.4	2.69±0.46	3.56±0.47
II	**3.35±0.24**	2.83±0.39	2.99±0.37	3.14±0.52	3.7±0.69
III	3.26±0.45	3.23±0.43	**3.31±0.42**	3.16±0.37	2.93±0.44
IV	3.35±0.48	3.04±0.59	3±0	2.75±0.43	2.85±0.53
V	3.04±0.25	3.53±0.74	3.25±0.44	**3.48±0.62**	**4.25±0.61**

Table III. Coefficient of variation and anova of Adai

Variations	Colour	Flavour	Texture	Taste	Overall Acceptability
LBGBR					
I	7.00%	**8.00%**	10.00%	16.00%	**11.00%**
II	**0.00%**	13.00%	10.00%	14.00%	17.00%
III	13.00%	13.00%	14.00%	**10.00%**	**11.00%**
IV	14.00%	19.00%	**0.00%**	13.00%	13.00%
V	7.00%	20.00%	12.00%	15.00%	13.00%
Prob>F	0.07211 **	2.12053×10^{-14}***	0.017391088**	$1.65672X10^{-11}$***	$8.27261X10^{-6}$***

Table IV. Nutrient analysis of *Adai*

Sr.No.	Nutrient Parameter	Value (per 100g)	Method Used
1.	Moisture (%)	50.5	Hot – air oven method
2.	Total Ash (%)	4.24	Muffle furnace method
3.	Energy (Kcals)	336.8	By calculation method
4.	Total protein (g %)	15.42	Micro- Kjeldahl method
5.	Total Fat (g %)	6.52	Soxhlet extraction method
6.	Dietary Fibre (g %)	4.10	Dietary Fibre Assay Kit method (SIGMA)
7.	Total Carbohydrate (g%)	54.11	By Calculation

Table V. Microbial analysis of *Adai*

Product Name	Total Viable Count(cfu/ml)		E- Coli	
No.of days	0 day	II day	0 day	II day
Adai	15×10^{-6}	35×10^{-6}	No growth found	No growth found

