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RESEARCHARTICLE

FORMULATION OF LOW GLYCEMIC INDEX PASTA BY USING SPROUTED MILLET, CEREAL AND LEGUMES FOR TYPE II DIABETIC SUBJECTS

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ABSTRACT

Diabetes mellitus is a chronic metabolic disease that occurs when the pancreas is no longer able to produce insulin, or when the body cannot make proper use of the insulin it produces. Not being able to produce insulin or use it effectively leads to increased glucose levels in the blood (known as hyperglycaemia). In India, more than half of patients have poor blood sugar control and have diabetes complications. The primary objective in the management of diabetes mellitus is the attainment of near-normal blood glucose levels. Therefore, there is an urgent need to develop a food containing complex carbohydrates with a higher amount of dietary fibre. In this context, to improve the hypoglycemic effect, healthy nutritional high fibre flour is developed with the combination of germinated whole grain cereal, millet, and pulses to formulate low glycemic index pasta. The formulated all three variations of pasta were organoleptically evaluated and checked their glycemic index (GI) and glycemic load (GL). All variations of pasta show that the overall acceptability of Mix I Pasta was high score than Mix –II and Mix-III and the GI of Mix I pastas was (51.03 ± 1.75) Mix II (56.47 ± 2.02) and Mix III (58.02 ± 1.95). The GL of mix I was 20.49, Mix II was 22.68 and Mix III was 24.27. Hence the developed pasta Mix-I from sprouted mix flour of millet, cereal, and pulses is low in glycemic index with a high score of overall acceptability. The formulation of enriched pasta able to control glycemic response could represent a strategy to improve the nutritional value of pasta.

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INTRODUCTION

The incidence of *Diabetes Mellitus* is increasing globally in an exponential manner. According to recent estimates, approximately 285 million people worldwide in the age group of 20 - 79 years are affected with diabetes in 2010 and 438 million people of the adult population, is expected to have diabetes by 2030 (International Diabetes Federation, 2009). Calling India the "Diabetes capital" of the world, the International Journal of Diabetes in developing Countries says that there is an alarming rise in. In India, this increase is estimated to be from 51 million people in 2010 to 87 million in 2030 (Ramachandaran and Snehalatha, 2009). Epidemiological studies consistently show that the risk for type II*diabetes mellitus* is decreased with the consumption of whole grains (Dam *et al*., 2003 and Murtaugh *et al*., 2003).Pasta is among one of the most favoured foods being consumed globally because of its affordable price, low glycemic index, easy cooking and desirable taste. Pasta is usually made from semolina, which is high in calories but poor in dietary fibre, minerals, vitamins, and essential amino acids (Ghandehari Yazdi *et al*., 2020).Pasta is a product with low glycemic index and it is generally cooked by boiling in water. In recent years, In India,pasta has become even more popular cuisine too due to its high nutritional properties. Research has shown that sugars are progressively liberated from pasta during digestion, leading to low postprandial blood sugar and insulin responses. Keeping this in view, an endeavour is made to produce low glycemic (GI) pasta incorporated with nutritional benefits of sprouted whole cereal, whole millet, and whole pulses-based pasta the following objectives:

