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# CONSUMPTION OF FOOD WITH RESISTANT STARCH IN PEOPLE WITH DIABETES MELLITUS 2

## *CONSUMO DE ALIMENTOS COM AMIDO RESISTENTE EM PESSOAS COM DIABETES MELLITUS 2*

**Matheus Daros da Silva[1], Ana Flávia Gonçalves de Souza[2], Letícia Neves Aires[3], Ludiana Cardozo Rodrigues[4], Nicole Fernandes Moresco[5], Verônica Marques Rocha[6] e Elisângela Colpo[7]**

**ABSTRACT**

Resistant starch (RS) is a type of carbohydrate that is not digested in the small intestine and is fermented in the colon. Present in foods such as rice, beans, and green bananas, it promotes metabolic benefits, including better glycemic control. Objective: To analyze the consumption of foods containing RS by people with type 2 Diabetes Mellitus (T2DM). Methodology: Descriptive and quantitative study, of a cross-sectional nature. Data collection occurred through a Google Forms questionnaire applied to individuals diagnosed with T2DM, evaluating the consumption of 36 foods and preparations containing RS, classified as types 1, 2, 3, and 4, distributed among legumes, fruits, cereals, oilseeds, tubers, and starches. In addition to food frequency, the form of food storage was analyzed, including refrigeration, freezing, and dry storage, considering its influence on starch retrogradation. Results: Most participants (80.77%) did not present complications associated with T2DM. Daily consumption of foods with RS was observed, the most frequent being rice (84%), bread (62%) and beans (54%). Refrigeration was the main form of storage (50%), favoring the formation of RS type 3, associated with metabolic benefits, such as better glycemic control, lower insulin response, modulation of the intestinal microbiota and increased satiety. Conclusion: RS consumption was present daily in the participants' diet, mainly in refrigerated form, favoring the formation of type 3 AR. This dietary pattern may represent a complementary nutritional strategy in the management of T2DM, although further research is needed to clarify its clinical effects.

**Keywords:** Metabolic Diseases; Dietary Fiber; Food Intake.

1 Acadêmico. Universidade Franciscana - UFN. E-mail: daros.matheus@ufn.eudu.br. ORCID: https://orcid.org/0000-0003-0799-5250

2 Acadêmica. Universidade Franciscana - UFN. E-mail: anaflaviagsouza@gmail.com ORCID: https://orcid.org/0009-0000-1218-7659

3 Acadêmica. Universidade Franciscana - UFN. E-mail: lnevesaires@gmail.com ORCID: https://orcid.org/0009-0008-6250-7874

4 Acadêmica. Universidade Franciscana - UFN. E-mail: ludianapsicologa@gmail.com ORCID: https://orcid.org/0009-0001-6460-1468

5 Acadêmica. Universidade Franciscana - UFN. E-mail: nicole-moresco@hotmail.com ORCID: https://orcid.org/0009-0002-4682-098X

