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Impact of processing on glycemic index of quality protein maize based flour under *in vivo* condition

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Abstract
Cereal grains are the main staple food like wheat, rice and number of coarse grain which are now termed as nutricereals like maize, sorghum, bajra, ragi, barely etc. The nutricereals having higher nutrient content. Maize, a nutricereal can be utilized for persons in stress if properly processed. The current study was undertaken to determine the impact of processing on glycemic index of quality protein maize based flour under *in vivo* condition. In this study, results revealed that the after incorporating whole bengal gram in quality protein maize, the level of glycemic index was found to be lower in case of boiled maize (52.75 ± 1.67) and alkali treated maize (54.13 ± 1.21) as compared to roasted maize (61.80 ± 1.82) and control maize (71.13 ± 0.96). The lower level of glycemic index in maize after boiling and alkali treatment is recommended for persons with Diabetes, obesity and cardiovascular diseases.

Keywords: Glycemic index (GI), processing, *in vivo* method, quality protein maize (QPM), Bengal gram

Introduction

Glycemic index has proven to be a more useful nutritional concept than is the chemical classification of carbohydrate (as simple or complex, as sugars or starches, or as available or unavailable), permitting new insights into the relation between the physiologic effects of carbohydrate-rich foods and health. Several prospective observational studies have shown that the chronic consumption of a diet with a high glycemic load (GI dietary carbohydrate content) is independently associated with an increased risk of developing type 2 diabetes, cardiovascular disease, and certain cancers [1].

Glycemic index is a measure of the effect of carbohydrates on blood sugar levels. Carbohydrates that break down quickly during digestion releasing glucose rapidly into the bloodstream, have a high GI; Carbohydrates that break down more slowly, releasing glucose more gradually into the blood stream, have a low GI. For most people, foods with a low GI have significant health benefits [2]. These factors include physical entrapment, rate of digestion, food form (physical forms, particle size), type of preparation (processing and cooking method), nature of starch (amylose or amylopectin), amount and presence of fibre, fat and protein and the presence of organic acids [3].

A popular application of GI is for body weight management. A low-GI diet is thought to promote weight loss through reduced food intake, reduced fat storage, and increased fat oxidation [4]. Physiological and metabolic advantages observed from consuming low GI foods are due to reduced rate of carbohydrate absorption in the small intestine. The metabolic advantages include; lower postprandial glucose rise; reduced daily insulin levels, flatter gastric inhibitory polypeptide response decreased 24 hours uninary C-peptide output, prolonged suppression of plasma free fatty acids; reduced urinary catecholamine cholesterol levels, reduced hepatic cholesterol synthesis, decreased serum uric acid levels and increased urinary uric acid excretion [5].

Cereal grains are the main staple food like wheat, rice and number of coarse grain which are now termed as nutricereals like maize, sorghum, bajra, ragi, barely etc. However, the nutricereals having higher nutrient content. Among all nutricereals maize is one of the staple food which contains, carbohydrate, protein, fat and appreciable amount of phosphorus, calcium and iron. In India, rice, wheat and maize are the three important staple food crops, out of these three crops, maize is very nutritious. Maize is a major crop for livestock feed and human nutrition in a number of developed and developing countries. QPM is the only cheapest cereal among food grains which provides both energy as well as good quality protein. QPM protein contains, in general, 55% more tryptophan, 30% more lysine and 38% less leucine than that of normal maize. At global level, India ranks 4th in area and 7th in production of maize. The productivity of maize is increasing in India day by day, but the intake of maize is decreasing. Hence the risk factors are also increasing day by day. So, considering all these points in mind it had been undertaken to study the impact of processing on glycemic index of quality protein maize based flour under *in vivo* condition.

Materials

Selection of the raw material

The most common varieties of quality protein maize (shaktiman-5) grain was selected for the study. Further for making the food mix with lower glycemic index bengal gram was taken as premix.

Procurement of quality protein maize grains and bengal gram

For the study, freshly harvested quality protein maize grain variety (shaktiman-5) and Bengal gram was collected from farmers of Bisanpur, Dighra, (District-Samastipur) in one lot. For the study, the 12 kg quality protein maize grains and 5 kg bengal gram were procured. The collected grains were cleaned by isolating damaged and unhealthy seeds and also by removing foreign matter. Ten kg of cleaned maize grains were divided into 4 portions each of 2.5 kg for processing. Each portion was sub-divided for processing into triplicate. In case of bengal gram, the lot was divided into two portion for processing. Each portion was subdivided for processing into triplicate.