OBJECTIVES OF THE STUDY

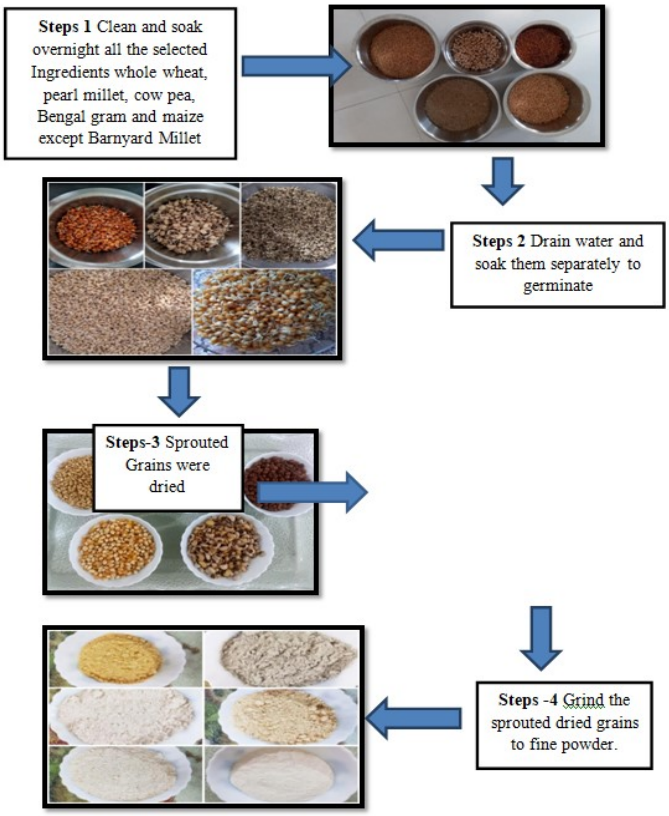
- Development of low glycemic index pasta
- Organoleptic evaluation of formulated pasta
- Evaluation of glycemic index and glycemic load of formulated pasta

METHODOLOGY

Selection and procurement of raw materials: The raw materials were selected for the study was Whole wheat, Pearl millets, Barnyard millets, Yellow maize, Bengal gram and Cow pea. Whole wheat provides nearly 55% of carbohydrate and 20% of the food calories. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, minerals 2.10% and considerable amount of vitamins (thiamine and vitamin-B) and minerals (iron, zinc). (Topping D, 2007). Yellow Maize As per United Nation Food and agriculture Organization the 100 g of Maize give 1698 KJ of energy, 10.4 g of protein, 5.3 g of fat, 82 g of carbohydrate, 8.1 g of fibre(United Nation Food and Agriculture Organization, 2017).Pearl millet is a rich source of energy (361 Kcal/100g) the carbohydrate content of pearl millet is 67.5 g/100g;it has high fibre content (1.2g/100g). The protein content of pearl millet is 11.6 g/100g as per the nutritive value of Indian foods (NIN, 2003).Barnyard millet is also important nutritious millet with a fair source of protein and rich source of minerals, fibre, resistant starch, and antioxidant. It is an excellent source of dietary fibre with good amounts of soluble and insoluble fractions. The carbohydrate content in barnyard millet is low and slowly digestible, which makes the barnyard millet a nature's gift for the modern mankind engaged in sedentary activities (Ugare, 2014).One of the most known benefits of Bengal gram is its ability to boosts the energy in the body and improves digestion. The fibre content in Bengal gram helps to improve your digestive system by improving the digestion process and averting constipation.Each cup of kala chana provides 13 g of dietary fibre. A high fibre diet lowers cholesterol levels and helps to regulate blood sugar levels in individual with diabetes (Natalia stein 2018).Cowpea provides a rich source of protein and calories as well as minerals and vitamins. (Miguel 2016). Cow pea is considered as an incredible source of many other health benefits components such as soluble and insoluble dietary fibre, phenolic compounds, minerals, many other functional compounds including B complex group vitamins (Mudryj 2012). The low glycemic index of cowpea is attributed to the action of resistant starch and dietary fibre which attenuate insulin responses and reduce hunger (Oboh, 2010).The above ingredients were selected for the product development because they are high in fibre, possess low glycemic index value. All above ingredients grade -1 quality were purchased from the market of Coimbatore (Kalapatti). The grains were hand sorted to remove all the dirt and foreign materials. Grains were subjected to processing such as sorting, cleaning, grading and finally processed for further steps.

