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EFFECT OF COOKING ON GLYCEMIC INDEX IN COMMONLY CONSUMED CORN IN INDIA

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Corn is most commonly consumed in India in boiled as well as roasted forms. There are six major types of corn which are available in Indian markets are dent corn, flint corn, pop corn, sweet corn, baby corn and corn flour. Due to modernisation and extensive marketing an increased consumption of corn flakes, sweet corn and pop corn is also observed. Thus, in this study corn in boiled and roasted on coal forms, sweet corn, baby corn, pop corn, corn roti and flakes are taken for studying invitro glycemic index. Factors effecting glycemic index such as resistant starch, rapidly and slowly digestible starch and Amylase inhibition are also studied to understand the reasons for changes in glycemic index in these varieties. The results showed that boiled corn, baby corn and roasted on coal methods had significantly lower glycemic indices (56.19±1.10), (56.92±2.48), and (64.57±4.04) respectively at a p value <0.05. An increase in resistant starch and amylase inhibition in the same samples was also observed. Thus, the study confirms that ancient methods of boiling the corn and roasting on coal are most favourable methods of cooking for corn to maintain the nutritional quality as well to have low glycemic index.

Keywords: Glycemic index, Resistant starch, Amylase inhibition, Slowly digestible starch, Rapidly digestible starch

INTRODUCTION

Zea mays or maize most commonly termed as corn is a large grain plant grown in temperate zones. The leafy stalk produces ears which contain the grain, which has seeds called kernels. Mostly in western countries maize kernels are used in cooking as a starch. The six major types of corn are dent corn, pop corn, flint corn, pop corn flour and sweet corn (Erwin, 1951). Baby corn or cornlettes, is taken from corn and harvested while the stalks are very small and immature. It typically is eaten whole with cob included unlike the mature corn whose cob is discarded. Baby corn is consumed both raw and cooked. Sweet corn (*Zea mays* convar. *saccharata* var. *rugosa)* is a variety of maize with high sugar content. It is due naturally recessive mutation in the genes which control conversion of sugar to starch inside the endosperm of the corn kernel. Sweet corn must be harvested when immature and prepared as a vegetable. Sweet corn has low storage period as the sugar converts to starch, hence sweet corn are usually consumes fresh, canned or frozen before the kernels become tough and starchy (Erwin, 1951; and Smith Andrew, 2013). Studies have shown that the consumption of corn kernels assists in the management of non-insulin dependent diabetes mellitus and is effective against hypertension due to the presence of

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phenolic phytochemicals in whole corn. Phytochemicals can regulate the absorption and release of insulin in the body, which can reduce the chance of spikes and drops for diabetic patients and help them maintain a more normal lifestyle (Woo Kim *et al.*, 2003). Studies have shown that, corn oil has been shown to have an anti-atherogenic effect on cholesterol levels, thus reducing the risk of various cardiovascular diseases. Glycemic index is defined as the rank given to the carbohydrate of food ingredient based on the post prandial blood glucose release (Jenkins *et al.*, 1982; and Jenkins, 2007). Glycemic index is classified into Low GI(<55), medium GI(56-65) and high GI(>65). Low GI foods slow the digestion and absorption of carbohydrates and show a gradual rise in blood glucose and insulin level which have many positive health benefits such as reducing the incidence and prevalence of heart disease, diabetes, obesity (Roberts, 2000; Wolever and Mehling, 2002; Jenkins, 2007; and Brand-Miller, 2007). With emphasis on diabetics and people with impaired glucose tolerance (Food and Agriculture Organization, 2003) has recommended an increase intake of low GI foods for the potential of low GI diets to prevent obesity and diabetes. Certain clinical studies have strongly shown that a possible relationship exists between prevention in insulin resistance and metabolic syndrome with dietary GI. GI must be confirmed by *invivo* clinical trials, however it is a non cost effective method when large number of samples is present, and therefore studies on measuring *in vitro* played a major role in estimating glycemic index (Granfeldt *et al.*, 1992; and Goni *et al.*, 1997). In certain studies conducted by Goni et al, *invitro* procedure had a high correlation with invivo glycemic response (Hoover and Zhou). According to rate of release of glucose and its absorption in the gastrointestinal tract, starch is classified into Rapidly Digestible Starch (RDS), Slowly Digestible Starch (SDS) and Resistant Starch (RS) (Englyst *et al.*, 1992). After ingestion of food a sudden increase in blood glucose level is observed due to RDS, however SDS is digested completely at lower rate in small intestine. RS cannot be digested in the gastrointestinal tract and hence is fermented in colon (Wang and Wang, 2003). RS has been observed to show in few studies certain physiological health benefits in preventing colon cancer, hypoglycaemic effects, hypocholesterolemic effects, and inhibition of fat accumulation and as a substrate for growth of probiotic microbes (Sailaja *et al.*, 2006). However, SDS has also has shown certain health benefits such as satiety, lowering glucose levels, mental performance (Han and BeMiller, 2007).The granular starches of maize and waxy maize are observed to have high amounts of SDS, due to granule size and interaction of protein or other surrounding material (Liu *et al.*, 1997; Woo and Seib, 2002; and Han and BeMiller, 2007).

