

Original

## Ground roasted peanuts leads to a lower post-prandial glycemc response than raw peanuts

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### Abstract

**Introduction:** Few studies have evaluated the effect of nuts processing on the glycemc response and satiety.

**Objective:** To evaluate the effect of peanut processing on glycemc response, and energy and nutrients intake.

**Method:** Thirteen healthy subjects (4 men and 9 women), with a mean age of  $28.5 \pm 10$  years, BMI  $22.7 \pm 2.5$  kg/m<sup>2</sup>, and body fat  $23.7 \pm 5.7\%$  participated in this randomized crossover clinical trial. After 10-12 h of fasting, one of the following types of test meals were consumed: raw peanuts with skin (RPS), roasted peanuts without skin, ground-roasted peanuts without skin (GRPWS) or control meal. The test meals had the same nutrient composition, and were consumed with 200 ml of water in 15 minutes. Glycemc response was evaluated 2 hours after each meal. Energy and nutrients intake were assessed through diet records reflecting the habitual food intake and food consumption 24 hours after the ingestion of test meal.

**Result:** The area under the glycemc response curve after GRPWS was lower ( $p = 0.02$ ) the one obtained for RPS. There was no treatment effect on energy intake, macronutrients and fiber consumption after the test meal.

**Conclusion:** The consumption of ground-roasted peanuts may favor the control and prevention of diabetes due to its reduction on postprandial glucose response. However, more prospective studies are needed to confirm this hypothesis.

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Key words: Peanuts. *Arachis hypogaea*. Blood glucose. Diabetes mellitus. Glycemc index. Food intake.

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### MANÍ TOSTADO Y MOLIDO CONDUCE A UNA MENOR RESPUESTA GLICÉMICA POSTPRANDIAL COMPARADO CON MANÍ CRUDO

### Resumen

**Introducción:** Escasos estudios han evaluado el efecto del procesado industrial de los frutos secos sobre la respuesta glicémica y la saciedad.

**Objetivos:** Evaluar el efecto del procesamiento de maní sobre la respuesta glicémica y la ingesta de energía y nutrientes.

**Métodos:** Trece sujetos sanos (4 hombres y 9 mujeres), con una edad media de  $28,5 \pm 10$  años, IMC  $22,7 \pm 2,5$  kg/m<sup>2</sup>, y un porcentaje de grasa corporal de  $23,7 \pm 5,7\%$  participaron en este ensayo clínico aleatorizado y cruzado. Tras 10-12 h de ayuno uno de los siguientes tipos de comidas test fueron consumidas: maní crudo con la piel (RPS), maní tostado sin piel, maní tostado y molido sin piel (GRPWS) o comida control. Las comidas test presentaban la misma composición nutricional, y fueron consumidas con 200 ml de agua en 15 minutos. Se evaluó la respuesta glicémica 2 horas después de cada una de las comidas. La ingesta de energía y nutrientes contenida en la toma alimentaria y las 24 horas posteriores a la comida test fueron determinadas mediante registros dietéticos.

**Resultados:** El área bajo la curva de respuesta glicémica después de GRPWS fue menor ( $p = 0,02$ ) que la de RPS. No hubo efecto de los tratamientos sobre la ingesta de energía, macronutrientes y fibra posterior a la comida test.

**Conclusión:** El consumo de maní tostado y molido sin piel, al reducir la respuesta glicémica postprandial podría ser beneficioso para el control y prevención de la diabetes. Sin embargo son necesarios estudios de intervención a largo plazo que lo confirmen.

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Palabras clave: Maní. *Arachis hypogaea*. Glucemia. Diabetes mellitus. Índice glicémico. Ingestión de alimentos.

## Abbreviations

AUC: Area under the curve.  
BIA: Electrical bioimpedance.  
BMI: Body mass index.  
CM: Control meal.  
GI: Glycemic index.  
GL: Glycemic load.  
GRPWS: Ground roasted peanuts without skin.  
RPS: Raw peanuts with skin.  
RPWS: Roasted peanuts without skin.

