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Research Article

ASSESSMENT OF GLYCEMIC INDEX OF A SPECIALLY DEVELOPED FOOD SUPPLEMENT FOR ADOLESCENT GIRLS WITH POLYCYSTIC OVARY SYNDROME (PCOS)

PA. RAAJESWARI AND S. SINDHU

Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher education for Women, Coimbatore.

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ABSTRACT

Glycemic Index (GI) is the ranking of carbohydrates on a scale from 0 to 100 according to the extent to which they raise blood sugar levels after eating. Foods with a high GI are those which are rapidly digested and absorbed and result in marked fluctuations in blood sugar levels. Low-GI foods, by virtue of their slow digestion and absorption, produce gradual rises in blood sugar and insulin levels and have proven benefits for health. Low GI diets also reduce insulin levels and insulin resistance. Polycystic Ovary Syndrome (PCOS) is exceptionally a common disorder of premenopausal women characterized by hyperandrogenism and chronic anovulation. It is believed that Insulin Resistance (IR) is the root cause of PCOS. In general, therapies that lower insulin levels and insulin resistance and lead to weight loss may prove useful for treating PCOS. Hence, to treat Insulin Resistance, Low Glycemic Index foods were identified, selected and formulated to six variations (Var I-Var VI) which were then subjected to organoleptic evaluation. By applying ANOVA and DMR test, the highly acceptable mix was standardized (Lo-GI mix). Glycemic Index was assessed using internationally recognised GI methodology, which has been validated by results obtained from small experimental studies and large multi-centre research trials. The results showed that the Var V has got the highest mean. The Glycemic Index (GI) analyses showed that the mix has low glycemic index. The findings of the study revealed that the ingredients found in Lo-GI mix which are available at our doorsteps are suitable low Glycemic Index foods to control Insulin Resistance in adolescent girls with PCOS.

Keywords: Hyperandrogenism, Anovulation, Insulin Resistance, Hyperinsulinemia, Glycemic Index Test.

INTRODUCTION

Adolescence is a transitional phase between childhood and adulthood characterized by marked acceleration in growth [1]. Adolescence is a time of major physical, cognitive and psychological growth and development [2].

Among adolescents, girls constitute a more vulnerable group, particularly in developing countries, where they are traditionally married at an early age and exposed to greater risk of reproductive morbidity and mortality. Developmentally it is a crucial period, particularly with reference to reproductive health. The young women who are at the brink of womanhood constitute the most crucial segment of our population from the point of view of the quality of our future generation [3].

Maternal age is the most significant factor related to a woman's ability to conceive [4]. In addition to age, there are a number of conditions that can interfere with a woman's fertility, including endometriosis, Polycystic Ovarian Syndrome (PCOS), pituitary tumours and pelvic inflammatory disease [5].

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder among women of reproductive age, affecting approximately four per cent of women [6]. Prevalence of PCOS in Indian adolescents is 9.13 per cent. This draws attention to the issue of early diagnosis of PCOS in adolescent girls [7].

It is a heterogeneous condition characterized by menstrual irregularities, hyperandrogenism, obesity, psychological and psychosexual morbidity associated with the accumulation of under-developed follicles in ovary. It is an important cause of hirsutism and infertility [8].

The classic triad of this syndrome consists of chronic anovulation, hirsutism and obesity. PCOS was first discovered by Stein and Leventhal in 1930 and its management has confused clinicians ever since. The exciting news recently involves understanding the contribution of insulin resistance to the aetiology and treatment of PCOS [9].

PCOS is a hormonal imbalance linked to the way the body processes insulin after it has been produced by the pancreas to regulate blood sugar (glucose). It is believed that Insulin Resistance (IR) is the root cause of PCOS [10].

Insulin Resistance can be encountered in women with PCOS that plays a role in lipoprotein disturbances and body morphology alteration and may predispose to early development of cardiovascular disease, diabetes and hyperlipidemia [11].

There are no known curative therapies for PCOS, though anti-diabetic medications do improve many of the metabolic abnormalities, like insulin resistance and elevated serum testosterone and total cholesterol levels. Dietary and exercise interventions also have some impact on improving insulin sensitivity. In general, therapies that lower insulin levels and insulin resistance and lead to weight loss may prove useful for treating PCOS [6].