Thus, due to positive health effects of corn in managing diabetes, the following paper emphasizes on understanding glycemic index of few commonly consumed corn recipes with effects shown from factors amylase inhibition, resistant starch, RDS and SDS.

MATERIALS AND METHODS

Test Foods

The test food products are corn, sweet corn, baby corn, corn flakes. Corn flour was prepared by removing moisture from the corn and processing into flour using Cyclone sample mill (UDYC, MODEL: 3010-019, USA). Corn flakes were purchased commercially from local market. Corn was most commonly consumed in boiled and corn cooked on coal methods.

Boiling Method: The outer leaves of the corn are removed and the 100 gm of corn kernels with cob are taken in a vessel. 500 ml of water is added and is boiled for 20 minutes.

Corn Roasted on Coal Method: The outer leaves of the corn are removed and the corn kernels are exposed to coal which is preheated with fire. The corn is turned on all sides to ensure complete roasting of corn on coal.

Corn Roti: 60 ml of boiled hot water was added to corn flour. The mixture is kneaded into dough and is kept aside for 10 min. By pressing with hand and fingers it is flattened to roti and is cooked on a pre heated pan for five by sifting the roti occasionally until it is cooked.

Pop Corn: The corn kernels are dried for two days at room temperature. 100 g of dried kernels are taken; 2 ml of oil is added in a pressure pan and closed for five min.

Carbohydrates, Resistant Starch, RDS and SDS

The carbohydrate content of the corn samples are measured by AOAC (2005) (Horwitz, 2005), Resistant starch was measured by a kit method from megazyme(K-RSTAR), Total dietary fiber was measured using Dietary fiber assay kit from Sigma Aldrich. Rapidly and slowly digestible starches were measured using Starch classifications based on digestible (digested within 20 min) starch (RDS), slowly digestible (digested between 20 and 180 min) starch (SDS).

Amylase Inhibitory Activity

Amylase inhibitory activity assay were based on Bernfeld's assay (Bernfeld, 1955). The corn extracts were mixed with amylase (pancreatic porcine amylase) and incubated at 30 min at 37°C. A buffered starch solution was added (2 mg starch in 0.02M phosphate buffer of pH 6.9 containing 0.04 M NaCl) to start the reaction and was incubated for 20 min. 3, 5-dinitrosalicyclic acid (DNS) reagent was added to terminate the reaction. The tubes were boiled for 5 min and cooled under running water and the color was read at 530 nm using spectrophotometer.