## Introduction

Non-communicable diseases are responsible for 47% of the morbidity in the world. Among these diseases, we emphasize cardiovascular diseases and diabetes mellitus. This percentage tends to increase due to the adoption of inadequate life-style, represented mainly by the consumption of unhealthy diets and by low physical activity.<sup>1</sup> The results of several studies illustrate the importance of the glycemic control to prevent diabetes complications.<sup>2-4</sup>

Among the dietary components, the carbohydrate is the macronutrient that has a greater affect on blood glucose levels. The consumption of low glycemic index (GI) diets results in lower glucose response, favoring an adequate glycemic control,<sup>5,6</sup> a reduction in serum cholesterol levels, and an increase in satiety.<sup>7-10</sup> While the consumption of high GI diet increases the risk of insulin resistance, glucose intolerance, cardiovascular disease, and obesity, the ingestion of low GI diet protects against these diseases.<sup>11</sup>

Several factors can affect the post-prandial glycemic response. Among these factors are the ratio of amylose to amylopectin in the starch, the occurrence of starch-nutrient interaction, the cooking method to which the food is submitted; the ripeness of fruit; and food content of fiber, fat and protein.<sup>12</sup> According to some authors,<sup>13-15</sup> highly processed foods are more rapidly digested and absorbed, resulting in more rapid increase on post-prandial glycemia. However, the effect of food processing on glycemia is still controversial.

Nut consumption leads to a small increase in glucose response,<sup>16-18</sup> which might lead to a positive effect on glycemic control.<sup>19-21</sup> Some authors believe that nuts can improve lipid profile and reduce type 2 diabetes risk due to their fat composition, and content of fiber, magnesium, vitamins, minerals, antioxidants, and protein.<sup>19,22</sup> Despite its high fat content and high energy density, the consumption of peanuts may exert a beneficial effect on body weight maintenance. This effect can be attributed to peanuts high fiber and protein content, the shape of the nut, and its low GI. It is also possible that all these factors act synergistically to promote an increase in satiety.<sup>22-24</sup>

The authors of a recently published study<sup>25</sup> emphasized the need to evaluate the effect of nuts (almonds, chestnuts, walnuts, peanuts) on appetite, energy intake,

body composition, and substrate oxidation. To our knowledge, there hasn't been published any study that evaluated the effect of peanut processing on glycemic response. Therefore, main purpose of this study was to investigate how peanuts roasting and grinding affect glycemic response and food intake.

## Methods

### *Experimental design*

This randomized crossover study involved the participation of thirteen subjects, which were recruited through public advertisements. Participants were non-smokers, not pregnant or lactating, non-diabetics, had no family history of diabetes or glucose intolerance, no diagnosis of type 2 diabetes and impaired fasting glucose (ADA, 2009),<sup>26</sup> were not under medication (except birth control pills), not on a therapeutic diet, had no recent weight loss or gain  $\pm$  3 kg over the previous 3 months, and ate breakfast regularly.

Participants were instructed to maintain their physical activity level constant throughout the study and not to consume alcohol the day before the tests. Food intake at the week before the beginning of the study was assessed through a dietary record in which participants registered their daily food consumption for 3 non-consecutive days (2 week days and 1 weekend).<sup>27</sup>

After 10-12 hours overnight fasting, participants reported to the laboratory and randomly consumed within 15 minutes, one of 4 types of test meal (3 containing peanuts (Yoki, Brazil<sup>®</sup>) or a control meal). The consumption of each test meal was separated by a washout period of 2 days. For test meal randomization, before the beginning of the study the names of each treatment were written on paper and drawn for each participant. After the ingestion of test meal, participants remained in the laboratory for 2 hours for postprandial glycemic response assessment. Following that, participants were asked to pursue their normal activities, but were instructed to keep free-feeding dietary records over the 24 hours after test meal consumption.

The protocol of this study was approved (n<sup>o</sup> 038/2009) by the Ethics Committee in Human Research of the Federal University of Viçosa, Brazil. All volunteers were informed about the objectives of the study and signed the written informed consent. A sample calculation<sup>28</sup> made before the beginning of the study, was based on a mean difference in glycemic response of 12 units,<sup>29</sup> assuming 80% power and a 5% significance level, indicated that a total of 13 subjects was necessary for this study.