Processing of maize and pulse grains

For the study, out of four sets (in triplicate), one set was kept as such as control (in triplicate). The other three sets (each in triplicate) were kept for processing. The processing methods applied were boiling, roasting and alkali processing.

Boiling of maize grains: Maize grains (in triplicate) were boiled in double amount of water by weight for 30 minutes. Then it was oven dried for 10 hours at 60 ºC.

Roasting of maize grains: Maize grains were roasted at temperature at 180 ºC for 20 minutes.

Alkali processing of maize grains: Maize grains were soaked for 5 minutes in double amount of 1% lime water by weight and then heat treatment was given for 30 minutes at 85 ºC. Then it was kept overnight. Next day the grains were washed 4 times and kept in oven for 10 hours at 60 ºC for drying.

Processing of bengal gram grains:

Bengal gram grains were soaked for overnight (8 to 10 hours) then dried in sunlight and then ground into flour.

Preparation of the sample

After the application of processing methods, the control as well as processed maize grains (all together 12 replicates) were subdivided into four sets. Similarly maize grain and Bengal gram after processing along with the control (all together 12 replicates maize grain and 6 replicates of whole bengal gram) were subdivided into four sets and two sets. Then, the maize grains and whole bengal gram were converted into flour with the help of grinder.

Methods

In vivo determination of glycemic index

Measurement of blood glucose levels in ten healthy subjects was carried out using standard protocol. The Study was conducted after a 12 h fasting. The foods were given between 9:00 am and 10:00 am and were eaten over 15 min. Finger-prick blood samples were taken using Glucometer (Dr. Morphine), with the blood sampling over the test strips provided and measuring blood glucose level with the instrument supplied. Fasting blood glucose levels were recorded for the subjects. For healthy individuals measurement was carried out at 15, 30, 45, 60, 90 and 120 min after taking 50 g of carbohydrate in the form of chapattis. To identify the GI of the chapattis results were compared with 50g glucose values. Volunteers were allowed to drink 150-300 ml of water depending on the food consumed during the study. The GI was calculated following the procedure of Wolever *et al*., (1986) [6]. These obtained values were compared with the GI of the ingredients from the literature. Glycemic index of the chapattis was calculated using the equations below:

$$GI = \frac{\text{IAUC OF TEST FOOD}}{\text{IAUC OF REFERENCE FOOD}} \times 100$$

Data analysis of glycemic index

The data obtained upon determination of quality parameter of maize grains had been analyses for statistical implication by using standard deviation and paired 't' test to find out the Impact of processing on glycemic index of quality protein maize based flour (Snedecor and Cochran, 1989) [7].

Results and discussion

The glycemic index of quality protein maize grains (before and after processing) with whole bengal gram was determined. The data obtained on glycemic index in flour and changes in glycemic index after application of different processing methods have been presented in Table 1 and illustrated through Fig. 1.

The freshly harvested QPM grains i.e. raw maize grains had been taken as control sample. The samples were boiled, roasted and alkali treated maize grains. It was revealed from table that the value of GI after incorporating bengal gram in QPM control maize sample was 71.13 GI. In boiled QPM sample was 52.75 GI and the roasted and alkali treated QPM sample was 61.80 and 54.13 GI.

It can be observed in Table 1 that the value of glycemic index in control maize grain sample was highest (71.13) followed by boiled maize sample (52.75), roasted maize sample (61.80) and alkali treated maize sample (54.13).

The statistical analysis clearly showed that the GI of QPM control maize sample with bengal gram was significantly higher than boiled maize sample ('t' value 24.86), roasted maize sample ('t' value 13.57), alkali treated maize sample ('t' value 30.99) at 1% level of probability. The boiled QPM sample was found to be significantly lower than the roasted maize sample ('t' value -15.13) at 1% level of probability. The difference between GI of boiled and alkali treated maize sample ('t' value -2.30) was found to be non-significant. Roasted maize sample was significantly higher than the alkali treated maize sample ('t' value 11.29) at 1% level of probability.