INVITRO DETERMINATION OF GLYCEMIC INDEX

The *invitro* glycemic index was determined according to the protocol given by Kirsty *et al.* (2003). Tewnty 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 buffer (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 100 U pepsin in 6 mL of 0.05 mol/L sodium potassium phosphate buffer (pH 1.5) then 5 mL of buffer is added again and the pH is adjusted to 1.5 with 1 M 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 100 mL 0.05 mol/L sodium potassium phosphate buffer (pH 6.9) and the pH of this solution was adjusted to pH 6.8 with 1 mol/L NaOH. Pancreatic amylase, 110 U (Type I-A), was added and the sample was incubated in a shaking water bath (120 rpm) at 37°C. Sample aliquots 2 mL 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.

Data Analysis for Glycemic Index

Values under the curve were calculated for each of the foods starch hydrolysis curves using Microsoft excel. Hydrolysis index were calculated for each replicated samples 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.* Predicted GI: Predicted $GI_{H90} = 39.21 + (0.803 X H_{90)}$. At 90 min and for complete glucose hydrolysis at 180 min, $GI_{HI180} = 39.71 + (0.549 * HI_{180})$. The results were then compared to the GI values from the literature.

Statistical Analyses

Mean and standard deviation of corn samples was calculated. The differences in mean values were tested using One way ANOVA at $p<0.05$.

RESULTS AND DISCUSSION

The change in moisture content of corn was significantly different between the cooking procedures. The heat processing in roti (12.13±0.95) (Table 1) and breakage of particle size during formation of flour (15.63±0.66), has decreased the moisture contents drastically as compared to other samples (Gunasekaran and Paulshen, 1985). The mean carbohydrate was observed to be (65.36±6.23). Among the fibres, the insoluble fibre was highest in boiled baby corn (11.03±0.37) showing that the boiling has cause partial gelatinisation of the grain, making the starch bonds intact and decrease the solubility (Joe Hughes and Barry Swanson, 1989). The soluble fibres were more or less unchanged in any of the cooking or processing method used (Harmeet Guraya *et al.*, 2001). However, corn cooked on coal had significantly high soluble dietary fibre (0.76±0.05). The rapidly digestible starch was significantly higher in corn flour (61.53±1.56) and corn flakes (65.16±1.05)(table 2). The small particle size in the flour has made gradual breakdown of starch chains increasing the rapidly digestible starch (Hermasson and Swegmark, 1996). Also, an increase in Rapidly digestible starch corresponds to an increase Glycemic index which was significantly high in these samples. Gelatinised starches had high RDS and thus the corn flakes, which are completely gelatinised in their consumed form, contain high RDS levels hence there is an increase in GI (Chung *et al.*, 2006). The Slowly digestible

Table 1: Moisture, Carbohydrate, Total Dietary Fiber Contents of Corn Samples ±

Ingredient/Recipe	Moisture[1] (g/100 g)	Carbo-Hydrate[1] (g/100 g)	IDF[1] (g/100 g)	SDF[1] (g/100 g)	TDF[1] (g/100 g)
Corn Boiled	22.07±2.80^{abc}	71.56±1.38^{a}	10.6±0.55^{a}	0.26±0.15^{bc}	10.63±0.54^{ab}
Corn Roasted on Coal	20.36±2.38^{bcd}	72.06±1.56^{a}	10.5±0.60^{a}	0.76±0.05^{d}	11.26±0.55^{ab}
Corn Flour	15.63±0.66^{ef}	64.53±2.61^{cd}	8.26±0.11^{c}	0.5±0.02^{ab}	8.76±0.23^{ab}
Corn Roti	12.13±0.95^{f}	67.56±1.45^{bc}	9.46±0.37^{b}	0.21±0.17^{bc}	9.68±0.30^{b}
Boiled Baby Corn	23.46±3.06^{ab}	61.63±1.40^{de}	11.03±0.37^{a}	0.11±0.01^{d}	14.48±5.99^{a}
Pop Corn	17.06±1.47^{de}	60.63±0.55^{e}	8.35±0.28^{c}	0.19±0.10^{d}	8.54±0.30^{b}
Sweet Corn	25.26±1.60^{a}	70.82±0.55^{ab}	10.63±0.49^{a}	0.36±0.25^{bc}	11.0±0.26^{ab}
Corn Flakes	18.8±1.99^{cde}	54.06±2.75^{f}	10.27±0.12^{ab}	0.26±0.07^{bc}	10.53±0.25^{ab}

Note: [1] dry weight basis; ± - Mean and standard deviation of the samples (p<0.05); $^{a-f}$ = Values followed by the same letter in the same column are not significantly different (P < 005). One way ANOVA.

