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EFFECT OF PROCESSING AND COOKING ON GLYCEMIC INDEX OF JOWAR VARIETIES

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ABSTRACT

An understanding of the Glycemic Index (GI) values of foods or beverages can help dieticians to plan and direct patients/consumers to choose sensible, low GI foods that are believed to "reduce the risk of developing type-2 diabetes. The data on the GI values of different varieties of foods within India is very limited. Also effect of processing and cooking on GI of these foods is also scanty. Though millets production and consumption in India was decreased to post green revolution period, but recent diabetes prevalence rates (5-16%) have made people to rethink about millets in their diet because of high dietary fiber and other nutritional benefits. In view of this background, the current study was undertaken to determine the assessment of GI in popular varieties of jowar and correlation with in-vitro digestibility of wheat flour. Millets were milled into flour and coarse flour (rava) using Cyclone sample mill (UDYC, MODEL: 3010-019, USA) .These flours and Rava were subjected to various cooking procedures like Boiling, Roti making, porridge preparation, sweet preparation and determined the Invitro GI. Results revealed that the GI of the variety, white jowar (flour) was lower (49.85±0.29) than the yellow Jowar (flour) variety (52.56± 0.87). Similar trend was observed in GI values of rava for these jowar varieties. When these flours of jowar varieties were boiled their GI values decreased. Similar observations were made with wheat flour for boiling. The current study clearly indicated that both milling and cooking methods effected the GI of the food significantly (P<0.001). Dietary fiber, Resistant starch, rapidly digestible starch, Alpha amylase inhibitors are the major contributing factors for lower GI values.

Key words: Glycemic Index, Dietary Fiber, Resistant Starch, Starch digestibility.

INTRODUCTION

Diabetes has affected more than 285million people around the world and is expected to reach 438 million in the next 17 yrs. (Flegal, K.M *et.al.*, 2010) Over the past 2 decades, Epidemiological studies have suggested a possible connection between low glycemic index (GI) and the control of chronic diseases such as type 2 diabetes, coronary heart disease and metabolic syndrome over the past 2 decades. Diabetes prevention and management has gained momentum due to dietary intervention. (Dixit et.al.2011) Low GI foods may reduce the insulin demand, improve blood glucose control, reduce blood lipid concentrations and body weight and thus could help prevent diabetes related cardio vascular events. Whole grains such as amaranth, barley, brown rice, millet, and sorghum were mostly used in Asian Indian cooking prior to 1950's. (Dixit *et.al.*, 2011)

Based on this information, the current paper focused on analyzing available varieties of sorghum for glycemic index and factors affecting the glycemic activity. In terms of both production and area planted, Sorghum is the world's fifth most important cereal (India Millets Info). Roughly 90% of the world's sorghum area and 95% of the world's millet area lie in the developing countries, mainly in Africa and Asia. In the desert regions of Rajasthan, Sorghum is primary crop and allied crop. Similarly, Sorghum is sown as major crop in the Telangana (Andhra Pradesh), Maharashtra and parts of Central India, while it is considered as fodder crop in some of the Southern regions. Continuous institutional promotion of Rice and Wheat dominates and there by shrinks the millet-growing region. Several communities in the dry/ rain fed regions having known the food-qualities of millets over generations continue to include a range of Millets in the traditional cropping patterns, which recognize Millets as an essential part of the local diet (India Millets Info).