Weight loss is the key factor in decreasing insulin resistance in obese women. It appears that a lower glycemic diet may play an important role in helping to control insulin levels as well as promoting weight loss [20].

Dietary modification using a low calorie low Glycemic Index (GI) diet could specifically reduce some of the health risks associated with PCOS including endometrial cancer when compared to other diets[21].

Low glycemic foods namely wheat bran, barley, oats, grainy breads, whole seeds, lentils, kidney beans—are recommended as they are digested slowly and induce less insulin secretion. They are associated with increased HDL, weight loss and improvement in insulin sensitivity and PCOS. High fibre diet consisting of low glycemic whole grains, pulses, vegetables and whole fruits is beneficial. Good fats including omega-3 fats (fish, flax seeds, walnuts) and mono unsaturated fats (mustard oil, olive oil, canola oil, groundnuts, almonds) are useful. Natural sources of fats from nuts and seeds are best way of obtaining good fats[12].

METHODOLOGY

The methodology adopted for the present study entitled is discussed under the following heads:

I. Identification and Selection of Low Glycemic Index Food Ingredients

II. Formulation and Organoleptic Evaluation of Lo-GI Balls

III. Assessment of Glycemic Index of the Standardized Lo-GI Balls

I. Identification and Selection of Low Glycemic Index Food Ingredients

To develop a suitable food supplement for the adolescent girls with PCOS, Low Glycemic Index foods were identified. Low Glycemic index foods like Barley, Roasted Bengal Gram Flour, Soy Flour, Carrot, Tomato and Groundnuts were selected based on the literature available on their low Glycemic Index nature (Plate I). The identified low Glycemic index foods represent the five major food group plans. Table I depicts the identified Low Glycemic Index food ingredients and its GI values.

Table 1: Identified low glycemic index food ingredients and its GI values

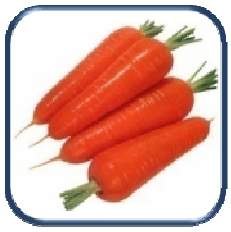
The Selected Food Ingredients	Botanical Name	Glycemic Index*
Barley	*Hordeum vulgare*	37
Roasted Bengal gram	*Cicer arietinum*	11
Soy flour	*Glycine max Merr.*	15
Carrot	*Daucus carota*	16
Tomato	*Solanum lycopersicum*	38
Groundnut	*Arachis hypogaea*	7

*=Source: International Table of Glycemic Index and Glycemic Load Values, 2002.

Barley

Roasted Bengal gram Flour

Soy Flour



Carrots

Tomatoes

Groundnuts

Plate I: Identified Low Glycemic Index Food Ingredients

II. Formulation and Organoleptic Evaluation of Lo-GI Balls

The identified food ingredients were processed separately before formulation (Figure 1).

A. Processing of the Selected Food Ingredients

1. Barley

The barley grains are oval-shaped and milky-white in colour. The outer husk is removed to make it edible[14].The good grade barley was procured and it was cleaned, carefully roasted to remove the raw flavour and also to enhance its flavour, texture and shelf-life and then it was ground into flour and sieved.

2. Roasted Bengal Gram Flour

High quality roasted Bengal gram was procured, cleaned, ground into flour then sieved and roasted to enhance the flavor and shelf life.

3. Soy Flour

Defatted soy flour (Sakthi Vigor Soya Flour - made from dried puffed balls manufactured by short time high temperature cooking of fine granulation un-toasted defatted soya flour in the extruder) was purchased and roasted slightly. Vigor Soy fortifies protein by giving excellent amino acid profile but also improves the functional characteristics of the end products in terms of better moisture retention and less oil absorption[15].

4. Carrot Powder

Well coloured carrots were selected and first washed to remove dirt and debris. The outer skin of the washed carrots were peeled off and scraped into thin pieces and blanched hygienically.

The blanched carrot pieces were then dried under sunlight till all the moisture evaporates completely leaving only the dried portion of the food, powdered and sieved.