### *Anthropometric and body composition assessments*

Body weight was assessed using an electronic platform scale (Toledo Brazil, Model 2096 PP<sup>®</sup>), with capacity for 150 kg and precision of 50 g. Height was

measured using a stadiometer (SECA model 206<sup>®</sup>) fixed to the wall. Body mass index (BMI) was computed based on weight (kg) and height (m<sup>2</sup>) (kg.m<sup>-2</sup>), and classified according to the parameters of the World Health Organization (2000).<sup>30</sup> Body fat percentage was measured by a tetrapolar electrical bioimpedance (BIA) (Biodynamics, Model 310<sup>®</sup>, TBW), according to the protocol of Lukaski et al. (1986).<sup>31</sup> Participants were instructed not to use diuretics 7 days before the assessment, not to exercise on the preceding 12 hours, not to drink alcohol on the preceding 48 hours and to avoid drinking any beverage before the test.

### *Test meals*

On each testing occasion, participants were given a test meal containing 63 g of raw peanuts with skin (RPS), roasted peanuts without skin (RPWS), ground-roasted peanuts without skin (GRPWS) or a cheese sandwich as control meal (CM). Participants also received 200 mL of water at each meal. The 4 types of meals provided had the similar energy (~362.5 kcal), carbohydrate (~14.5 g), protein (~14.7 g), fat (~27.3 g) and fiber (~1.89 g) content.

The peanuts (3.000 g) were roasted in five medium baking sheets (30 x 20 cm) in low temperature for 25 minutes in a household oven (DAKO, Model sensible-ness<sup>®</sup>), pre-heated for 5 minutes. While in the oven, the nuts were mixed frequently to ensure uniform roasting without burning. After reaching a light brown color, the nuts were kept in room temperature to cool off and the skin was manually removed. Part (1.500 g) of the roasted peanuts was ground for 40 seconds in a food processor (Britania, Model Multipro Super<sup>®</sup>), with a knife type metal blade, to obtain small peanut granules. The control meal contained 24.9 g of whole wheat bread, 51 of cheese, 12.5 g of butter and 3.1 of sugar.

### *Glycemic response assessment*

Capillary finger-stick blood samples were taken in the fasting state (0 min) and 30, 45, 60, 90 and 120 minutes after the start of each meal. Glucose levels were measured using a One Touch Ultra<sup>®</sup> glucometer. The positive area under the curve (AUC) changes in blood glucose were computed by the trapezoidal method (FAO, 1998)<sup>32</sup>, using the SlideWrite 7.0<sup>®</sup> software.

### *Test meal glycemic index*

The glycemic index (GI) of the peanut containing meals was estimated considering the mean values published for peanuts.<sup>33-35</sup> The control meal GI was achieved by the sum of the values obtained by adding the product of the proportion of carbohydrate contained in bread and in sugar by their respective GI.<sup>36,37</sup>

Since the carbohydrate content of cheese and butter in the control meal is very low or absent, these ingredients were not considered to estimate the GI of that meal.

### *Food intake assessment*

Before the beginning of the study, all participants were instructed to register their food intake on 3 non-consecutive days (2 week days and 1 weekend)<sup>27</sup> in order to describe their eating habits at baseline. To ensure accuracy, participants received written guidelines and were trained to estimate the consumed food portions using household items. Participants received a standardized record form to register the type and amount of foods and beverages consumed before the beginning of the study (baseline) and over the 24-hour after the consumption of each test meal. Each dietary record was reviewed in the presence of the volunteer in order to ensure its accuracy and completeness. Food portions were converted into grams and the subsequent meal energy intake (satiety), 24 h-total post-meal energy intake, macronutrients and fiber consumption were analyzed using the software Avanutri<sup>®</sup> 3.1.5.