The majority of the carbohydrates are starch, while soluble sugar, pentosans, cellulose, and hemicelluloses are low in sorghum and millets. 23 to 30% amylase is present in Regular endosperm sorghum types, whereas waxy varieties contain less than 5% amylose. (David 1995) Sorghum is a good source of fibre, mainly the insoluble (86.2%) fibre. The insoluble dietary fibre of sorghum and millet may decrease transit time and help in prevention of gastrointestinal problems. Factors such as genotype, and water availability, temperature, soil fertility and environmental conditions during grain development vary the Protein content and composition. The protein content of sorghum is usually 11-13% but sometimes higher values are reported (David 1995).Prolamins (kafirins) constitute the major protein fractions in sorghum, followed by glutelins. Traditionally, the bread which cannot be baked from sorghum and millet is only cake bread as lack of gluten is characteristic of protein composition. As Grain protein is notoriously deficient in the essential amino acid lysine. Sorghum grain contains about 1.5 ppm of total carotenoids. Significant amount of β- carotene, the pro-vitamin of vitamin A, which is important in human physiology, is seen in sorghum in comparison to maize and durum wheat. Sorghum is an important source of B vitamins except B 12, and good source of tocopherols. The B vitamins and minerals are concentrated in the aleurone layer and germ. Removal of these tissues by decortication produces a refined sorghum product which has lost part of these important nutrients. (FAO (1996) and Kent (1978) Sorghum is considered a good source of potassium and is practically devoid of sodium. Whole grains are good sources of magnesium, iron, zinc, and copper. The bioavailability of iron in sorghum is negatively affected by the presence of polyphenols and phytates, but Derman et al. (1980) reported that iron absorption was more than 12 times greater from sorghum beer than from gruel. (Irén 2004)

In addition to glycemic index, factors which effect glycemic index play a major role in explaining the efficiency of glycemic index. Among the various factors which contribute for lowering glycemic index, resistant starch, dietary fiber and amylase inhibitors are few of them. In this paper, the effect of resistant starch under various processing conditions was analyzed. Foods with a low GI and higher RS help slow absorption of carbohydrates and prevent extreme blood glucose fluctuations (Jarvi *et.al* 1999 and Jenkins *et.al.,* 2008). RS is the sum of any starch and starch degradation products not absorbed in the small intestine, because RS escapes digestion it contributes to the fermentable carbohydrates entering the colon and provides a source of nutrients for colonic bacteria (Grandfelt *et.al.,* 2010). As these microorganisms metabolize the carbohydrate material via fermentation, the colonic pH is lowered and short chain fatty acids (SCFA) (e.g., acetate, propionate, and butyrate) are released. Because of these attributes, RS may also reduce the risk for colon cancer, obesity, diabetes and inflammatory bowel disease (Flegal, K.M *et.al.,* 2010, Hendrich 2010 and Le Bourvellec and Renard 2012).

MATERIALS AND METHODS

CHEMICALS AND REAGENTS

Di-Sodium dihydrogen phosphate dihydrate ($Na_2H_2Po_4.2H_2O$), 1M Hcl,1M Naoh, Potassiumdihydrogen phosphate(KH_2Po_4), Pepsin (Sigma-Aldrich), Pancreatic alpha amylase(Sigma-aldrich), Resistant starch Kit(K-RSTAR,Megazyme),GOPOD reagent(Megazyme),2M KOH, Sodium maleate buffer (100mM, pH 6.0), Sodium Acetate Buffer (1.2M pH 3.8) and (100mM, pH 4.5) , Aqueous ethanol (or IMS).

FOOD SAMPLES

Food samples were purchased from local market. Wheat and two varieties of sorghum locally available in the market purchased were white sorghum and yellow sorghum. All the food samples were individually processed for various techniques such as milling into coarse kernels using Kenstar Blender, and some of the sample were further milled to flour using Cyclone sample mill (UDYC, MODEL: 3010-019, USA). These flours and rava were subjected to cooking methods like boiling and then further cooked into recipes such as halwah, chapatti and upma.

METHODOLOGY

TEST FOODS

PREPARATION OF HALWAH

30 gms of flour or rava were taken and were roasted in a pan. Another vessel was taken and was preheated and then the roasted flour or rava was added and was boiled with a cup of water. Sugar was added and the ingredients were mixed thoroughly until the sugar dissolved. Further ghee was added at the end for flavor.

PREPARATION OF UPMA

30 gms of rava were taken and were kept aside. In a pan, 5ml of oil was added. After preheating, cumin seeds, mustard seeds, onion and curry leaves, were added and fried until onions turned pink. 200 ml of water was added and immediately rava was added and simultaneously mixed to avoid clumps and salt to taste was added and mixed until done.