5. Tomato Powder

Fresh, fully ripe and good quality tomatoes were selected and washed thoroughly. It was then blanched in boiling water for 30- 60 seconds then dipped in cold water to crack the outer skin. The skin was then peeled off and the tomatoes were cut into small pieces. It was then sundried till all the moisture evaporates completely leaving only the dried portion of the food, powdered and sieved to get fine tomato powder.

6. Groundnut

Crispy roasted groundnuts were selected and made coarse by grinding it.

B. Formulation of the Processed Food Ingredients

Six variations of the Lo-GI mix were formulated by combining all the identified and processed Low Glycemic Index food ingredients in various proportions. Barley, roasted Bengal gram flour, soy flour, carrot powder, tomato powder and groundnut were weighed accurately as per each formulation to a total of 100g and all the six ingredients in each and every variation were mixed together. Table II gives the details on formulation of Lo-GI mix.

Table 2: Formulation of LO-GI mix

The Selected Food Ingredients	Variations (g)					
	I	II	III	IV	V	VI
Barley	15	10	20	15	25	15
Roasted Bengal Gram Flour	15	20	10	25	20	20
Soy flour	25	20	15	20	15	20
Carrot Powder	20	25	20	15	15	25
Tomato Powder	15	20	25	10	15	15
Groundnut	10	5	10	15	10	5

C. Organoleptic evaluation of the formulated Lo-GI balls

Sensory evaluation is a scientific discipline used to evoke measure, analyze and interpret reactions to those characteristics of food and materials as they are perceived by the senses of sight, smell, taste and touch [16].

Each and every formulation was made into balls for the ease of consumption during sensory evaluation. The organoleptic qualities of the formulated Lo-GI Balls were evaluated for its acceptability using quantitative numerical scoring method.

Using this method, a scoring system was used to evaluate the sensory qualities such as appearance, colour, flavour, texture, taste and overall acceptability of the formulated mixes. Twenty semi – trained panelists were given the score card and were asked to evaluate the six variations of the Lo-GI Balls by assigning the respective scores. With the same panel members, the evaluation was conducted for three times. The results of the samples evaluated were compared and analyzed statistically using Analysis of Variance Technique (ANOVA) and Duncan's Multiple Ranking (DMR) test; finally Lo-GI Balls were standardized.