Processing of raw materials: Processing is commonly done to enhance the quality of the grains by converting them into edible form. Utilization of millets could be enhanced by processing them into various forms such as roasted, sprouted, and fermented products (Jaybhaye et, al 2014).Germination is the process occurring at the beginning of the development of seeds into plants, during which they sprout (Rumiyati, James, & Jayasena 2012). Germination facilitates the enzymatic breakdown of carbohydrates into simple sugars through activation of endogenous enzymes such as α-amylase thereby improving digestibility (Oghbaei& Prakash, 2016).For this study, sprouting method of processing was selected, to germinate the grains, all raw materials except barnyard millet like whole wheat, peal millet, yellow maize, bengal gram and cowpea were cleaned and rinsed several times under running water, then these grains were soaked in clean water in a pan separately for overnight for at least 12 hours at room temperature (24º C). Next day drain off the excess water from the pan and cover the moist grains in a closed container for 24-48 hours. After 24-48 hours, a white root will come out from each of the grains around ½ inch of size. Then take out the germinated grains for sundried for at least 6-8 days till the grains were completely dried. Once the grains were dried completely, and then separately they were ground to fine powder (0.1 mm of size) to the flour mill. Then flours were separately kept in an airtight container.

FLOW CHART OF SPROUTING OF GRAINS



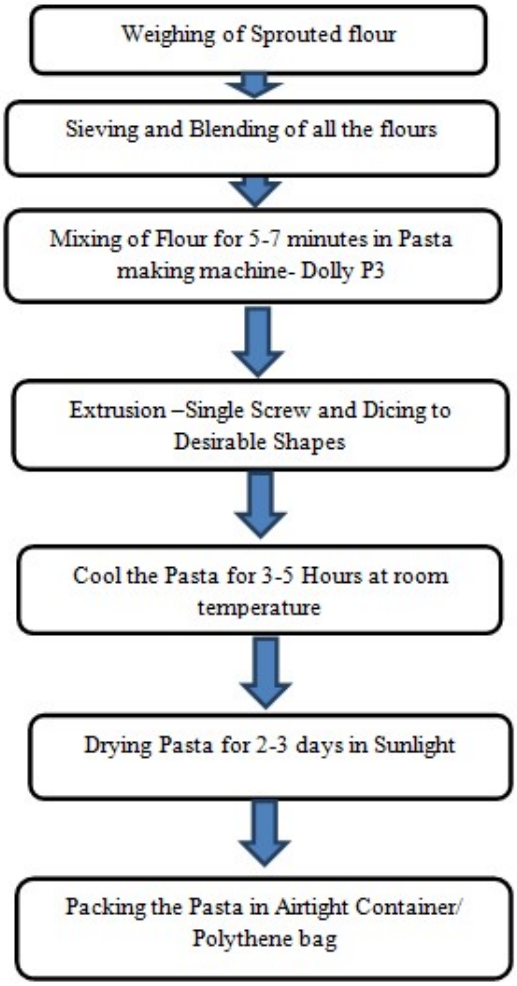
Standardisation of Mix: In the present study, the sprouted flour was standardized in three variations.

Table 1. Standardization of sprouted mix flour- 1000 g

Ingredients	Mix I (g)	Mix II (g)	Mix III (g)
Whole wheat flour	500	500	500
Yellow maize flour	100	200	100
Pearl Millets	100	100	200
Barnyard millets	200	100	100
Bengal gram flour	50	50	50
Cow pea flour	50	50	50

Preparation of Pasta Product by using Dolly P3 Machine

FLOW CHART OF PREPARATION OF PASTA



Three variations of sprouted mix flour Pasta

Organoleptic evaluation of developed Sprouted product Pasta: Besides any food having high nutritional value, it is acceptable to people by means of its good colour, flavour, taste and texture. When a food fulfils all these qualities positively, it becomes most acceptable food product to the people.So, developed pasta of three variations were evaluated organoleptically by a panel of 30 subjects (male and female with the age ranging from 20-30 yrs.) comprising of semi trained panellist and faculty of department of food and nutrition Dr. N.G.P arts and science college, Coimbatore for the sensory attributes like appearance, colour, texture, flavour and overall acceptability. Pasta (25 g) was cooked in 250 ml of boiling water at optimum time Until the centre core disappeared (checked by pressing between two glass slides). A standardized amount of salt was added. It took 5 minutes cook the pasta completely. The pasta was subsequently drained using a stainless-steelsieve. The panellist was asked to present their score from 1-5 (1- Very poor, 2- Poor, 3- Fair, 4- Good, 5- Very Good) the sample (Pasta) for colour, appearance, flavour, taste and overall acceptability by using a score card.