### *Statistical analysis*

Shapiro-Wilk test was applied to analyze data normality. Parametric tests were applied when data presented normal distribution, otherwise non-parametric tests were applied. Changes in glycemic response were assessed by analysis of covariance (ANCOVA) test using baseline values as covariate. Energy intake was assessed by analysis of variance (ANOVA) with type of meal as independent variable. Bonferroni's test was used for multiple post-hoc contrasts. Analyses were conducted using the software SigmaPlot<sup>®</sup> 11.0 and SAEG<sup>®</sup> 9.1. The criterion for statistical significance was  $p < 0.05$ . The results related to the characterization of the sample are presented as mean  $\pm$  standard deviation. Dietary intake and glycemic responses results are presented as mean  $\pm$  standard error.

## **Results**

### *Participants' characteristics*

A total of 13 (4 men and 9 women) healthy adults (mean  $28.5 \pm 10$  years of age), BMI  $22.7 \pm 2.5$  kg/m<sup>2</sup>, body fat  $23.7 \pm 5.7\%$  were recruited. All the recruited participants finish the study.

### *Estimated test meals glycemic index*

While the GI value estimated for the peanut-based meals were equivalent to 14.33 units, the control meal GI corresponded to 22.26 units.

**Table I**  
Mean  $\pm$  standard error glycemic response after the consumption of test meals

Time (min.)	RPS	RPWS	GRPWS	CM	P value
0	83,31 $\pm$ 2,14	85,85 $\pm$ 1,87	81,23 $\pm$ 1,90	85,23 $\pm$ 1,90	0.28
15	84,69 $\pm$ 2,05 <sup>b</sup>	89,38 $\pm$ 1,93 <sup>a,b</sup>	82,46 $\pm$ 2,27 <sup>b</sup>	92,62 $\pm$ 1,86 <sup>a</sup>	< 0.05
30	91,00 $\pm$ 3,59 <sup>a,b</sup>	88,31 $\pm$ 1,93 <sup>b</sup>	84,08 $\pm$ 2,32 <sup>b</sup>	99,23 $\pm$ 3,26 <sup>a</sup>	< 0.05
45	90,77 $\pm$ 2,44	89,54 $\pm$ 2,02	84,08 $\pm$ 1,77	93,23 $\pm$ 3,69	0.19
60	90,23 $\pm$ 2,89	92,85 $\pm$ 3,13	83,23 $\pm$ 2,52	87,38 $\pm$ 3,17	0.25
90	92,85 $\pm$ 2,08 <sup>a</sup>	90,46 $\pm$ 2,22 <sup>a,b</sup>	82,31 $\pm$ 1,57 <sup>b</sup>	85,46 $\pm$ 1,99 <sup>b</sup>	< 0.05
120	94,08 $\pm$ 2,36 <sup>a</sup>	88,31 $\pm$ 2,16 <sup>a,b</sup>	82,85 $\pm$ 2,04 <sup>b</sup>	85,69 $\pm$ 2,65 <sup>b</sup>	< 0.05

RPS: Raw peanuts with skin; RPWS: Roasted peanuts without skin; GRPWS: Ground-roasted peanuts without skin; CM: Control meal. <sup>a,b</sup>Mean values for glycemic responses within a row with unlike superscript letters are significantly different from each other.

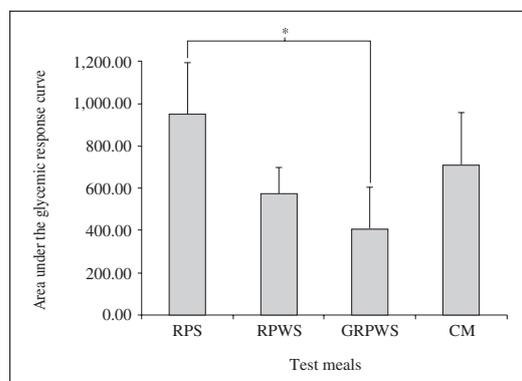


Fig. 1.—Mean  $\pm$  standard error of the area under the glycemic response curves (AUC) evaluated for 120 minutes after ingestion of the study test meals (RPS: Raw peanuts with skin; RPWS: Roasted peanuts without skin; GRPWS: Ground-roasted peanuts without skin; CM: Control meal). Mean RPS AUC value is significantly higher than GRPWS AUC values (\* $p$  = 0.02).