6 Acadêmica. Universidade Franciscana - UFN. E-mail: veronicamrch@gmail.com ORCID: https://orcid.org/0009-0007-6259-6742

7 Doutor. Universidade Franciscana - UFN. E-mail: elicolpo@ufn.edu.br. ORCID: https://orcid.org/0000-0002-3886-0765

***RESUMO***

*O amido resistente (AR) é um tipo de carboidrato que não é digerido no intestino delgado, sendo fermentado no cólon. Presente em alimentos como arroz, feijão e banana-verde, promove benefícios metabólicos, incluindo melhor controle glicêmico. Objetivo: Analisar o consumo de alimentos contendo AR por pessoas com Diabetes Mellitus tipo 2 (DM2). Metodologia: Estudo descritivo e quantitativo, de caráter transversal. A coleta de dados ocorreu por meio de um formulário via Google Forms aplicado em indivíduos diagnosticados com DM2, avaliando o consumo de 36 alimentos e preparações contendo AR, classificados nos tipos 1, 2, 3 e 4, distribuídos entre leguminosas, frutas, cereais, oleaginosas, tubérculos e féculas. Além da frequência alimentar, analisou-se a forma de armazenamento dos alimentos, incluindo refrigeração, congelamento e armazenamento seco, considerando sua influência na retrogradação do amido. Resultados: A maioria dos participantes (80,77%) não apresentou complicações associadas ao DM2. Observou-se consumo diário de alimentos com AR, sendo os mais frequentes arroz (84%), pão (62%) e feijão (54%). A refrigeração foi a principal forma de armazenamento (50%), favorecendo a formação de AR tipo 3, associado a benefícios metabólicos, como melhor controle glicêmico, menor resposta insulinêmica, modulação da microbiota intestinal e aumento da saciedade. Conclusão: O consumo de AR esteve presente diariamente na alimentação dos participantes, principalmente na forma refrigerada, favorecendo a formação de AR tipo 3. Esse padrão alimentar pode representar uma estratégia nutricional complementar no manejo do DM2, embora investigações futuras sejam necessárias para esclarecer seus efeitos clínicos.*

***Palavra-chave:*** *Doenças Metabólicas; Fibra Alimentar; Ingestão Alimentar.*

## INTRODUCTION

Human diets are becoming increasingly processed, with worrying consequences for global nutrition, public health, and the environment (BAKER *et al*., 2020). Current epidemiological data highlight the association between the effects of ultra-processed foods on various chronic diseases and metabolic syndrome (SROUR *et al*., 2022). One of the growing pathologies in the world is Diabetes Mellitus, which describes a group of metabolic disorders characterized by high blood glucose levels. In particular, type 2 diabetes mellitus (T2DM) is characterized by peripheral resistance to insulin action and insufficient insulin release from beta cells located in the pancreatic islets (CHO *et al*., 2018; COHRS *et al*., 2020). In this scenario, Brazil ranks sixth in the world in terms of the number of adults with diabetes, with 23.2 million people, according to the International Diabetes Federation Atlas 10th edition (MAGLIANO, 2021).

Foods containing resistant starch (RS) have a slower digestion process. Consequently, their consumption leads to a slow release of glucose into the bloodstream, explaining their beneficial effects on blood glucose levels (BIRT *et al*., 2013). RS plays an important role as a source of fiber related to the reduction of postprandial blood glucose and insulin response, as shown in Monteiro's research (2013). Additionally, this food is classified as prebiotic due to its ability to resist digestion and subsequent fermentation in the colon, which results in the gradual release of energy, contributing to the reduction of the glycemic index of foods and promoting a prolonged feeling of satiety (PEREIRA, 2007;

BOJARCZUK *et al*., 2022). In conclusion, the review by Rashed *et al*. (2022) observed that the intake of different forms of RS was directly correlated with minimization through various mechanisms, far beyond the reduction of blood glucose in the better control of pre-diabetic and diabetic conditions, representing an important strategy in the treatment of patients with T2DM.

Thus, RS is presented as a form of strategy, since it is routinely present in the Brazilian population's diet. Therefore, resistant starches are classified as RS type 1, which is physically inaccessible starch that cannot be hydrolyzed due to the cell wall barrier present in bread, seeds, and vegetables. Type 2 RS is characterized as raw starch, which due to its structure is not absorbed, contained in raw potatoes, green bananas, and corn. Type 3 RS undergoes retrogradation, which is formed when food is cooked and then cooled, in which long branched chains form double branched chains of amylopectin, forming a double helix that cannot be hydrolyzed by digestive enzymes. It is found in potatoes, rice, beans, oats, and bread. Type 4 RS is enzymatically modified with the addition of certain chemical functional groups and is found in some commercially produced breads and pastries. Finally, type 5 RS is called resistant maltodextrin, which is a combination of long, unbranched starch chains with free fatty acids forming a structure that is difficult to digest, included in foods containing artificially produced amylose-lipid complexes (BOJARCZUK, *et al*. 2022).