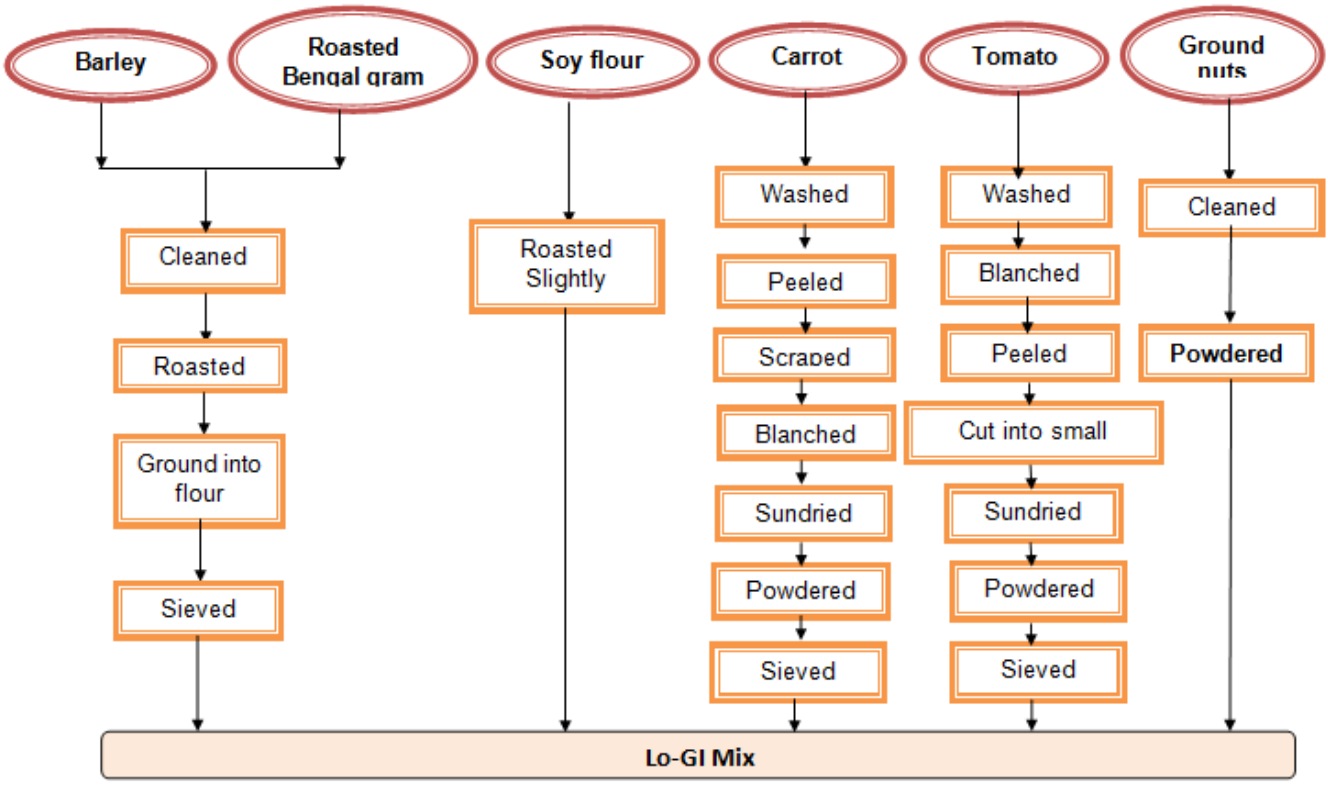


Fig. 1: Processing of the selected food ingredients

Assessment of Glycemic Index (GI) of the Standardized Lo-GI Balls

The Glycemic Index (GI) of a food is calculated as the incremental area under the blood glucose response curve for the food relative to the incremental area under the blood glucose response curve for a reference food which is set to be 100.

The GI test was conducted using internationally recognised GI methodology, which has been validated by results obtained from small experimental studies and large multi-centre research trials.

A group of 10 healthy, adolescent girls aged between 17-20 years, were selected for the test. Adolescent girls volunteering to participate in the test were excluded if they: were over-or-underweight; were dieting; had impaired glucose tolerance; were suffering from any illness or food allergy; or were taking prescription medication. The average age of the subjects was 18.7 years and the groups' average body mass index score was 20.23.

Pure Glucose sugar **(**Glucon-D – Original Powder, **Heinz in India)** dissolved in water (50 g in 250ml) was used as the reference food on the first day. The standardized Lo-GI balls (test food) were served to the subjects in fixed test portions containing 50 g of digestible (available) carbohydrates (i.e. 85.5g) on the next day. On both the days, fasting and post prandial plasma glucose were estimated by withdrawing fasting blood and post prandial blood at 30, 60, 90 and 120 minutes after eating had commenced. Therefore, a total of five blood samples were collected from each subject on a day.

The glycemic index of the Lo-GI balls 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 area under the two-hour plasma response curve (AUC) was then calculated in order to obtain a single number, which expresses the total increase in blood glucose in those subjects as a result of ingesting that food during the two-hour test session. GI value for the Lo-GI balls was then calculated by dividing the two-hour glucose AUC value for the test product by their average two-hour glucose AUC value for the reference food and multiplying by 100 to obtain a percentage value.

$$\text{GI value for test food (\%)} = \frac{\text{Plasma glucose AUC value for test food}}{\text{Average AUC value for the equal- carbohydrate portion of the reference food}} \times 100$$

RESULTS AND DISCUSSION

The results are discussed under the following headings:

I. Evaluation of Acceptability of Formulated Lo-GI Balls
II. Assessment of Glycemic Index of the Standardized Lo-GI Balls

I. Evaluation of Acceptability of Formulated Lo-GI Balls

As outlined in the methodology, the formulated and developed Lo-GI mix is subjected to standardization for the acceptability trial.

A. Organoleptic evaluation of Lo-GI Balls

As stated in the methodology, the organoleptic evaluation was conducted for three times and the mean scores for each criterion given by the semi-trained panelists were tabulated and presented in the Table IV.