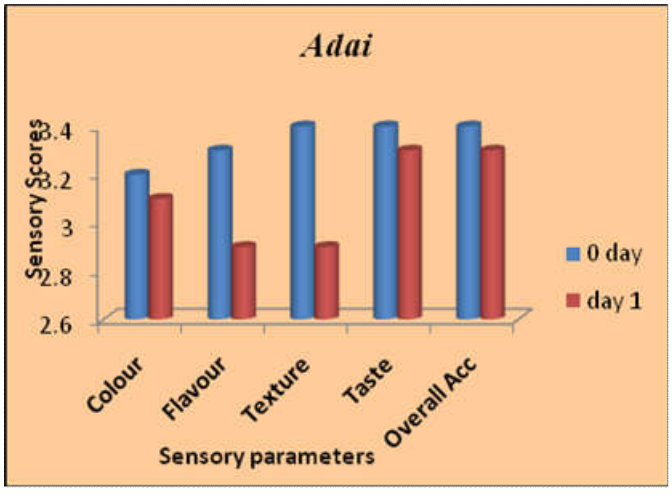

Figure I. Changes in the sensory parameters during storage period

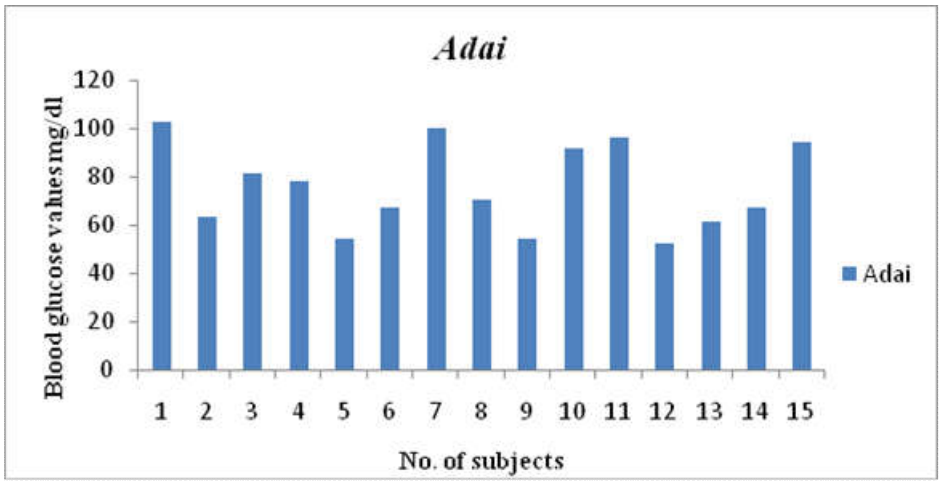

Figure II. Individual blood glucose responses of subjects

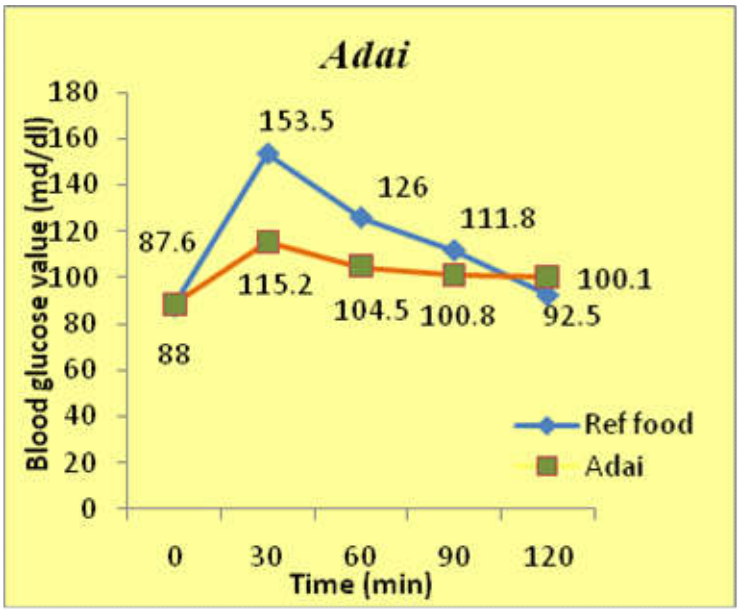

Figure III. Mean blood glucose responses of *Adai*

Glycemic index was evaluated using the prescribed standardised internationally recognised methodology. Glycemic Index is defined as relation of the incremental area under the B-glucose response curve (IAUC) of a tested meal containing 50 g of digestible carbohydrates and the Incremental Area Under the B-glucose response Curve of the standard food, 50 g pure glucose. (IAUCS)(Jenkins DJ, *et.al,* 2002). The students were first oriented about the concept of glycemic index prior to taking their consent. The students were enquired about their health status whether they were diabetic or any other complications or were taking any kind of medication etc. Girls falling under these criteria were not included in the study. Thus fifteen healthy subjects aged between 20- 25 years were selected for the study. The height of the selected subjects was measured using a measuring tape while weight of students was taken using LAICA Electronic personal scale, model PL8033. Basal Metabolic Index (BMI) was calculated as {Weight (kg/Height m^2))}. The average BMI of students was 22.7 kg/m^2.

The subjects were given general instructions to avoid any physical exertion, medication, fast or feast during the experimental period. The Glucose Tolerance Test (GTT) was carried on overnight fasted subjects at 7.00 a.m. with a glucose load of 50 g pure glucose (Glucon –D – Original powder, Heinz India). Pure glucose was given in the form of powder. This was used as the reference food and was administered on the first day. Fasting blood glucose level was checked prior to administration of reference food and test food. Blood sample was drawn after the initiation of food at specific intervals, at 30 minutes, 60 minutes, 90 and 120 minutes by finger prick method. The sample was collected on Glucocard ^{TM} sensor. The blood glucose was measured on glucometer brand Arkray Blood Glucose Monitoring Kit, Glucocard ^{TM} 01- mini. A time interval of 48 hours was maintained between the administration of the reference food and test food. The most acceptable product was served to the subjects in a fixed test portion containing 50 g digestible (available) carbohydrate. Similar procedure was followed for the test food too.

Therefore, a total of five blood samples were collected from each subject on the same day. The subjects were asked not to consume any sweetened drinks during the course of the test and avoid physical exertion. The Glycemic Index of the product was calculated by taking the average of the glycemic response of both the reference and test food at 30, 60, 90 and 120 minutes and a glycemic response curve was constructed. The incremental area under blood glucose response curve (iAUBGR) was calculated. The Glycemic Index value of each individual was calculated as

$$\text{GI value for test food (\%)} = \frac{\text{iAUBGR curve after test food} \times 100}{\text{iAUBGR curve after reference food}}$$

The average Glycemic Index of 15 subjects was taken as the Glycemic Index Value of the product. Student t - test was carried out to determine the significance.