Evaluation of Glycemic Index and Glycemic Load of the formulated Sprouted Pasta

Preparation of standard food: Glucose powder (GluconD,India) was purchased from a local pharmacy of Coimbatore Nehru Nagar and used as a standard/ reference food for this study. Fifty grams (50 g) of glucose was measured using a Kitchen scale (Health Sense India Model No- Ks-33) and diluted into 250 ml of tap water.

Instrument for Blood test:A glucometer from Accu- chek were used to check the blood sample. Kit contains fine needle with pen, strips and glucometer to test the blood sample.

Subjects for the study:10 normal subjects of the age group of 18-24 yrs. both male and female, height 145-175 cm, weight 45-75 kg and BMI- 18-24 kg / m² were randomly selected from Dr. N.G.P Arts and Science College, Coimbatore. The subjects were given general instruction to avoid feast, fast, medication and any form of physical exertion during the experimental study.

Ethical approval: The ethical approval was approved before conducting the experiment before feeding the food items and checking the blood glucose on human subjects by the Institutional Review Board under the approval number DAIRB_ TVL_21_05 having been approved by Dr.Agarwal's Eye Hospital (Institutional Review Board), No-10 Bypass Road,VannarpettaiTiruneiveli 627003.

Consent form: Potential participants were given an overview of the purpose of the research and the procedure of the test. Each willing participants prior to the blood test were asked to fill and signed the consent form.

Calculation of Glycemic Index and Glycemic Load: It is used to classify carbohydrate foods based on their blood glucose raising potential. Low-GI foods are those that are digested and absorbed slowly, resulting in low fluctuations in blood sugar levels. (Brand-Miller *et al*.2014).

$$Glycemic\ Index = \frac{Area\ under\ the\ test\ food\ curve * 100}{Area\ under\ the\ reference\ food}$$

The GI is a ranking of foods based on how quickly they raise blood glucose levels. The reference foods such as glucose have a GI of 100. Foods with carbohydrate that are digested, absorbed and utilized quickly are referred to as high glycemic index food (GI≥70). Those absorbed moderately (56-69) are referred to as medium GI foods while those that are digested, absorbed and utilized slowly are referred to as a low GI (GI≤ 55) food. The glycemic index was calculated using incremental is method under the blood glucose response curve (iAUC). The area under curve is calculated by the formula:

$$L = \frac{\Delta 30t}{2} + \Delta 60t + \frac{(\Delta 30 - \Delta 60)t}{2} + \Delta 90t + \frac{(\Delta 60 - \Delta 90)t}{2} + \Delta 120t + \frac{(\Delta 90 - \Delta 120)t}{2} + \Delta 150t + \frac{(\Delta 120 - \Delta 150)t}{2}$$

Note:

L= the area under the curve
t = time interval of blood taking (30 min)
Δ 30= the blood difference of glucose level 30 min after fasting
Δ 60= the blood difference of glucose level 60 min after fasting
Δ 90= the blood difference of glucose level 90 min after fasting
Δ 120= the blood difference of glucose level 120 min after fasting
Δ 150= the blood difference of glucose level 150 min after fasting

Glycemic load represents the product of the GI and the total available carbohydrate content in a specified portion of food divided by 100. From the Glycemic Index we calculate the Glycemic Load.

$$Glycemic\ Load = \frac{Glycemic\ Index\ * Available\ Carbohydrate}{100}$$

Glycemic load of 20 or more is high a glycemic load is 11to 19 (both inclusive) is medium and a glycemic load of 10 or less is very low. To calculate Glycemic Index and Glycemic Load, 10 non-diabetic subjects are selected from the department of food and nutrition Dr. N.G.P arts and science college, Coimbatore. One day, a subject blood sugar after 12 hr. of overnight fasting is taken, then the subjects are made of eat the boiled pasta containing 50 g of carbohydrate. Further five blood sugar levels were noted with an interval of30, 60, 90, 120 and 150 minutes by using glucometer (Accu chek). Next day, the same steps were repeated on the same subjects but with 50 g. of glucose**.** 50 g of dextrose (glucose monohydrate) dissolves in 200 ml water were used as the reference food.

