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Abstract

The study aimed to understand the impact of processing for selected food on the postprandial glycemic and insulinemic response in individuals with type 2 diabetes. Blood samples of diabetic individuals and paired normal subjects were collected after an overnight fast and up to 2 hours post consumption of test and standard food on different occasions. Glucose and insulin levels were measured using glucometer and ECLIA method. Rice puff exerted a significant high peak and overall glycemic response in diabetic individuals than both boiled rice ($p<0.005$, $p<0.05$) and white bread ($p<0.05$). Insulinemic response for RP was higher than BR but statistically insignificant. Normal group showed similar glycemic response. Both peak and IAUC insulin response was significantly higher for RP as compared to BR ($p=0.05$). Selected processing of rice increases its glycemic and insulinemic impact which could be detrimental in case of people with diabetes with compromised insulin status.

Keywords: Diabetic subject, Glycemic Impact, Insulinemic Impact, Rice, Selected processing.

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Introduction

The world today is facing the burden of non-communicable diseases, especially diabetes. It has been reported that by the year 2020 chronic diseases will account for about three quarters of all deaths worldwide and that 70% of death would occur due to diabetes in the developing countries (Misra and Khurana 2008). The increase in the prevalence of diabetes could be attributed to change in food habits due to rapid urbanization, nutrition transition, increase in sedentary lifestyle etc. (Hu 2011). It is possible that change in diet pattern is the most derogative factor in higher prevalence of diabetes today. With time it is seen that processed foods or ready to eat foods are gaining popularity in our changed life style and have become an important part in our daily diet.

Processing techniques used in instantiation of foods such as refining, use of extreme temperature cooking, puffing, rolling etc. affect its digestibility (Brand et al. 1985). It is important to understand the postprandial blood glucose and insulin responses to such processing especially in case of people with diabetes. In the dietary management of diabetes, Glycemic Index (GI) is normally used to assess the suitability of a food for its postprandial impact. GI measures the raise of blood sugars by available carbohydrate (CHO) fraction of food (Jenkins et al. 1981), which varies from food to food. To overcome this limitation of GI it would be helpful if foods are considered as a whole and not on single nutrient basis. Therefore, Glycemic Index$_{food}$ (GI$_{food}$) has been introduced which compares foods on equi-quantity basis (Monro 2003).

In the present study to understand the impact of processing, the postprandial glycemic and insulinemic impact of different test foods made from the same core ingredient (rice) is determined and compared on equi quantity basis with standard food bread in individuals with diabetes and normal individuals.

Materials and Methodology

The research proposal was cleared through Ethics committee (Reg. no. 1433). Subjects with Type 2 diabetic on oral hypoglycaemic agents and with no other clinical complication, having blood HbA1c level <8%, having comparatively stable sugar level at the age group of 45 - 65 yrs, along with paired clinically healthy adults as normal group were enrolled after receiving informed written consent.

Selected Food Sample

The most commonly consumed staple Indian food- rice and rice puff (processed product made from rice) was selected as the experimental food. The rice was prepared fresh every morning prior to the testing, following standardized procedure and Rice puff were procured from local market. White bread (Britannia Daily Fresh) was used as standard reference food.

Study Design

The subjects were tested for postprandial impact of Boiled rice (BR), Puffed rice (RP) and white bread on different occasion. After overnight fast, the subjects were given measured amount of food (50g) and asked to chew the given quantity of food thoroughly and finish within 10 min. 100 ml water was given with each serving.

Blood Analysis

Finger tip capillary blood was used for the estimation of blood glucose using a glucometer (Optium exceed, manufactured by Abbott pharmaceuticals) and venous blood was used for the estimation of insulin and HbA1c using ECLIA. The blood was collected in separate tubes for insulin and HbA1c (anticoagulant coated tube) estimation. Collection was made in the fasting state and at 30, 60, 90 and 120 min post consumption of foods (standard and test). The incremental area under the curve (IAUC) for each food sample was calculated using the standard trapezoid rule.

Food Composition Analysis

The food samples were analyzed in triplicate for total, free reducing sugar and starch by Lane and Eynon method, Moisture by Vaccum oven method, Protein by Macro-kjeldhal method, Fat using Soxhelet method and Dietary Fiber by Enzymatic Digestion.

Statistical Analysis

Mean total glycemic and insulinemic IAUC and the peak glycemic values of test and standard food was compared using paired students T test and was considered statistically significant at $p \leq 0.05$ on two tailed testing. Standard deviation was calculated for the food composition values.

