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Effect of cooking and ageing on total glycemic index of rice, under *in vitro* conditions

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Abstract
The glycemic index ranks carbohydrates or carbohydrate containing foods on how quickly they raise blood sugar response. The Glycemic Index (GI) of two varieties of Indian rice (Parmal sella and Golden sella) was analyzed, after cooking. Also, the effect of ageing on GI of rice was observed. The consequence of ageing and cooking on GI of rice, was experimentally evaluated using the calculations of Hydrolysis Index (HI), Area under curve (AUC), Reducing sugars released (RSR) and Total available carbohydrates (TAC). *In vitro* starch digestibility was carried out using a multi-enzyme dialysis system. GI of four samples of rice was calculated. TAC/100g of sample was highest in Golden Sella followed by Parmal Sella. In both the varieties TAC followed a decreasing trend after cooking. Among other food groups pulses expressed a highest TAC count.GI of Parmal Sella was low among the two varieties. When both the two varieties were cooked the glycemic index was more in Golden sella old rice while as low in parmal sella old rice.

Keywords: rice, ageing, cooking, TAC, glycemic index

Introduction

Glycemic index provides a measure of the ability of different types of foods that contain carbohydrate to raise the blood glucose levels within 2 hours. Foods containing carbohydrates that break down most quickly during digestion have the highest glycemic index. The term "Glycemic Index" was conceived in 1981 by David Jenkins [25]. Using the GI in meal planning can improve diabetes control and other health parameters [12]. The carbohydrates have a high GI. Thus, the real problem for people is carbohydrates. Some carbohydrates are quickly broken down in the intestine, causing the blood glucose level to rise rapidly [14]. There are several other factors that affect GI like fibre, sugar, acidity, amount and nature of carbohydrates present, processing and cooking methods etc. The extent how fibre affects GI is yet unclear. However, it is believed that viscous, soluble fibre thickens the mixture of food in the digestive tract, which slows down enzymes from digesting the starch. This results in a lower blood sugar response hence, a lower GI [17]. An increase in the acidity of meal can greatly lower its GI. Increasing the amount of vinegar or sour dough bread to a meal affects the glucose response. The addition of sourdough bread toa meal can result in different GIs, depending on its content of organic acids [5]. Heat, amount of water and cooking time affects a food's GI. Foods containing starch that is swollen are more easily digested and thus have high GI. For example, baked potato it is 85 and for brown rice, it is 50. Amylose and amylopectin molecules have different effects on GI. Amylose is harder to digest than amylopectin. It is found that legumes and basmati rice have a higher ratio of amylase to amylopectin and therefore have a lower GI than foods with more amylopectin [22].

Rice, wheat, and maize are considered as the world's three leading nourishment food crops; they directly supply over 42% of total calories consumed by the humans. Large part of world population, mostly in Asia, is entirely dependent upon rice as the main product diet. Rice had been generically considered as a high GI food, which can increase a person's chances of getting Diabetes. However, IRRI research has shown that different types of rice have different GI's, ranging from a low GI of 48 to a high GI of 92, with an average medium of 64.This indicates that rice can be a part of healthy diet for the average consumer and that people who have diabetes are at a risk of developing it can select the right kind of rice to help keep a healthy low GI diet. Therefore, this study aims at determining the GI of two Indian Rice varieties, Golden sella and Parmal sella and effect of cooking (microwave) and ageing on their GI. Fresh and ols samples of rice were selected for analysis.

In vitro methods are used in order to represent the *in vivo* digestion process.

Material and Methods

The work was carried out on different food samples to know the effect of ageing process and cooking on the GI of Rice. The implementation of a sealed setup in this study, i.e. including dialysis tubing, associates the procedure to absorption processes alternately to digestion alone, since the uniform concentration of reducing sugars in the dialysate depicts the carbohydrates that have passed across the membrane.