Table 2: Rapidly Digestible Starch and Slowly Digestible Starch in Corn Samples ±

Ingredient/Recipe	RDS (g/100 g)	SDS (g/100 g)
Corn Boiled	27.8±3.51^{c}	64.03±3.48^{a}
Corn Roasted On Coal	28.13±1.05^{c}	64.86±1.56^{a}
Corn Flour	61.53±1.56^{a}	48.13±1.05^{b}
Corn Roti	51.6±1.44^{b}	51.86±2.88^{b}
Boiled Baby Corn	24.63±1.50^{c}	66.56±1.61^{a}
Pop Corn	53.33±2.80^{b}	42.23±1.70^{c}
Sweet Corn	63.26±1.05^{a}	31.86±2.08^{d}
Corn Flakes	65.16±1.05^{a}	28.26±1.00^{d}

Note: ± - Mean and standard deviation of the samples (p<0.05); $^{a-f}$ = Values followed by the same letter in the same column are not significantly different (P < 005). One way ANOVA.

Table 3: Glycemic Index, Resistant Starch and Amylase Inhibitory Activity in Corn Samples ±

Ingredient/Recipe	GI	RS (g/100 g)	AI (%)
Corn Boiled	56.19±1.10^{d}	1.64±0.041^{a}	14.60±2.17^{a}
Corn Roasted On Coal	64.57±4.04^{c}	1.49±0.032^{b}	14.01±1.26^{a}
Corn Flour	82.57±2.25^{a}	1.15±0.036^{d}	9.27±1.00^{cd}
Corn Roti	68.89±1.67^{bc}	1.48±0.378^{b}	11.09±0.39^{bc}
Boiled Baby Corn	56.92±2.48^{d}	1.62±0.20^{a}	13.23±0.87^{ab}
Pop Corn	66.87±2.02^{c}	1.29±0.010^{c}	9.09±1.05^{cd}
Sweet Corn	72.01±1.48^{b}	1.28±0.015^{c}	12.54±1.56^{ab}
Corn Flakes	81.65±1.70^{a}	1.17±0.188^{d}	7.96±0.77^{d}

Note: ± - Mean and standard deviation of the samples (p<0.05); $^{a-f}$ = Values followed by the same letter in the same column are not significantly different (P < 005). One way ANOVA.

starches were highest in boiled baby corn (66.56±1.61) and boiled corn (64.03±3.48) owing to the fact that boiling has caused partial gelatinisation of starch and hence has made starch fractions inaccessible to the starch hydrolysing enzymes. Also, these foods corresponded to the least glycemic index due to slow release of glucose.