Percent changes in glycemic index in quality protein maize based product as compared to quality protein maize under different processes.

Percent change in glycemic index in processed maize flour after incorporating whole Bengal gram as compared to control sample can be observed in table 2 and illustrated through fig.2. The GI in boiled maize sample was decreased by 25.84% percent whereas it was decreased in roasted and alkali treated sample 13.12% percent and 23.89% percent respectively.

Table 1: Level of glycemic index in quality protein maize based flour (maize grain with bengal gram) through *in vivo* condition under various processes.

Maize flour sample	Glycemic index on quality protein maize based flour (mean ± SD)
Control (A)	71.13 ± 0.96
Boiled (B)	52.75 ± 1.67
Roasted (R)	61.80 ± 1.82
Alkali treated (D)	54.13 ± 1.21
't' value among maize samples	
A×B	24.86**
A×C	13.57**
A×D	30.99**
B×C	(-) 15.13**
B×D	(-) 2.30 1NS
C×D	11.29**

Each value is the mean of six observations
NS Not significant
**Significant at 1% level of probability
± mean and standard deviation of the samples (p<0.01)

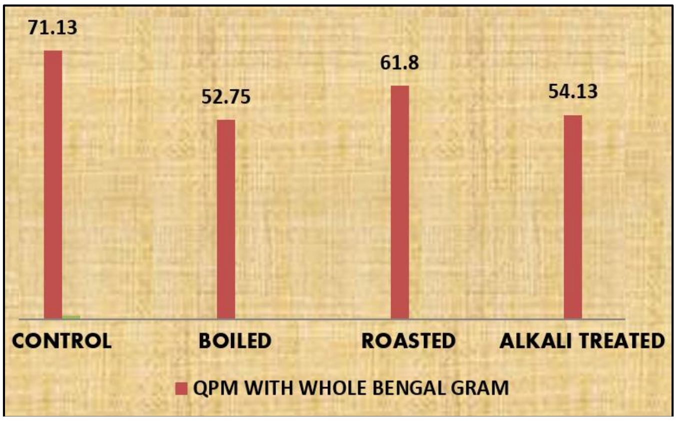

Fig 1: Level of glycemic index in quality protein maize based flour (maize grain with bengal gram) through *in vivo* condition under various processes

Table 2: Percent changes in glycemic index in quality protein maize based product as compared to quality protein maize under different processes.

Percentage change in maize grains	
	Glycemic index on Maize based flour (%)
Boiled (B)	25.84↓
Roasted (C)	13.12↓
Alkali treated (D)	23.89↓

↓ Indicates decreasing trend

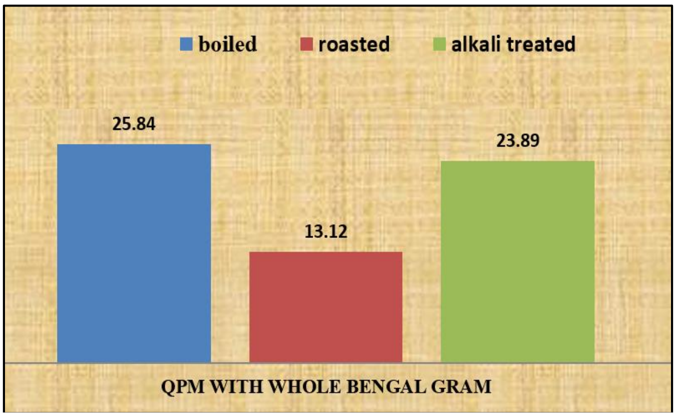

Fig 2: Percent changes in glycemic index in quality protein maize based product as compared to maize under different processes.

Conclusion

The GI found in control maize flour sample with pulse was highest (71.13) followed by boiled maize sample with pulse (52.75), alkali treated maize sample with pulse (54.13) and roasted maize sample with pulse (61.80).

Hence, low glycemic index maize based food mixes is recommended in stress condition such as obesity, diabetes, heart diseases etc. and also high glycemic index maize based food mixes is recommended in case of malnutrition, given after exercise for extra energy, sports person, lactating and pregnant women for extra energy to fulfill their requirement.

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