

# Development of Low Glycemic Index Balls for Adolescent Girls with Polycystic Ovary Syndrome

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**Abstract:** *Polycystic Ovary Syndrome (PCOS) is considered as a hormonal disorder of premenopausal women characterized by hyperandrogenism and chronic anovulation. It is believed that Insulin Resistance (IR) is the root of PCOS. Hence to treat IR, Low Glycemic Index foods were identified and formulated to six variations from which the highly acceptable mix was standardized using organoleptic evaluation and statistical analysis. The standardized (Lo-GI) mix was then subjected to nutrient analysis, shelf life study and Glycemic Index analysis. The findings of the study revealed that the ingredients used in Lo-GI mix which are available at our doorsteps are suitable foods with low Glycemic Index for adolescent girls with PCOS.*

**Keywords:** Polycystic Ovary Syndrome, PCOS, Insulin Resistance, Nutrient Analysis, Glycemic Index.

## 1. Introduction

Adolescence is a transitional phase between childhood and adulthood characterized by marked acceleration in growth<sup>1</sup>. 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<sup>2</sup>. Maternal age is the most significant factor related to a woman's ability to conceive<sup>3</sup>. 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<sup>4</sup>. Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder characterized by menstrual irregularities, hyperandrogenism, obesity, psychological and psychosexual morbidity associated with the accumulation of under-developed follicles in ovary seen among women of reproductive age, affecting approximately four per cent of women<sup>5</sup>. Prevalence of PCOS in Indian adolescents is 9.13 per cent<sup>6</sup>. It is an important cause of hirsutism and infertility<sup>7</sup>.

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<sup>8</sup>. It is also thought of linked to the way the body processes insulin. It is believed that Insulin Resistance (IR) is the root cause of PCOS<sup>9</sup>. Insulin Resistance can be encountered in women with PCOS may predispose to early development of cardiovascular disease, diabetes and hyperlipidemia<sup>12</sup>. There are no known curative therapies for PCOS, though anti-diabetic medications do improve many of the metabolic abnormalities. Therapies that lower insulin levels and insulin resistance and lead to weight loss may prove useful for treating PCOS<sup>5</sup>. Low glycemic foods namely wheat bran, barley, oats, grainy breads, whole seeds, lentils, kidney beans are digested slowly and induce less insulin secretion. They will increase improve insulin sensitivity. Good fats including omega-3 fats (fish, flax

seeds, walnuts) and mono unsaturated fats (mustard oil, olive oil, canola oil, groundnuts, almonds) are useful.

## 2. Methodology

The four phases of the methodology is discussed under the following heads:

### 1) 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 like Barley, Roasted Bengal Gram Flour, Soy Flour, Carrot, Tomato and Groundnuts were selected based on the literature available.

### 2) Processing, Formulation and Organoleptic Evaluation of Lo-GI Balls

The identified food ingredients were processed separately before formulation. Good grade barley and roasted Bengal gram 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. Defatted soy flour was roasted slightly. 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. Fresh, fully ripe and good quality tomatoes were selected and washed thoroughly. It was then blanched. 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. Crispy roasted groundnuts were selected and made coarse by grinding it.

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. Each formulation was made into balls (Lo-GI balls) for the ease of consumption during sensory evaluation. The organoleptic qualities were evaluated using quantitative numerical scoring method in which 20 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 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.

### 3) 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 research trials. A group of 10 healthy, adolescent girls with average age of the subjects 18.7 years and the groups' average body mass index score 20.23 were selected for the test. Pure glucose sugar 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 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.

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

### 4) Nutrient Analysis and Shelf Life Study

The standardized Lo-GI mix was analyzed for the nutrients like moisture, ash, energy, total carbohydrates, total protein, fat, crude fiber, iron, calcium, magnesium, sodium and potassium using standardized procedures given by AOAC<sup>17</sup>. The percentage of moisture and ash were also calculated. The shelf life of the Lo-GI mix was analysed for total bacterial, fungal and mould growth at the first day, eighth day and fifteenth day of the product.

## 3. Results and Discussion

### a) Organoleptic Evaluation of Lo-GI Balls

**Table 1: Mean Score for the LO-GI Balls**

| Variations (6) | Appearance | Color | 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                  |

Thus from the Table I, it is obviously seen that the Variation V has got the highest mean score in all sensory qualities except color.

### b) Analysis of Variance (ANOVA) for Organoleptic Evaluation

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 on the Organoleptic Qualities of Lo-GI Balls

Based on the results of Duncan's Multiple Ranking (DMR) Test on Appearance, Color, Taste, Texture, Flavor and Overall Acceptability variation V obtained highest mean scores except color (Variation IV). These data clearly explains that the Variation V has got first preference in all the organoleptic qualities except color. It also reveals that the Variation III has not been preferred 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. The standardized Lo-GI mix contains 25 per cent of barley, 20 per cent of roasted Bengal gram flour and 15 per cent of soy flour, 15 per cent of carrot powder and tomato powder was added respectively. 10 per cent of groundnuts were added.

### d) Assessment of Glycemic Index of the Standardized Lo-GI Balls

The area under the curve was obtained (Figure 2) 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. 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.

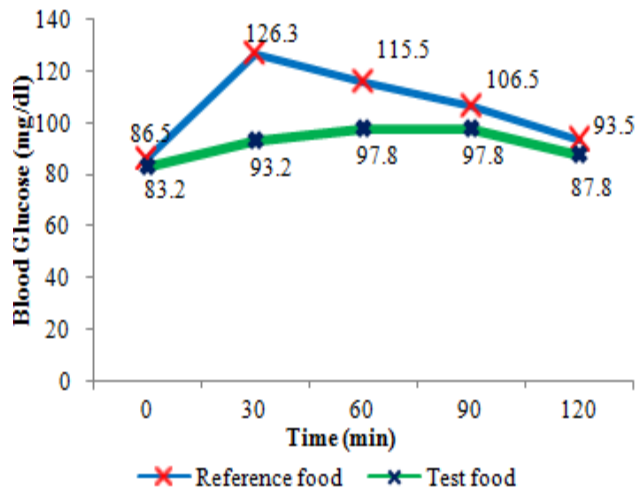


Figure 2: Glycemic Response Curve

Applying the formula to find the Glycemic Index, it was 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.

#### e) Nutrient Content and Shelf Life Study of the Standardized LO-GI Mix

The Lo-GI Mix (variation V) was analyzed for its nutrient content using standardized procedures. It provides 374 Kcal of energy. The total carbohydrate content was 58.46 per cent and the total protein was 18.9 per cent. It contained 7.1 per cent of fat and 4.45 per cent of crude fibre. The mix was rich in potassium (624 mg), calcium (329 mg) followed by sodium (265 mg) and magnesium (186 mg) whereas it contained only 5.5 mg of iron.

The Food and Environmental Hygiene Department suggests that cereal based products were acceptable microbiologically when it contains less than  $10^4$  cfu/g. It was considered unsatisfactory when the cfu/g is more than  $10^5$ . The bacterial enumeration of the Standardized Lo-GI Mix revealed a bacterial growth of  $2 \times 10^3$  on the first day whereas on the fifteenth day, the load has increased to  $5 \times 10^5$  showing rod shaped bacterial species. The fungal growth on the first day of the analysis was found to be  $1 \times 10^5$  which has increased up to  $11 \times 10^4$  on the fifteenth day. The Lo-GI mix has developed Rhizopus Species on 15<sup>th</sup> day shelf life study which presence's was suspected due to the incorporation of groundnuts. Therefore, it has been suggested that the shelf life of the Lo-GI mix was found to be less than 15 days.

#### 4. 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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