When the standard errors of prediction of predicted GI_{HI} and *invivo* 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 statistical analysis data showed that corn boiled (56.19±1.10) and baby corn (56.91±2.48) show least GI values among various methods of cooking and variety of corn used. The medium glycemic index values were observed in corn cooked on coal (64.57±4.04) and nearing to medium values where pop corn (66.87±2.02) and corn roti (68.89±1.67) (Rable 3). The high Glycemic index was observed in Corn Flour (82.57±2.25), Sweet corn (72.01±1.48) and corn flakes (81.65±1.70). The high glycemic index in corn flour and corn flakes corresponds to its small particle size in corn flour making the starch more easily digestible. However in flakes, loss of nutrients during mechanical processing and a low content of protein and fat correspond to high glycemic index. The sweet corn during boiling completely gelatinises, due to low insoluble fiber, and hence an increased RDS is seen in this is also a factor for increased glycemic index. The medium glycemic index in pop corn and corn roti is due to a slight puffing of the carbohydrate which increased the slowly digestible starches and a kind of partial gelatinization of starch could be a reason for medium GI values The low glycemic index in boiled corn and boiled baby corn is due to partial gelatinisation of starch and hence an increase in slowly digestible and resistant starch could be a reason for lowering the glycemic index in these methods. Resistant starch contents were significantly highest in boiled corn (1.64±0.041) and baby corn (1.62±0.20). The least were in corn flour (1.15±0.036) and corn flakes (1.17±0.188). The highest resistant starch in boiled varieties is because of the partial gelatinization of starch which occurs during boiling which doesn't allow the starch to break easily in digestion process and hence reduces the glycemic index. Corn flakes and corn flour have reduced resistant starch due to complete dissociation of starch into available carbohydrate, increasing the glycemic index values. The amylase inhibitory activity is highest in corn boiled (14.60±2.17) and corn roasted on coal (14.60±2.17). The least was observed in corn flakes (7.96±0.77), pop corn (9.09±1.05) and corn flour (9.27±1.00). The medium inhibition was observed in corn roti, sweet corn and boiled baby corn. Statistical analysis showed a significant difference in amylase inhibitory activity on corn boiled, corn roasted on coal, boiled baby corn and sweet corn with other cooking methods considered. The heat treatment by boiling has caused the gelatinization of starch chains and restricted access to hydrolysing enzymes and hence has shown better inhibition in boiled and roasted procedures compared to flakes, pop corn, corn roti and flour.

CONCLUSION

The glycemic indices of the sweet corn, corn flakes and corn flour are similar. The increase in rapidly digestible starches after boiling in sweet corn, and due to its high sugar content an increased glycemic index is observed. The corn flour due to its small particle size, also enables easy gelatinisation of starch when cooked and hence shows high glycemic index. Corn flakes which are most commonly taken as breakfast cereals, however ranges in high glycemic index range possibly due to the fact of processing changes, decreasing its slowly digestible starches. Thus, the glycemic index of boiled corn, corn roasted on coal and baby corn boiled varieties showed to be the least and plays a role in incorporating in dietary management of diabetes. The decrease in rapidly digestible starches in these samples when boiled shows partial gelatinization of starch units, making them inaccessible to the hydrolysing enzymes. Also, an increase in resistant starch and Amylase inhibitory activity may contribute to the increased polyphenolic characteristics of the corn, and thus making boiling and roasting on coal for corn most suitable methods for consumption.

REFERENCES

- Bernfeld P (1955), "Amylases-Alpha and Beta Methods", *Enzymol*, Vol. 1, pp. 149-150.
- Brand-Miller J (2007), "The Glycemic Index as a Measure of Health and Nutritional Quality: An Australian Perspective", *Cereal Foods World*, Vol. 52, pp. 41-44.
- Chung H J, Lim H S and Lim S T (2006), "Effect of Partial Gelatinization and Retrogradation on the Enzymatic Digestion of Waxy Rice Starch", *Journal of Cereal Science*, Vol. 43, pp. 353-359.
- Englyst H N, Kingman S M and Cummings J H (1992), "Classification and Measurement of Nutritionally Important Starch Fractions", *European Journal of Clinical Nutrition*, Vol. 46, pp. S33-S50.
- Erwin A T (1951), "Sweet Corn—Mutant or Historic Species?", *Economic Botany*, Vol. 5, No. 3, pp. 302-306.
- Food and Agriculture Organization/World Health Organization (2003), "Carbohydrates in Human Nutrition", Report of a Joint FAO/WHO Expert Consultation, FAO, Rome.
- Goni I, Garcia-Alonso A and Saura-Calixto F (1997), "A Starch Hydrolysis Procedure to Estimate Glycemic Index", *Nutrition Research*, Vol. 17, pp. 427-437.
- Granfeldt Y, Björck I, Drews A and Tovar J (1992), "An *in vitro* Procedure Based on Chewing to Predict Metabolic Responses to Starch in Cereal and Legume Products", *European Journal of Clinical Nutrition*, Vol. 46, pp. 649-660.
- Gunasekaran S and Paulshen M R (1985), "Breakage Resistance of Corn as a Function of Dry Rates", *American Society of Agricultural Engineers*, Vol. 28, No. 6, pp. 2071-2076.
- Han J A and BeMiller J N (2007), "Preparation and Physical Characteristics of Slowly Digesting Modified Food Starches", *Carbohydrate Polymers*, Vol. 67, pp. 366-374, (*Pisum sativum cv Trapper*), Starch (2007), Vol. 40, pp. 383-387.
- Harmeet S Guraya, Charles James and Elaine T Champagne (2001), "Effect of Cooling, Freezing on