STATISTICAL ANALYSIS

Data were expressed as means ± standard deviations (SD) by multiple comparisons one-way analysis of variance (ANOVA) using 't' test, IBM SPSS Statistics 23 software program where probability ($p < 0.05$) considered statistically significant.

RESULTS

The Organoleptic Evaluation of Formulated Sprouted mix flour Pasta is given below

Table 2. Mean of Organoleptic Evaluation of Sprouted Mix Flour Pasta

Sprouted Mix Flour Pasta	Mix I		Mix II		Mix III	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Appearance	4.46	0.50	3.97	0.66	4.20	0.71
Taste	4.03	0.61	4.10	0.80	3.97	0.89
Flavour	4.03	0.71	4.03	0.85	3.90	0.75
Texture	4.23	0.67	4.07	0.78	3.80	0.92
Overall Acceptability	4.40	0.49	4.17	0.64	4.13	0.81

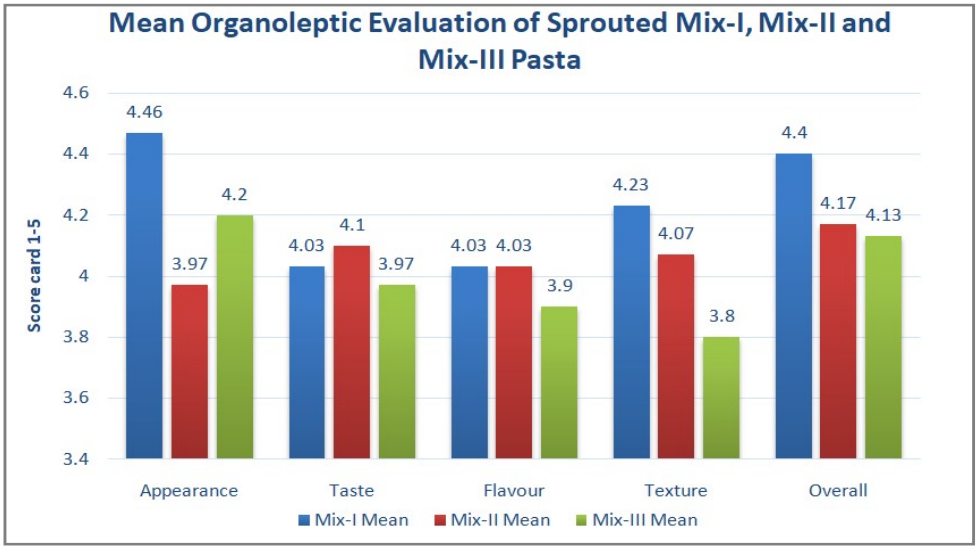


Figure 1. Mean of Organoleptic Evaluation of Sprouted flour Mix-I, Mix-II, Mix-III

Table- III Mean of Organoleptic Evaluation of Sprouted flour Mix-I, Mix-II, Mix-III (By One way ANOVA)

Sensory Evaluation	Sources of variation	Sum of Squares	df	Mean Square	F	P
Appearance	Between Groups	3.75	2	1.87	4.38	0.01
	Within Groups	37.23	87	0.42		
	Total	40.98	89			
Taste	Between Groups	0.26	2	0.13	0.22	0.80
	Within Groups	52.63	87	0.60		
	Total	52.90	89			
Flavour	Between Groups	0.35	2	0.17	0.29	0.74
	Within Groups	52.63	87	0.60		
	Total	52.98	89			
Texture	Between Groups	2.86	2	1.43	2.22	0.11
	Within Groups	56.03	87	0.64		
	Total	58.90	89			
Overall Acceptability	Between Groups	1.26	2	0.63	1.41	0.24
	Within Groups	38.83	87	0.44		
	Total	40.10	89			