RESULTS AND DISCUSSION

From the sensory analysis the Adai prepared from the combination two pulse (Lentil flour +black gram flour) and one cereal (brown rice flour) was found to be the most acceptable. All the variations using different green leafy vegetables were also found to be acceptable. The results have been represented below

The mean scores from Table II reveal that in Combination 1, Variation I has scored the highest score for flavour (4.41), Variation II for colour (3.35), Variation III for texture (3.31) and Variation V has scored the highest with respect to taste (3.48) and overall acceptability (4.25). Variation IV has scored very low scores in all the parameters due to dull colour and strong flavour development of curry leaves. Table III represents Coefficient of co variation and ANOVA of *Adai* prepared from lentil flour, black gram flour and brown rice flour. Here, Variation I in the *Adai* has got the least scores in flavour and overall acceptability parameters. Variation II has secured nil percentage in the colour parameter while Variation III has scored low in taste and overall acceptability. So, Variation I have been consistent in flavour and acceptability while variation III has been consistent in taste and overall acceptability parameters. In terms of texture parameter, Variation IV has been the most consistent. The P values for flavour, taste and overall acceptability reveal a significant difference between the scores of variations at one per cent level while the P value for colour and texture shows significance at five per cent level. Thus the Adai prepared in Variation III using drumstick leaves was considered the most acceptable.

The nutrient analysis was carried using standardised protocols (AOAC, 2000). The parameters analysed include moisture, total ash, protein, total carbohydrate, total fat and dietary fibre content. The results are represented in table given below.

The nutrient analysis was carried out in triplicates. The nutrients analysed in the cereal – pulse based product, Adai include moisture- 50.55%, total ash- 4.24%, energy- 336.8 kCals, protein- 15.42g, fat- 6.52 g dietary fiber- 4.10g and total carbohydrate- 54.11g. The moisture content indicated that Adai is high moisture containing product, fiber content may be attributed mainly to the green leafy vegetable used in the product. Adai was subjected to microbiological analysis for the parameters – Total Viable Count and E-coli. The shelf life analysis was carried out by storing the product in the Low Density Polyethylene Pouches (LDPE) at room temperature. The changes in the sensory parameters were judged by a panel of 10 semi- trained panelists for colour, flavour, texture, taste and overall acceptability. The results have been represented as follows. *Adai* showed a microbial load of 15 colonies at 10^{-6} dilution on the first day. An increase in the number of viable organisms (30 colonies) was observed on the second day. During the storage period of three days no growth of coli forms was found. However, the product developed fungal growth after two days. It may due to high moisture content of the product. Thus the product is safe for consumption and storage up to one day from the day of preparation.

The organoleptic scores for Adai shows that the product was found to be acceptable during the first day of storage that is on the day of preparation and the next day. But on day two the product developed a fermented flavour and taste, and a dull appearance making the product unfit for consumption. Thus, the product can be stored for a period of only two days.

Evaluation of Glycemic Index

The available carbohydrate content was calculated in the prepared product. Definite quantities providing 50 g of available carbohydrate (Total carbohydrate - dietary fiber) was provided to the subjects and the glycemic responses were taken. The total carbohydrate content in Adai was 46.4g and the serving size of the product served was 110g. The number of subjects used in the study was fifteen. Their individual responses have been represented in the above figure. Student t – test was used to statistically analyse the blood glucose response. The p value of 0.899 indicates a significant difference between the blood glucose response values. The mean glycemic response has been represented as follows.

The Reference food reached a peak (153±39.3) in first 30 minutes after consumption and the peak declined rapidly at 90 minutes. This is because of rapid absorption and utilisation of pure glucose in the body. Adai showed an increase (115.2±15) in the first 30 minutes after consumption. No increase in the blood glucose level was observed in the next 60 minutes. A gradual decrease was observed in the next 30 minutes. Different factors can influence blood glucose response. These include the physical form of the food, degree and type of processing, cooking method and time, amount of heat or moisture used (Pi-sunyer, 2002), type of starch (that is, amylose versus amylopectin), and Co ingestion of protein and fat with test foods. (Manders *et al.,* 2005) The incremental area under the blood glucose response (iAUBGR) for *Adai* was 437.5±93.5 and glycemic index value obtained was 75.5±17.6 indicating *Adai* as a high glycemic index food. The milling process of the medium glycemic brown rice and low glycemic lentil and black gram ingredients may be attributed to cause an increase in the glycemic response. Milling increases the surface area and particle size. This directly affects the Glycemic Index of the product as starch becomes easily

available for digestion. The addition of the green leafy vegetable has not shown any influence on the Glycemic Index of the product. However further investigation and study is required.

Conclusion

The product Adai prepared from brown rice flour, whole black gram flour and lentil flour fortified with drumstick leaves and other vegetable was found to produce a glycemic index of 75.5 which is a high glycemic index food. But, considering the ingredients used in the product, they provide wholesomeness and a good nutritive value to the product. The amount of available carbohydrate could be reduced by increasing the dietary fiber content. Addition of fibre rich substances like guar gum, oat fibre, rice bran can help in delaying the glycemic response. However, an attempt has been made in exploring the utilisation of brown rice in the conventional meals so that brown rice can be used in more better way rather than being regarded as cattle feed.

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