The proximate examination of the food samples were carried out. Moisture, Ash, Crude fiber and Fat content was determined using AOAC official methods. For the estimation of protein content acid protein assay method was selected. TAC (Total available carbohydrates) was figured using the proximate composition of foods. The test samples were cooked in a microwave oven at 800W on an average temperature for 5 min. The sample was placed within the preactivated dialysis tubing, leaving enough space for expansion and the ends of the tubing closed by thread. The sample was then submerged into a solution of potassium phosphate buffer. A concentration gradient is established and sugars present in the test sample, diffused across the membrane into the surrounding buffer, in order to achieve equilibrium. The test sample (2g) was homogenized; as eaten. It was dissolved in Sodium Potassium Phosphate buffer (pH 6.9), 1:2 ratio. The pH was adjusted to 1.5 (gastric pH). Pepsin solution equal to 2.5 ml was added. The whole mixture was incubated at 37ºC on a shaking incubator at 150 rpm. The pH was again adjusted to 6.9.Alpha amylase solution was added and the sample mixture was transferred to the dialysis tubing previously activated. The tubing containing the sample was placed into a beaker containing potassium phosphate buffer. It was kept for incubation for 4 hrs. at 37 ºC,on a shaking incubator at 150 rpm. An eliquot of dialysate was taken in an eppendorf initially at zero reading and after every 30 min. for 4 hrs, replacing the same volume with buffer. Amounts of reducing sugars in the dialysate were determined spectrophotometrically at, 560 nm after reaction with 3, 5 dinitro salicylic acid, 1.1 M potassium sodium tartrate in distilled water. A maltose standard (1g/L) was used for the calculation. Amounts of reducing sugars released (RSR %) were computed as maltose equivalents (in g) as % age of the total available carbohydrate (TAC) in the given sample: [RSR= (A sample *500*0.95)/ A maltose standard *TAC)*100]; where As ample i s sample absorbance, Am altose standard is absorbance of maltose standard, TAC is total available carbohydrates in the test sample that was taken as the % of food taken in combination with rice, wherein rice was taken as 1g and for individual samples TAC/100g of sample was taken, 150 was the total volume of buffer placed in the outside dialysis beaker, 0.95 is conversion factor from maltose to starch]. Amounts of reducing sugars in the dialysate were determined spectrophotometrically at 560 nm after reaction with 3,5-dinitrosalicylic acid,1.1M potassium sodium tartrate in distilled water. A maltose standard 1g/L was used for the calculation. Amounts of reducing sugars released, RSR (%) were calculated as maltose equivalents (g) as percentage of the total available carbohydrate. The amount of RSR (g/100g TAC) was plotted against digestion time (min) and the area under hydrolysis curve (AUC, g/100g TAC* min) was calculated geometrically for 180 min using the trapezoidal method described by Wolver and Jenkins, 1986. The hydrolysis index (HI) was calculated from AUC of the test sample as a percentage of the corresponding area of the reference white bread; (HI= AUC sample /AUC white bread *100). The predicted GI was calculated using the equation: GI= 0.549*HI + 39.71 (Capriles and Areas, 2013); [23].

Results

Proximate analysis of various samples can ber seen in fig.1. The graph indicates that the cokking process affects the composition in all the samples. After cooking protein, fat and water content increased in rice while as there was not much change in crude fiber and ash content after cooking.

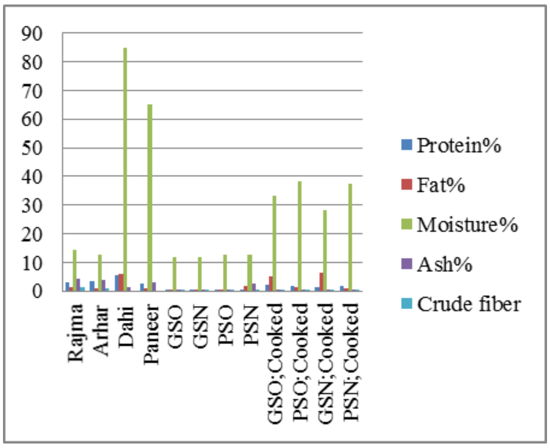

Fig 1: Proximate analysis of the food samples

The TAC after cooking of rice samples (both aged and new) can be analysed in the graphs given in fig.2. It was calculated fibre from total carbohydrates and was observed that TAC was decreased due to cooking process. TAC in pulses and rice was more due to presence of more starch.