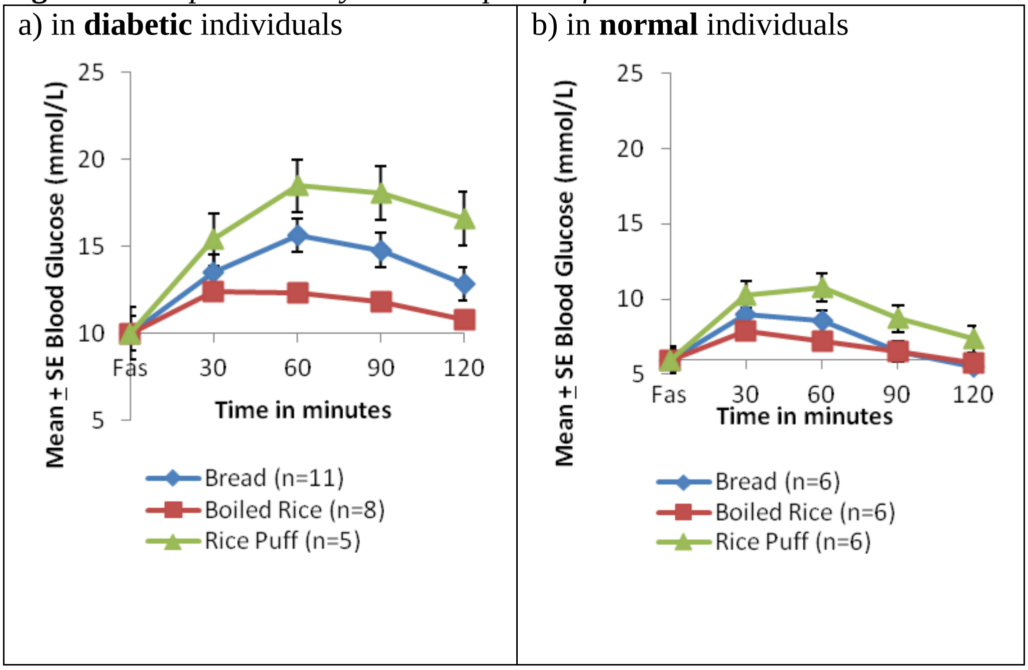
Results and Discussion

To understand the impact of specific processing of rice on postprandial glycemic and insulin levels, two products namely boiled rice and rice puff were selected and compared with standard food bread.

In diabetic individuals (Figure 1a) it is seen that Cmax (mmol/L) is reached fastest by boiled rice at 30m and is significantly lower than both bread ($p<0.05$) and rice puff ($p<0.005$). With this boiled rice also showed a significantly lower glycemic response (Figure 2) in comparison with bread ($p=0.012$) and rice puff ($p=0.017$).

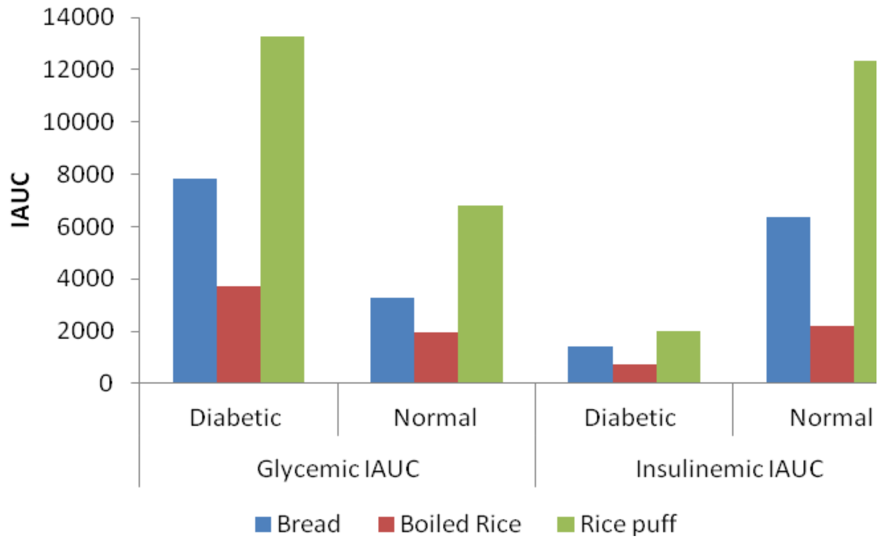
In case of normal individuals (Figure 1b), rice is again seen to exert the lowest glycemic response followed by bread ($p<0.05$) and rice puff (Figure 2). Boiled rice reaches Cmax at 30m whereas its processed counterpart, rice puff, attains Cmax by 60m.

Figure 1. *Postprandial Glycemic Response of Standard and Test Foods*



Source: Authors' estimations

Figure 2. *Glycemic and Insulinemic IAUC of Standard and Test Foods in Diabetic and Normal Individuals*



Source: Authors' estimations

The data in the present study indicates the implication of food processing on postprandial glycemic responses.