B. Analysis of Variance (ANOVA) for Overall Acceptability

The Analysis of Variance (ANOVA) for overall acceptability for Lo-GI balls is given in the Table X.

Table IV: Mean score for the LO-GI balls

Variations (6)	Appearance	Colour	Taste	Flavor	Texture	Overall acceptability
Variation I	73.6	79.6	64	70.3	76.3	69.6
Variation II	74.6	79.6	64.3	70.3	76.6	68
Variation III	72	76.3	59.6	65	72.6	64.6
Variation IV	73.3	80.3	67.6	69	75.3	70.6
Variation V	76	79.6	68.6	70.3	76.6	72.3
Variation VI	74	77.3	67	69.6	75.6	68.3

As far as the variation I is concerned, the scores were 73.6, 79.6, 64, 70.3, 76.3 and 69.6 for its characteristics like appearance, colour, taste, texture and overall acceptability. Similarly variation II secured 74.6, 79.9, 64.3, 70.3, 76.6 and 68 respectively for all the above characteristics. The variation IV has got a high mean score (80.3) with respect to the colour of the product. The organoleptic evaluation of variation III and VI has got an overall acceptability of 64.6 and 68.3 respectively. Thus from the data given above, it is obviously seen that the Variation V has got the highest mean score in appearance (76), taste (68.6), flavor (70.3), texture (76.6) and overall acceptability (72.3) except colour (79.6).

Table V: Analysis of variance (anova) for overall acceptability

Criteria	Degrees of freedom	Sum of squares	Mean sum of squares	F- value
Evaluation (E)	2	0.5511	0.2755	65.26**
Variations	5	0.259	0.0518	12.27**
Error	10	0.0422	0.0042	
Total	17	0.8523		

**=significant at 1 % level

From the results of the organoleptic evaluation, it was clear that the ANOVA scores for overall acceptability revealed a significant difference between the products on all the three evaluations conducted. The F-value for the six variations expressed a significant difference at one per cent level.

Hence there was significance among the six variations on all the three evaluations, it is necessary to find the variation which has secured the maximum score. Hence, Duncan's Multiple Ranking (DMR) test was applied for the same data.

C. Duncan's Multiple Ranking (DMR) Test for Overall Acceptability of Lo-GI Balls

The investigator observed from the scores of DMR for overall acceptability that variation V obtained highest mean scores (3.617) with regard to overall acceptability followed by Variation IV (3.533), Variation I (3.483), Variation VI (3.417), Variation II (3.400) and Variation III (3.233).

The data clearly explains that the Variation V has got first preference in all the organoleptic qualities such as appearance, taste, texture, flavor and overall acceptability except colour. It also reveals that the Variation III has not been preferred by the panelist in any of the organoleptic qualities stated above. Thus by taking into consideration of both ANOVA and DMR test, variation V was selected as a highly acceptable product. Figure 2 provides the proportion of ingredients in the standardized Lo-GI mix – Variation V.

II. Assessment of glycemic index of the standardized LO-GI ball

The Glycemic Response of the Reference food and the Lo-GI balls are given in the following TableVI.