Digestibility of Debranched Rice Starch and Physical Preparation of Resulting Material", *Starch/Starke*, Vol. 53, pp. 64-74.

- Hermasson and Swegmark (1996), "Developments in the Understanding of Starch Functionality", *Trends in Food Science and Technology,* Vol. 7, pp. 345-353.
- Hoover R and Zhou Y (2003), "*In vitro* and *in vivo* Hydrolysis of Legume Starches by Amylase and Resistant Starch Formation in Legumes—A Review", *Carbohydrate Polymers*, Vol. 54, pp. 401-417.
- Horwitz W (2005), *AOAC: Official Methods of Analysis*, 18th Edition, AOAC International, Gaithersburg, MD,USA.
- Jenkins A L (2007), "The Glycemic Index: Looking Back 25 Years", *Cereal Foods World,* Vol. 52, pp. 50-53.
- Jenkins D J A, Thome M J, Camelon K, Jenkins A L, Rao A V, Taylor R H *et al.* (1982), "Effect of Processing on Digestibility and the Blood Glucose Responses: A Study of Lentils", *American Journal of Clinical Nutrition*, Vol. 36, pp. 1093-1101.
- Joe S Hughes and Barry G Swanson (1989), "Soluble and Insoluble Dietary Fibers in Cooked Common Bean Seeds", *Food Microbiology*, Vol. 8, pp. 15-21.
- Kirsty A Germaine, Samir Samman, Catherine G Fryirs, Patrica J Griffiths, Stuart K Johnson and Kenneth J Quail (2008), "Comparison of *in vtro* Starch Digestibility Methods for Predicting the Glycemic Index of Grain Foods", *Sci Food Agric*., Vol. 88, pp. 652-658.
- Liu H, Ramsden L and Corke H (1997), "Physical Properties and Enzymatic Digestibility of Acetylated, ae, wx and Normal Maize Starch", *Carbohydrate Polymers*, Vol. 34, pp. 283-289.
- Roberts S B (2000), "High-Glycemic Index Foods, Hunger, and Obesity: Is There a Connection?", *Nutrition Reviews*, Vol. 58, pp. 163-169.
- Sailaja M G, Singhal R S and Kulkarni P R (2006), "Resistant Starch—A Review", *Comprehensive Reviews in Food Science and Food Safety*, Vol. 5, pp. 1-17.
- Smith Andrew F (2013), *The Oxford Encyclopedia of Food and Drink in America*, 2nd Edition, Oxford U, Oxford.
- Wang Y J and Wang L (2003), "Physicochemical Properties of Common and Waxy Corn Starches Oxidized by Different Levels of Sodium Hypochlorite", *Carbohydrate Polymers*, Vol. 52, pp. 207-217.
- Wolever T M S and Mehling C (2002), "High-Carbohydrate–Low-Glycaemic Index Dietary Advice Improves Glucose Disposition Index in Subjects with Impaired Glucose Tolerance", *British Journal of Nutrition*, Vol. 87, pp. 477-487.
- Woo K Kim, Chung M I K, Nam E Kang, Myung H Kim and Ock J Park (2003), *Journal of Nutritonal Biochemistry*, Vol. 14, No. 3, pp. 166-172.
- Woo K S and Seib P A (2002), "Cross-Linked Resistant Starch: Preparation and Properties", *Cereal Chemistry*, Vol. 79, pp. 819-825.

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