Glycemic Index and glycemic Load of Sprouted Mix Flour Pasta: Glycemic Index and Glycemic Load of Sprouted Mix Flour Pasta- Mix-I is given below

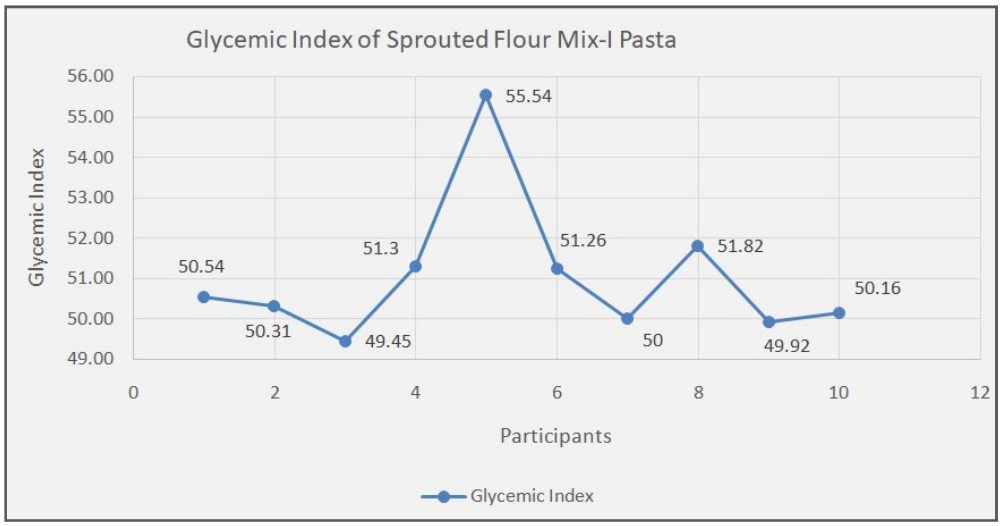


Figure II. Glycemic Index of Sprouted Flour Mix-I Pasta

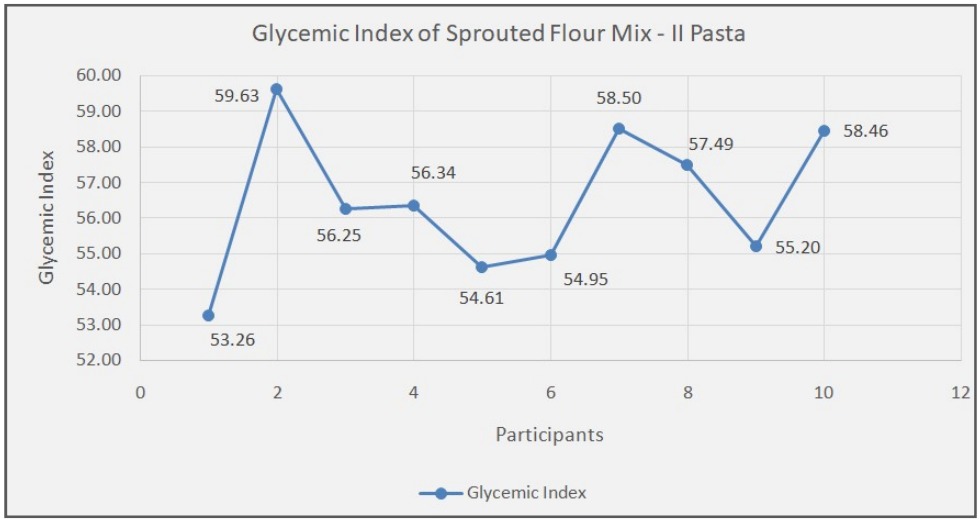


Figure III. Glycemic Index of Sprouted Flour Mix-II Pasta

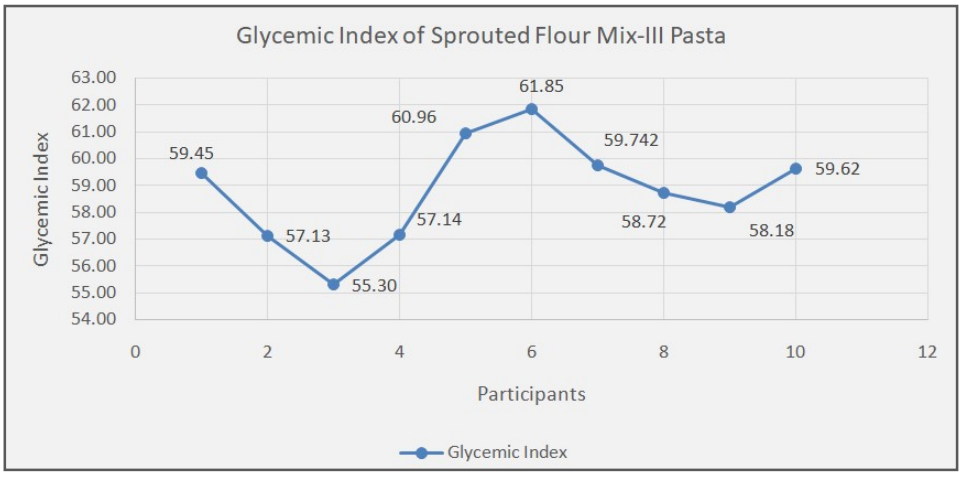


Table IV. Glycemic Index of Sprouted Flour of Mix- I, Mix –II, Mix –III Pasta

Table IV. Glycemic Index of Sprouted Flour of Mix- I, Mix –II, Mix –III Pasta

Sprouted Mix Flour -I		Sprouted Mix Flour –II		Sprouted Mix Flour- III	
Participants	GI	Participants	GI	Participants	GI
Participant-1	50.54	Participant-1	53.26	Particpant-1	59.45
Participant-2	50.31	Participant-2	59.63	Particpant-2	57.13
Participant-3	49.45	Participant-3	56.25	Particpant-3	55.30
Participant-4	51.3	Participant-4	56.34	Particpant-4	57.14
Participant-5	55.54	Participant-5	54.61	Particpant-5	60.96
Participant-6	51.25	Participant-6	54.95	Particpant-6	61.85
Participant-7	50.0	Participant-7	58.50	Particpant-7	59.74
Participant-8	51.81	Participant-8	57.49	Particpant-8	58.72
Participant-9	49.91	Participant-9	55.20	Particpant-9	58.18
Participant-10	50.16	Participant-10	58.46	Particpant-10	59.62
Mean Glycemic index	51.03	Mean Glycemic Index	56.47	Mean Glycemic Index	58.82
Std. Deviation	1.75	Std. deviation	2.02	Std. deviation	1.95
Available Carbohydrate	40.15		40.16		41.16
Glycemic Load	20.49		22.68		24.21
p- value	0.9958		0.9988		0.9987
Null Hypothesis at 10%, 5% and 1% significance	Don't Reject		Don't Reject		Don't Reject