#### Glycemic responses

The GRPWS and RPS glycemic responses at 15 minutes were lower than CM responses ( $p$  < 0.05). The GRPWS and RPWS glycemic responses at 30 minutes were lower than the ones obtained after the ingestion of the CM ( $p$  < 0.05). At 90 and 120 minutes after consumption of GRPWS and CM these responses were lower than the one obtained for RPS ( $p$  < 0.05) (table I). The GRPWS AUC was significantly ( $p$  = 0.02) lower than the one obtained for RPS (fig. 1).

#### Food intake

Mean baseline 24-h total post-meal energy intake (1,794.29  $\pm$  166.82 kcal) did not differ ( $p$  = 0.93) between treatments groups (1724.75  $\pm$  93.78 kcal for RPS, 1,684.75  $\pm$  96.58 kcal for RPWS, 1,728.76  $\pm$

109.59 kcal for GRPWS, 1,738.40  $\pm$  125.91 kcal for CM) (table II). There was also no effect of test meal on the subsequent meal energy intake ( $p$  = 0.29), on 24h-total post-meal energy intake ( $p$  = 0.28), or daily protein ( $p$  = 0.20), fat ( $p$  = 0.76) and fiber ( $p$  = 0.35) consumption. However, daily carbohydrate consumption was lower for RPWS, GRPWS and CM than at baseline ( $p$  < 0.05).

#### Discussion

Post-prandial glycemic response can be affected by several factors, including the type of method used to process starch; the amount of fiber, fat and protein present in a meal and the digestibility of the carbohydrate present in that meal.<sup>38,39</sup> When submitted to dry heat, starch is converted into dextrin, facilitating its digestion and increasing post-prandial glycemic response.<sup>40</sup> In the present study, the amount of fiber and macronutrient of the test meals were similar. Instead of starch, the peanut-based test meals have sucrose, glucosamine, raffinose and stachyose as carbohydrate sources. Heat does not break these oligosaccharides into glucose.<sup>41</sup> Therefore, this is probably the reason why the 120 minutes glycemic response AUC obtained for raw (raw peanuts with skin) and roasted peanuts (roasted peanuts without skin) did not differ in the present study.

Peanuts are rich in fiber, fat and protein,<sup>16</sup> which may act synergistically to promote a reduction in the post-prandial glycemic response.<sup>37</sup> However, the physiological effects observed after nut consumption may also be affected by the integrity of its cell wall, which may affect the release and subsequent absorption of fat and other nutrients present.<sup>42</sup> In present study, the lower glycemic response AUC observed after the ingestion of ground roasted peanuts than after raw peanuts may have occurred due to the grinding process to which the nuts were submitted. It is possible that the cleavage of the cell walls after this processing method release the

**Table II**  
Mean  $\pm$  standard error of baseline and treatments daily energy, macronutrient and fiber consumption

	Energy intake (kcal)	Carbohydrate (g)	Protein (g)	Lipids (g)	Fiber (g)
Baseline	1,794.29 $\pm$ 166.82	254.3 $\pm$ 18.48 <sup>a</sup>	72.05 $\pm$ 4.97	57.91 $\pm$ 7.78	13.61 $\pm$ 1.27
RPS	1,724.75 $\pm$ 93.78	221.2 $\pm$ 15.58 <sup>ab</sup>	64.78 $\pm$ 2.83	63.60 $\pm$ 6.06	11.39 $\pm$ 1.68
RPWS	1,684.75 $\pm$ 96.58	206.78 $\pm$ 12.70 <sup>b</sup>	77.00 $\pm$ 8.31	66.62 $\pm$ 4.97	11.76 $\pm$ 1.26
GRPWS	1,728.76 $\pm$ 109.59	211.2 $\pm$ 16.18 <sup>b</sup>	77.40 $\pm$ 7.94	59.49 $\pm$ 7.02	10.88 $\pm$ 0.99
CM	1,738.40 $\pm$ 125.91	209.65 $\pm$ 18.23 <sup>b</sup>	73.58 $\pm$ 4.63	62.76 $\pm$ 7.51	11.79 $\pm$ 1.07
p value	0.93	<0.05	0.20	0.76	0.35

RPS: Raw peanuts with skin; RPWS: Roasted peanuts without skin; GRPWS: Ground-roasted peanuts without skin; CM: Control meal. <sup>a,b</sup>Mean values for carbohydrate consumption within a column with unlike superscript letters are significantly different from each other.

fat content of the nuts, resulting in the lower glycaemic response observed.