Kolam, swarna, mahsuri, ponni and basmati are the common rice varieties consumed in India. According to the GI values, these rice varieties have been classified as a high glycemic index product with a GI range of 54-121 when white bread is used as standard (Miller et al. 1992). However a recent study by

Srinivasa et al. (2013) showed the GI value of Indian branded basmati rice to be <55, classifying it as a low GI product. The present study clearly shows the low glycemic impact of rice in both normal individuals and individuals with diabetes. The GI values change with the change in variety and therefore is denoted as a range and not an absolute value.

A high moisture content of rice as compared to rice puff could also be a major contributing factor for the low glycemic impact observed (Table 1). Higher moisture content of foods act as an energy diluent by decreasing the amount of total solid, consumed in a single meal (Senray and Singhania 2014, Senray and Paharia 2013).

Further, the processing of rice puff involves soaking of the kernels, heating and subsequent puffing of the grains either by increasing the pressure or sand roasting. Because of these processes involved in the production of rice puff, the final dry product obtained is pre-gelatinized, porous and with this retains no native tissue or starch granule structure to resist amylase activity making it a rapidly digestible and a high glycemic impact product (Mishra et al. 2012, Jimoh et al. 2008).

The pre-gelatinized starch present in the rice puff results in enhanced digestibility despite its very low moisture content (Holm et al. 1988). Puffed rice has also shown an in vitro digestibility of approx 83% with high amounts of damaged starch which shows increased water retention and susceptibility to amylosis (Singhania and Senray 2012) and therefore higher hyperglycemic impact.

Table 1. *Proximate Composition of Standard and Test Foods*

Food Product	Moisture g%	Protein g%	Fat g%	TRS g%	Dietary Fiber g%	Starch	
						wwb g%	dwb g%
Bread	37.26 ± 2.53	8.31 ± 1.25	1.71 ± 0.95	3.22 ± 1.01	4.04	33.97 ± 0.69	53.87 ± 1.33
Rice boiled	75.15 ± 1.2	7.33 ± 0.57	1.35 ± 0.9	-	3.61	20.47 ± 0.38	82.84 ± 2.42
Rice puff	6.65 ± 2.33	6.54 ± 0.53	0.1	-	1.53	28.76 ± 0.95	30.51 ± 0.57

Note: dwb–dry weight basis; wwb-wet weight basis, TRS-total reducing sugars.
The values in g% represent the nutrient content in 100g of food. As the tests were conducted in triplicate the values are represented as mean ± SD.
Source: Authors' estimations.

Food structure is also known to play an important role in determining the rate of starch hydrolysis (Wong and O'Dea 1983). Boiled rice seems to have more intact botanical structure as compared to rice puff. Venn and Mann (2004) reported that the postprandial glycemic response to grains having an intact structure is lower than when the grain structure is disrupted. They further suggested that the intact botanical structure may cause a delay or make some portion of the starch unavailable for absorption.

On the other hand, the open porous structure of rice puff is seen to have a high internal surface area which along with the absence of the native starch structure causes rapid penetration of enzymes resulting in an immediate collapse and digestion of the product (Mariotti et al. 2006, Mishra et al. 2012).

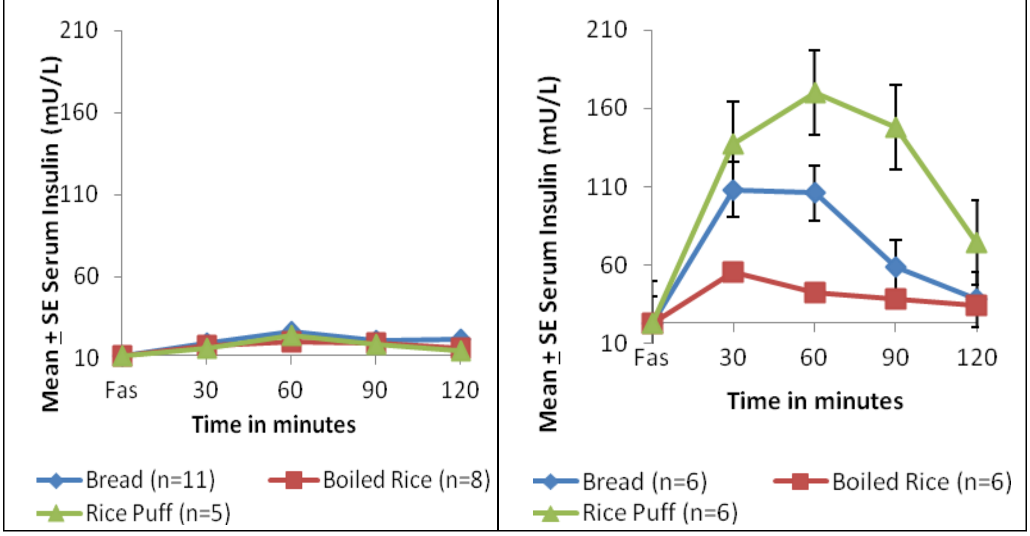
Relative Insulinemic Impact of Standard and Test Foods in Diabetic and Normal Individuals

Figures 3a and 3b clearly show the diminished insulin status of a person with diabetes in comparison with normal individuals. In normal individuals (Figure 3b) we see that the despite similar glycemic responses, the insulinemic responses are greatly different. The peak insulinemic response (Cmax mU/L) of boiled rice was significantly lower than rice puff (p=0.05). The insulinemic response (Figure 2) of boiled rice was significantly lower than bread (p<0.05) and was about 6 times lower than equi-quantity proportion of rice puff (p=0.05).