PREPARATION OF CHAPATTI

30gms of flour and water enough to knead into dough was taken. Salt and wheat flour where mixed with water and where kneaded into small sized dough and was left or an hour. The ball was smeared with dry flour and rolled out on a rolling board. Heating the griddle, the chapatti was put on it and roasted on both sides. Nutritive value preserving with different flours is given in table 1.

INVITRO DETERMINATION OF THE FOOD PRODUCTS

The invitro determination of glycemic index was performed according to the protocol given by Kirsty *et al* (2008) 20 gram portion of the test foods were used. To aid processing equal portions of water was added to the products 15min prior to testing. Samples were minced through a mixer, and the portions of the minced food containing one gram of available carbohydrate were weighed into tubes containing 5 mL 0.05 mol/L sodium potassium phosphate buffers (pH6.9). The minced samples were then evaluated in duplicate using a randomized design. After 1 min 15 seconds of adding buffer, the samples were treated with 100U pepsin in 6mL of 0.05 mol/L sodium potassium phosphate buffer pH 6.9, then 5mL of buffer is added again and the pH is adjusted to 1.5 with 1M HCl. The sample was incubated at 37°C for 30 min.

INCUBATION USING NON RESTRICTED SYSTEM

In the non restricted system the sample was added to 100mL of 0.05mol/L sodium potassium phosphate buffer (pH 6.9) and the pH of this solution was adjusted to pH 6.9 with 1 mol/L NaOH. Pancreatic amylase, 110 U (Type I-A), was added and the sample was incubated in a shaking water bath (120rpm) at 37°C. Sample aliquots

Table1- Nutritive Value Yellow Jowar Halwah, White Jowar Halwah and Wheat Halwah

Recipe	Energy(kcal)		Protein(g)		Fat(g)		Carbohydrate(g)		Total dietary fiber(g)	
	Total cooked (65g)	Per serving (30g)	Total cooked (65g)	Per serving (30g)	Total cooked (65g)	Per serving (30g)	Total cooked (65g)	Per serving (30g)	Total cooked (65g)	Per serving (30g)
Wheat flour halwah	291.8	133.01	3.595	1.64	10.57	4.45	45.67	21.6	0.57	0.26
Wheat semolina halwah	293.9	137.11	3.145	1.42	10.24	4.33	47.29	21.82	0.06	0.027
Wheat vermicelli payasam	328.6	112.49	4.235	0.75	12.17	4.61	50.64	8.42	0.06	0.01
Yellow jowar flour halwah	294.2	135.78	3.64	1.68	10.63	4.45	47.95	23.13	0.57	0.23
Yellow jowar rava halwah	303.8	137.04	4.14	1.88	10.76	4.56	46.27	22.12	0.64	0.29
Whitejowar flour halwah	294.2	131.46	3.145	1.52	10.59	4.54	46.63	21.13	0.48	0.19
White jowar rava halwah	299.8	140.03	3.80	1.78	10.61	4.52	48.59	23.43	0.52	0.22

Table2- Nutritive Value Yellow Jowar Upma, White Jowar Upma and Wheat Upma

Recipe	Energy (kcal)		Protein (g)		Fat (g)		Carbohydrate (g)		Total dietary fiber(g)	
	Total cooked (76.5g)	Per serving (30g)	Total cooked (76.5g)	Per serving (30g)	Total cooked (76.5g)	Per serving (30g)	Total cooked (76.5g)	Per Serving (30g)	Total cooked (76.5g)	Per serving (30g)
Wheat semolina upma	214.39	94.89	5.784	2.4186	8.944	3.509	28.513	13.411	1.176	0.433
Wheat vermicelli upma	215.59	64.10	5.274	1.4286	8.824	3.425	29.563	6.891	1.176	0.418
Yellow jowar rava upma	214.69	94.82	6.294	2.8786	9.334	3.736	29.173	12.421	1.686	0.698
White jowar rava upma	214.69	98.10	5.784	2.7786	9.274	3.696	27.853	13.431	1.596	0.628