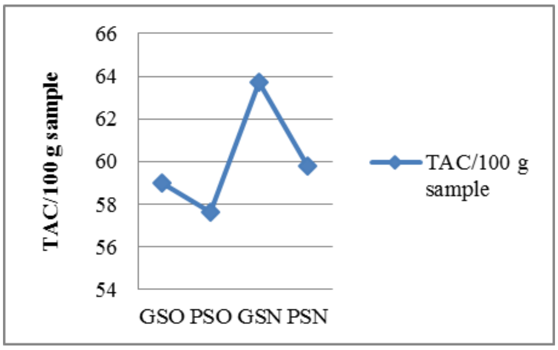

Fig 2: Total available carbohydrates in cooked rice samples

Effect of ageing and cooking on Glycemic Index of different rice varieties is shown in Fig.3. The Glycemic Index of Golden sella new rice was seen highest among the four rice samples.

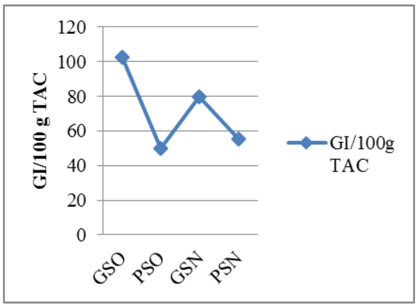

Fig 3: Glycemic Index of rice varieties

Effect of cooking on Glycemic Index of mixed food sample of new rice is shown in fig.4. In Parmal sella there was decrease in Glycemic index after cooking with arhar. However, there was not much decrease seen in same variety of rice when cooked with rajma. Also, the total glycemic index showed an increase in case of dahi taken with Parmal sella. Among the four samples of Golden sella, there was a decrease in total Glycemic index of two samples i.e., Golden sella with arhar and dahi.

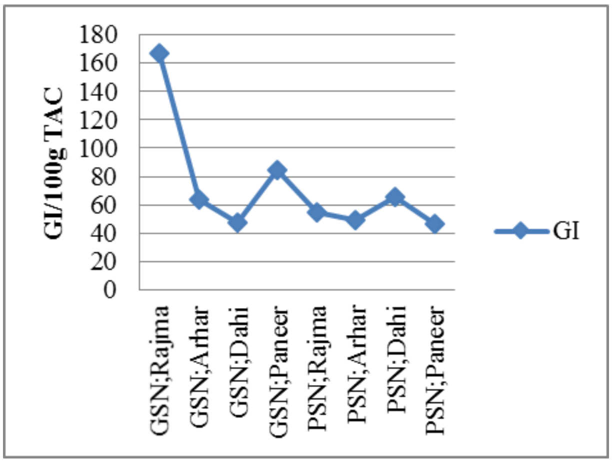

Fig 4: Effect of cooking on Glycemic Index of new rice.

Effect of cooking on Glycemic Index of mixed food sample of old rice is shown in fig.5. Total Glycemic index was decreased after cooking Golden sella old rice with different samples but there was no effect on total Glycemic Index of Parmal sella old rice after cooking with different food samples.