According to some authors, the amount of fat released and absorbed in the digestive system depends on the degree of maceration and breakage of the cell wall, affecting the glycaemic and insulinemic responses.<sup>17,37,42</sup> Fat reduces gastric emptying rate, reducing meal digestion and absorption rate, favoring a reduction in its GI.<sup>12</sup> While the total disruption of the cell wall of nuts may occur with the use of multi processor, this does not occur completely with mastication.<sup>42,43</sup> This explains why raw peanuts glycaemic response AUC was significantly higher than the one obtained for ground roasted peanuts, but did not differ from the one for roasted peanuts.

It has been reported that milling disrupts the starch granules, facilitating their hydrolysis and increasing prandial glycaemic response.<sup>44</sup> However, the results of a study<sup>23</sup> indicated that the processing type did not affect the 2h post prandial glycaemic response AUC for maize (whole grains, broken grains and flour) and oats (whole grains, flakes and flour). Similar results were observed in another study where the glycaemic response after the consumption of whole wheat bread and ultrafine wheat flour bread was not affected.<sup>24</sup> The results of these two studies<sup>23,24</sup> suggest that this type of response is not always affected by the processing to which the grain is submitted.

According to Bornet et al. (2007),<sup>45</sup> due to the lower rate of digestion and absorption, the consumption of foods with low GI results in lower glycaemic responses, favoring an increase in satiety. In the present study, although raw peanuts AUC glycaemic response was greater than ground roasted peanuts AUC glycaemic response, there was no difference in food intake between these two treatments. Previous studies indicate that peanuts GI varies from 7 to 23.<sup>33-35</sup> On the other hand, the estimated GI for the control meal tested in this study was equal to 22.26. Therefore, the test meals evaluated in the current study are considered low GI (GI  $\leq$  55) meals according to the classification proposed by Brand-Miller et al.

(2003b).<sup>46</sup> These results suggest that meals that differ in glycaemic response, but have the same GI may not affect food intake.

In another study, the effect of GI and glycaemic response on food intake was measured 60 minutes after the consumption of foods differing in GI in adult men. However, an inverse relationships were observed between glycaemic response AUC versus appetite ( $r = -0.23$ ,  $p < 0.05$ ) and food intake ( $r = -0.24$ ,  $p < 0.05$ ).<sup>47</sup> On the other hand, in another study, although there was no correlation between appetite and glycaemic response, there was a positive correlation was observed between the glycaemic response and energy intake ( $r = 0.33$ ,  $p < 0.05$ ) 3 hours after the consumption of breakfast meals differing in GI.<sup>48</sup> The results of these last two studies show that the effect of the glycaemic response on food intake is still controversial.

It should be pointed out however, that in the present study the nutritional composition of test meals was determined according to food labels. In a recent study, the nutritional composition displayed in the labels of 10 commercial brands of peanuts was compared to the one obtained by physicochemical analytical methods. The difference in terms of carbohydrate in 40% of the samples, and in terms fiber content in 15% of the analyzed samples was greater than 20%.<sup>49</sup> Therefore, considering that the carbohydrate and fiber content of a meal can affect the postprandial glycaemic response,<sup>50</sup> a difference in terms of these nutrient contents indicated on the label and that obtained after chemical analysis may have affected the reliability of the nutritional composition of this study test meals.

## Conclusion

These results suggest that among the meals tested in the present study, the ingestion of 63 g of ground-roasted peanuts without skin in the breakfast leads to a lower carbohydrate intake and reduces postprandial glycaemic response, which might contribute to improve the glycaemic control and reduce diabetes risk. How-

ever, prospective studies are needed to confirm this hypothesis.

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