Table 3- Nutritive Value Yellow Jowar, White Jowar and Wheat Flour Chapati

Recipe	Energy(kcal)		Protein(g)		Fat(g)		Carbohydrate(g)		Total dietary fiber(g)	
	Per 100g	Per serving (30g)	Per 100g	Per serving (30g)	Per 100g	Per serving (30g)	Per 100g	Per serving (30g)	Per 100g	Per serving (30g)
Wheat flour chapati	245	73.5	7.8	2.34	0.7	0.21	51.9	15.57	12.5	3.75
Yellow jowar chapathi	221	66.3	7.7	2.31	0.6	0.0429	50.12	15.036	9.33	2.79
White jowar chapati	219	65.7	6.9	2.07	0.4	0.0462	49.12	14.736	9.12	2.73

2mL were removed at 0,30,60,90,120,150 and 180 min and placed in boiling water for 5 min then cooled on ice. The aliquots were then centrifuged at 15600 X g for 5 min and the supernatant was analyzed for reducing sugar content using 3,5- Dinitro salisylic acid method and were compared to standard maltose curve.

RS content in the food was measured using the method described by Goñi *et al*. (1996). In brief, the main steps of the procedure include removal of protein from samples with pepsin (Art.7190, Merck, Darmstadt, Germany) followed by α-amylase (A-3176, Sigma-Aldrich Inc.) incubation for 16 h to hydrolyze digestible starch. The hydrolysate was centrifuged for 10 min at 1,500 × *g* and the supernatant was discarded. The residue is treated with 2M KOH for 1 h to solubilize resistant starch and the sample is then incubated with amyloglucosidase before glucose content is determined using a glucose oxidase assay (GOPOD reagent, Megazyme International). RS was calculated as glucose (mg) × 0.9 on dry basis (Englyst, 1992).

RESULTS AND DISCUSSION

DATA ANALYSIS

Values under the curve were calculated for each of the foods starch hydrolysis curves using Microsoft excel. Hydrolysis index were calculated for each replicated using the equation HI= (AUC of test food/avg AUC of white bread) *100. The average AUC of white bread tested using the equivalent method was given an HI=100. HI values were calculated at the time points when the aliquot was collected, with the results reported as standard deviation. Statistical differences between HI values were determined using a t-test where the significance was taken at $p<0.01$, using ANOVA Predicted GI values were then calculated based on HI values (predicted GI) using the formula developed by Goni et al (13). Predicted GI: Predicted GI_{H90} = 39.21 + (0.803 X H_{90}). (6)The results were then compared to the GI values from the literature.

RESULTS FOR PREDICTED GI_{HI} AND PREDICTED GI_{90}

Predicted GI equations were used to determine the GI invitro. When the standard errors of prediction of predicted GI_{HI} and *in vivo* GI values were compared, the ranking methods for their ability to predict GI were altered. Using this equation there were no significant differences ($p<0.01$) between the GI_{HI} and GI for any of the foods. As the prediction is based on single starch reading at 90 min and not on the area under the curve, compared to dialysis methods non restricted system provided better results. The invitro glycemic index values showed greater differences in the various products analyzed (Table 4).

Table 4*: Reported Glycemic Index Values Vs. Invtro Glyemic Index Values*

Recipe	Reported glycemic index	Mean glycemic index values	Recipe	Reported glycemic index	Mean glycemic index values	Recipe	Reported glycemic index	Mean glycemic index values
Wheat kernels	61.12	57.22±2.13	**Yellow jowar**	51.33	46.52±4.87	**White jowar**	50.12	44.32±2.24
Wheat kernels boiled		54.39±6.77	**Yellow jowar boiled**		46.12±2.14	**White jowar boiled**		48.32±3.22
Wheat rava		49.21±1.68	**Yellow jowar frava**		45.23±1.22	**White jowar frava**		49.33±3.43
Wheat rava boiled		48.12±1.45	**Yellow jowar rva boiled**		44.70±6.92	**White jowar rva boiled**		48.62±5.67
Wheat flour		64.87±5.08	**Yellow jowar flour**		51.66±3.12	**White jowar flour**		57.12±2.13
Wheat flour boiled		41.06±0.42	**Yellow jowar flour boiled**		49.85±0.29	**White jowar flour boiled**		52.56±0.87
Wheat flour halwa		71.61±2.11	**Yellow jowar rava upma**		46.40±4.79	**White jowar rava upma**		45.12±7.44
Wheat flour chapati	62±3	61.34±3.12	**Yellow jowar rava halwah**		74.05±1.72	**White jowar rava halwah**		55.60±0.29