Glycemic Load of Sprouted Mix-I, Mix-II, and Mix-III Pasta

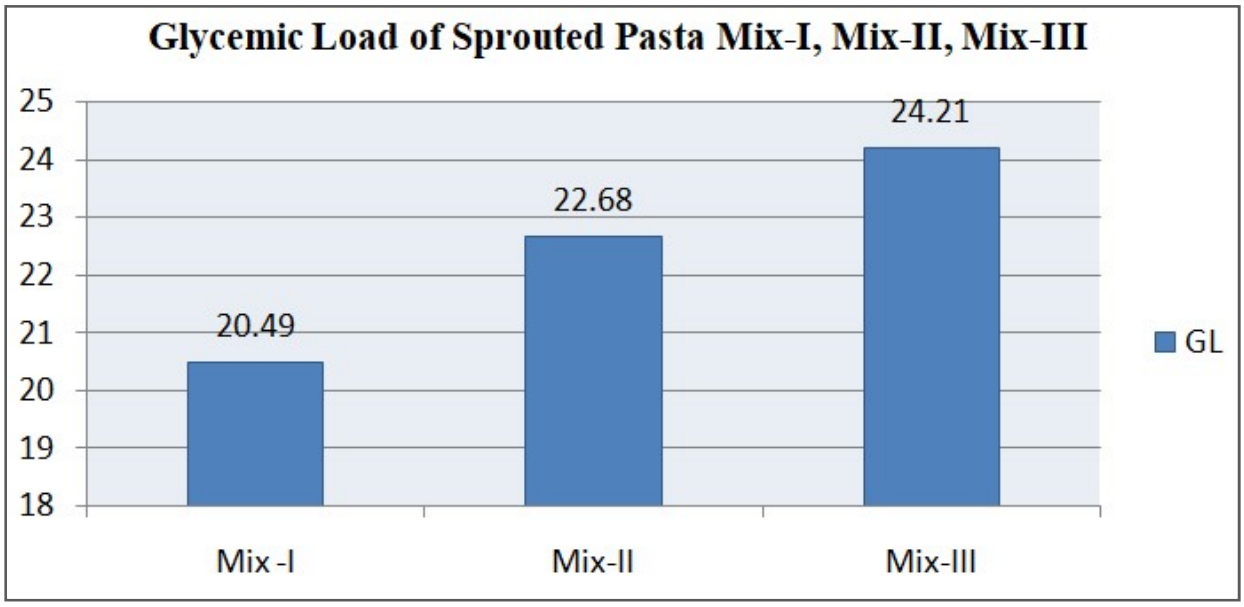


Figure V. Mean Glycemic Index of Sprouted Mix-I, Mix-II, Mix-III pasta

DISCUSSION

Table-I The composition of whole wheat flour in all three mixes were 500 g, Bengal gram flour were 50 g and cow pea flour were 50 g. The remaining ingredients were yellow maize, pearl millet and barnyard millet is alternate in proportion.Table- II The mean and standard deviation for Mix I, Mix II, and Mix III in terms of appearance, flavour, texture, and overall acceptability after sprouting are displayed in Table II. In Mix I, the mean for appearance is 4.46, mean for taste and flavour is 4.03, mean for texture is 4.23 and for overall acceptability the mean is 4.40. In Mix II, the mean score for appearance is 3.97, the mean score for taste is 4.10, the mean score for flavour is 4.03, the mean score for texture is 4.07, and the mean score for overall acceptability is 4.17. In Mix III, the mean for appearance is 4.20, 3.97 for taste, 3.90 for flavour, 3.80 for texture, and 4.13 for overall acceptability. Table-III the findings of the ANOVA calculated to examine the acceptability of three combinations by sprouting are shown in Table III. The difference in means for appearance is statistically significant at 0.01. There is no further statistically significant information found.Table IV illustrate that the mean glycemic Index of sprouted mix flour –I is 51.030 ± 1.75, which comes under low glycemic index, the mean glycemic index of sprouted mix flour-II is 56.47 ± 2.02 and the mean glycemic index of sprouted mix flour-III is 58.82 ± 1.95 respectively which comes under medium glycemic index value. Table IV illustrate that the mean glycemic load of sprouted mix flour - I is 20.49, sprouted mix flour - II is 22.68 and sprouted mix flour - III is 24.21 respectively. Since p-value > 0.05, the null hypothesis is correct and there is no difference in the mean glycemic index of the population.

CONFLICT OF INTEREST: The authors declare no conflict of interest.

FUNDING: This research received no external funding.

CONCLUSION

Study concluded that pasta is medium–low-GI food. The present study would be a useful tool for pasta producers to formulate low GI high fibre enriched pasta with a high nutritional value with specific consumer categories especially type II diabetes. The formulated selected variation pasta belonging to the same category and it proves the inevitable role of formulation in influencing the GI of pasta, one of the mostly consumed starchy foods in our Indian diet. To get a clear picture of this relationship further human intervention studies are needed.

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