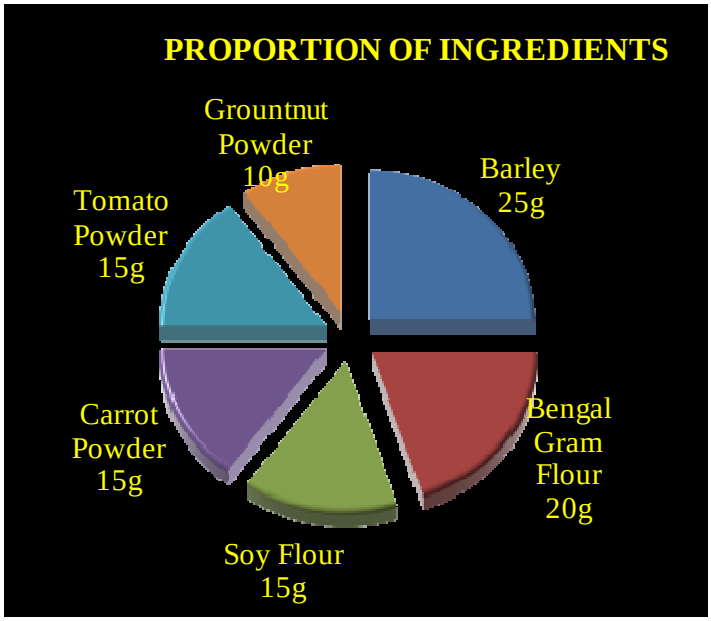


Fig. 2: Proportion of ingredients in standardized LO-GI mix – variation V

The standardized Lo-GI mix contains 25g of barley from cereal groups, 20g of roasted Bengal gram flour and 15g of soy flour from the group of pulses. From the roots and fruits group, 15g of carrot powder and tomato power was added respectively. For nuts, 10g of groundnuts was added.

Table VI: Glycemic response of the reference food and the LO-GI balls

Glycemic Response [Blood Glucose Concentration (mg/dl)]											
Time Interval	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean ± S.D**
Fasting											
Reference	78	88	99	84	90	74	80	86	91	95	86.5 ± 7.74
Test	81	76	91	82	76	95	76	83	87	85	83.2 ± 6.49
30 min											
Reference	132	125	149	88	126	131	98	143	133	138	126.3 ± 19.14
Test	91	89	99	96	83	97	85	96	98	98	93.2 ± 5.80
60 min											
Reference	127	96	116	116	120	128	70	134	122	126	115.5 ±19.01
Test	98	95	95	91	94	99	84	102	103	115	97.8 ± 8.17
90 min											
Reference	107	92	98	112	109	115	76	126	116	114	106.5 ± 4.33
Test	95	88	94	94	89	96	82	99	99	104	94 ± 6.32
120 min											
Reference	108	85	86	80	103	92	80	104	100	97	93.5 ± 10.33
Test	84	81	92	87	83	94	86	88	91	92	87.8 ± 4.36

The mean glycemic response of the reference food reached a peak value of 126.3 at 30 minutes after the fasting (86.5) whereas for the test food it is 93.2. Hence, there is a sudden increase in the glycemic response of the reference food at 30 minutes compared to the test food. It is clear that the glycemic response of the test food reached a peak of 97.8 only, one hour after the ingestion of the same, but the reference food's glycemic response had dropped gradually to 115.5. It was also noted that there is a gradual decrease in the glycemic responses of both the test and the reference food after 90 minutes and 120 minutes respectively. From this study, the investigator found that there is a sudden increase in the Glycemic response for the reference food compared to the test food.

As mentioned in the methodology, the area under the curve was obtained (Figure 3) from the mean glycemic responses of both the reference food and the test food at fasting, 30 minutes, 60 minutes, 90 minutes and 120 minutes respectively.

Applying the formula to find the Glycemic Index, the investigator found that the GI of the Lo-GI balls (test food) is **49.5** which clearly show that the standardized Lo-GI mix (Variation V) is a **low Glycemic Index Food**.

The Glycemic Index of a food varies depending on factors such as processing methods and levels of organic acids. It has been used to classify carbohydrate foods for various applications, including health effects relating to diabetes, sports nutrition and weight management [18].

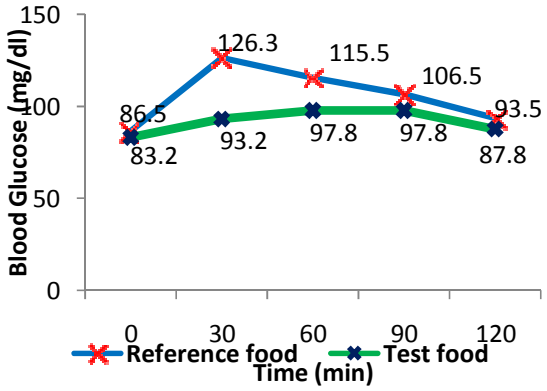


Fig. 3: Glycemic response curve

CONCLUSION

The findings of the study revealed that barley, roasted Bengal gram flour, soy flour, carrot powder, tomato powder and groundnuts which are available at our doorsteps are suitable foods with low Glycemic Index for adolescent girls with PCOS.

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