Figure 3a and Figure 3b show the trend or the pattern of insulin response of postprandial impact of standard and test foods in insulin deficient type of diabetic individuals as compared to normal individuals. To understand the changes at micro level, the Figure 3a has been expanded (Figure 4).

Figure 3. *Postprandial Insulinemic Response of Standard and Test Foods*

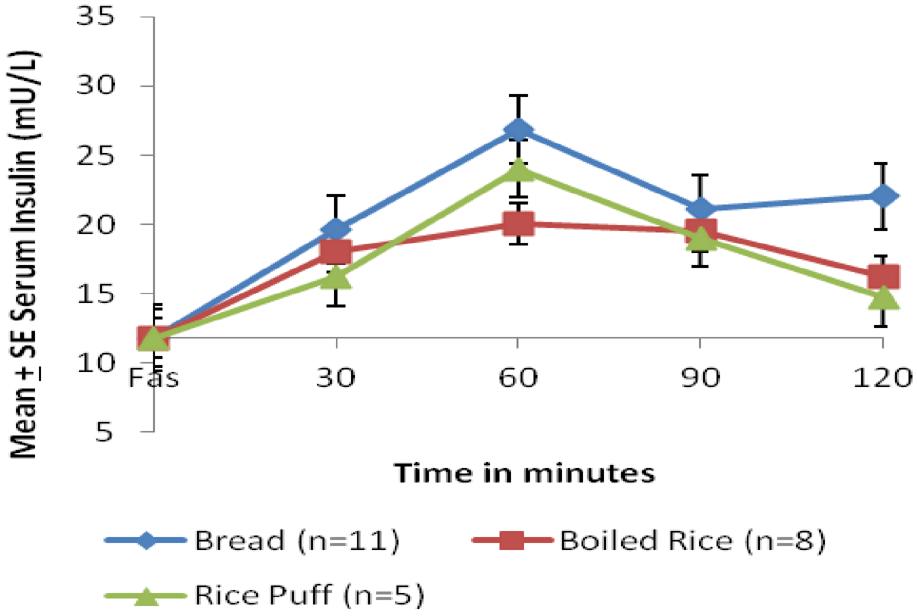
a) in **diabetic** individuals | b) in **normal** individuals



Source: Authors' estimations

In diabetic individuals, the insulin response pattern (Figure 4) for rice puff is seen to be lower than that of bread despite the high glycemic levels (Figure 1). The Cmax (mU/L) for all products is reached at 60 min after which it is seen to decline towards baseline for boiled rice and rice puff and continues to stay elevated for bread. Normally when glycemic response of a product is high we generally assume the insulin response also to be high. But insulin deficient diabetic person cannot satisfy the insulin demand of very strong hyperglycemic product.

Figure 4. *Postprandial Insulinemic Response of Standard and Test Foods in Diabetic Individuals (Expanded Scale)*



Source: Authors' estimations

The above results further confirm the high glycemic and insulinemic nature of rice puff. Processing of foods alters its postprandial glycemic and insulinemic responses. It could be said that higher degree of processing would increase the glycemic and insulinemic impact of the product (Jimoh et al. 2008, O'Dea et al. 1980, Wong and O'Dea 1983, Haber et al. 1977).

Conclusions

The data from the present study clearly shows that specific processing of foods, in the present study puffing of rice, alters their glycemic and insulinemic impact. Normal individuals are able to tightly regulate their blood sugars due to sufficient insulin status. This mechanism is however compromised in case of diabetic individuals. In such cases foods such as rice which is seen to exert a lower glycemic and insulinemic response are better suited. Foods such as rice puff, which are generally considered ideal snacking option as they are light and easy to digest, are highly glycemic in nature should be avoided or consumed in restricted amounts to prevent postprandial hyperglycemia in diabetic individuals. Consumption of foods in their whole natural form may help in better control of blood sugars. It is known that prolonged hyperglycemia is not desired in diabetic individuals as it may lead to development of diabetes associated complications in the future. Puffed rice is usually made from par-boiled rice. Further in depth research is needed to identify the rice type that will limit glycemic excursions and its impact on insulin secretion.

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