The results of glycemic index estimated invitro showed ample differences suggesting sorghum for having better health benefits in comparison to wheat when analyzed with various processing and cooking practices. The glycemic index of white jowar kernels showed a value of 44.32±2.24 which was comparatively lower to yellow jowar kernels and wheat kernels. Further when these kernels were boiled, the lowest glycemic index was observed in yellow jowar (46.12±2.14) followed by white jowar (48.32±3.22).These kernels when processed to rava or coarsely ground flour, the lowest glycemic index was observed in yellow jowar rava (45.23±1.22) and much lesser when this rava was boiled (44.70±6.92). This aspect could be explained that there was a significant change in resistant starch content in the boiled rava with a value of 0.17±0.22 in comparison to the kernels having 0.13±0.087. Also, because of the polyphenolic components present in yellow jowar, the highest amylase inhibition activity

Table 4: Reported Glycemic Index Values Vs. Invtro Glyemic Index Values

Recipe	Reported glycemic index	Mean glycemic index values	Recipe	Reported glycemic index	Mean glycemic index values	Recipe	Reported glycemic index	Mean glycemic index values
Wheat rava halwah		58.12±2.67	Yellow jowar flour chapati		50.50±1.49	white jowar flour chapati		41.96±0.3
Wheat rava Upma		49.21±1.68	Yellow jowar flour halwah		68.25±3.12	white jowar flour halwah		69.96±0.3
Wheat semolina halwa		68.30±4.32						
Wheat semolina upma		71.82±2.56						
Wheat vermicelli payasam		74.34±2.27						
Wheat vermicelli upma		64.33±1.34						

among various processing was observed in yellow jowar rava boiled with 34.5% which could contribute to lower glycemic index. Further all the three ingredients where processed into flour where in again yellow jowar flour had lowest glycemic index (51.66±3.12) in comparison to white jowar flour (57.12±2.13). However, as no flour is consumed as such, when this flour was subjected to cooking methods like boiling, the boiled flour of wheat flour was much lower in glycemic index in comparison to jowar flours. Hence, these flours were further analyzed by preparing sweet such as halwah, where in the glycemic index of white jowar flour halwa (69.96±0.3) and yellow jowar halwah (68.25±3.12) was comparatively low in comparison to wheat but however was in the category of foods ranging with high glycemic index. The most commonly cooked breakfast preparations such as upma and chapatti were also made with rava and flours of these ingredients where in yellow jowar rava upma had lower glycemic index (46.40±4.79) and white jowar rava upma with (45.12±7.44).

CONCLUSION

Thus, we can conclude that glycemic index of a food product varies under different processing and cooking techniques applied. According to this experiment, we can say that the glycemic index among the various processed and cooked preparation of wheat prepared, the glycemic index of oiled wheat flour (41.06±0.42) was lowest and the highest was observed in vermicelli payasam (74.34±2.27). Similarly, when the jowar varieties were subjected to various techniques and their preparations were analyzed, the glycemic index of yellow jowar rava boiled was lowest with (44.70±6.92) and the highest was in halwah prepared by same rava(74.05±1.72). Trends in white jowar flour showed that least glycemic index was seen in white jowar flour chapatti (41.96±0.3) and highest were seen in white jowar flour halwah (69.96±0.3). Hence further research should be focused on lower the glycemic activity of the millets by various and appropriate processing techniques which could help in dietary management of type-2 diabetes for increasing the sustainability of life.

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