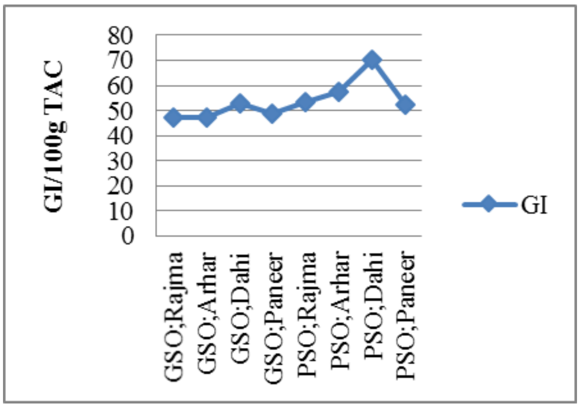

Fig 5: Effect of cooking on Glycemic Index of old rice.

Discussion: Different rice varieties cultivated in different geographical regions may affect the physical and chemical properties of rice grain which will contribute to different GI values [11]. The GI value of an individual food can vary widely depending on its type, the way it is processed, and the way it is prepared [17]. The method of processing of a single food can greatly change its GI. Starch exists in carbohydrate foods in the form of large granules [27]. These granules must be disrupted so that the amylose or amylopectin starch macromolecules become available for hydrolysis. Grinding, rolling, pressing, or even thoroughly chewing a kernel or other starch food can disrupt the granules. Rolling or pressing foods, such as is done in the processing of many grains, disrupts the outer germ layer and granules and increases GI [17]. The action of heat and moisture affects starch granules. Disorganization of the crystalline structure occurs as it encounters greater heat and moisture for a longer period of time [17]. Gelatinization occurs first, with disruption of the crystalline structure, followed by a disruption of the granules. If the starch is then let stand, or stored for a time, so that cooling occurs, the starch becomes a gel, which will vary in structure depending on the amount of moisture, the amylose to amylopectin ratio and the time and temperature of storage [1]. A crystallinity to the gel can occur that is called retrogradation of the starch. These starch complexes are insoluble and not amenable to hydrolysis in the small intestine. Repeated cycles of heating and cooling can further the retrogradation [19]. Starch can also form insoluble complexes with proteins, such as occurs in the browning (Maillard) reaction, making it unavailable for digestion and absorption [17]. The heat utilized, the amount of water, and the time of cooking, all have a significant effect on the GI [17]. Rice exhibits very wide ranges of cooking quality and rheological properties that are largely determined by the swelling, gelatinization and retrogradation characteristics of its starch [20].

The GI of rice is affected by the proportion of amylose to amylopectin in the grains. Amylose is a linear molecule with D-glucose units linked in an (α1–4) fashion. Amylopectin has both (α1–4) and (α-1–6) linkages [1], and is thereby a branched structure. The higher the proportion of amylopectin, the higher the GI, because amylopectin, which is made up of branched-starch molecules, is more easily hydrolyzed in the gut than is the single-strand amylose [17]. Contradictory data have been reported on the effect of ageing on amylograph peak viscosity. Amylograph peak viscosity of slurries prepared from fresh rice, although the opposite effect was reported least changes in reducing sugars, acidity hardness by Villareal *et al* (1976). The increase in peak viscosity shows that the starch granules of stored rice are more resistant to swelling than those of fresh rice. The decrease in breakdown value indicates that the capacity of the starch granules to rupture after cooking is reduced significantly by ageing of the granules [24].

People do not generally eat single foods, they eat meals or snacks made up of ≥2 macronutrients. Several studies have investigated the effects of combinations of macronutrients on the GI and higher the proportion of carbohydrate in a specific food, as opposed to protein and fat, the higher the GI; and a mixed meal of carbohydrate, protein, and fat will have a different and variable glucose response depending on the proportions of each nutrient. Thus, the glucose responses of a food eaten alone or in combination with other foods differ [21, 6].

Conclusion: From this study, we concluded that the glycemic index of Golden sella rice was more than that of Parmal sella rice. There is conflict of interest whether the ageing process affects GI or not. In some samples like GSN with Dahi and Arhar, PSN with Arhar and Paneer GSO with Rajma, Arhar, Dahi and Paneer, there was a drop in total GI.

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