The present study aims to analyze the consumption of foods containing resistant starch by people with T2DM. In view of this, the theme of this research is justified by the importance of new forms of nutritional approach in a pathology that has shown a global and continuous increase in recent years, representing enormous challenges for individual health and financial costs for society.

## METHODOLOGY

This is a descriptive, quantitative, cross-sectional study. This study is part of a master's project entitled "Self-care of people living with Diabetes Mellitus II," from the Master's in Health and Life Sciences program at a graduate school in the inland of Rio Grande do Sul, approved by the Ethics and Research Committee, with approval number 76501023.0.0000. 5306.

The study was conducted in a municipality located in the central region of Rio Grande do Sul, at an association for people with diabetes and an endocrinology clinic at a local hospital, from March to May 2024.

Data were collected using a sociodemographic questionnaire, a clinical questionnaire, and a structured form on dietary frequency. People with a medical diagnosis of T2DM, of both sexes, adults aged 18 years and older, were invited to participate in the study. Exclusion criteria included individuals with other endocrine conditions or prediabetes, as well as cognitive difficulties that could impair understanding of the study or its objectives.

Participants were recruited in person at an association for people with diabetes, as well as at an endocrinology clinic, through direct invitation, telephone contact, and messaging app (WhatsApp). The sample was selected for convenience. Finally, for the consent and clarification of the participants, an informed consent form was signed.

Data collection was performed through structured face-to-face interviews with participants, using a semi-quantitative food frequency questionnaire developed in Google Forms, adapted with 36 foods and preparations containing RS in their composition and organized according to the specific type of RS.

This instrument was used not only to identify the intake of foods containing, but also to analyze storage practices, including refrigeration, freezing, and dry storage methods. The frequency of food consumption was categorized as: daily consumption, 2-3 times per week, 4-6 times per week, less than once per week, or never.

At the end of the survey, a folder containing relevant information about the treatment of T2DM was prepared and delivered. It included nutritional guidelines, suggestions for a healthy lifestyle, information about medication, suggestions for healthy snacks, in accordance with the Food Guide for the Brazilian Population (MINISTRY OF HEALTH, 2014), according to the Supplementary Material.

## RESULTS

The study evaluated 26 individuals with T2DM, residing in the central region of Rio Grande do Sul. The demographic analysis, as presented in Table 1, revealed that the predominant age distribution is between 63 and 78 years old, corresponding to the majority of the sample. In terms of gender, there was a prevalence of females. Regarding ethnicity, most participants identified as white. In terms of education, the majority of participants had incomplete elementary school education.

**Table 1 -** Sociodemographic data of people with type 2 diabetes mellitus.

| **Age (years)** | **n** | **%** |
|---|---|---|
| 47 a 62 | 11 | 42,3 |
| 63 a 78 | 14 | 53,8 |
| ≥ 80 | 1 | 3,8 |
| **Sex** | | |
| Female | 17 | 65,3 |
| Male | 9 | 35,6 |
| **Ethnicity** | | |
| Black | 4 | 15,3 |
| White | 15 | 57,6 |
| Brown | 4 | 15,3 |
| Indigenous | 3 | 11,5 |
| Yellow | - | |

| | | |
|---|---|---|
| **Education** | | |
| Incomplete elementary school | 9 | 35,6 |
| Complete elementary and secondary school | 7 | 26,9 |
| Incomplete secondary school or higher education | 4 | 15,3 |
| Higher education | 6 | 23,0 |

Regarding clinical data, most participants do not consume alcoholic beverages. As for T2DM, most individuals had been diagnosed more than 10 years ago, with systemic arterial hypertension being the most common comorbidity, found in 50% of cases. Most participants did not present complications related to T2DM; however, the most recurrent complication was diabetic retinopathy (Table 2).

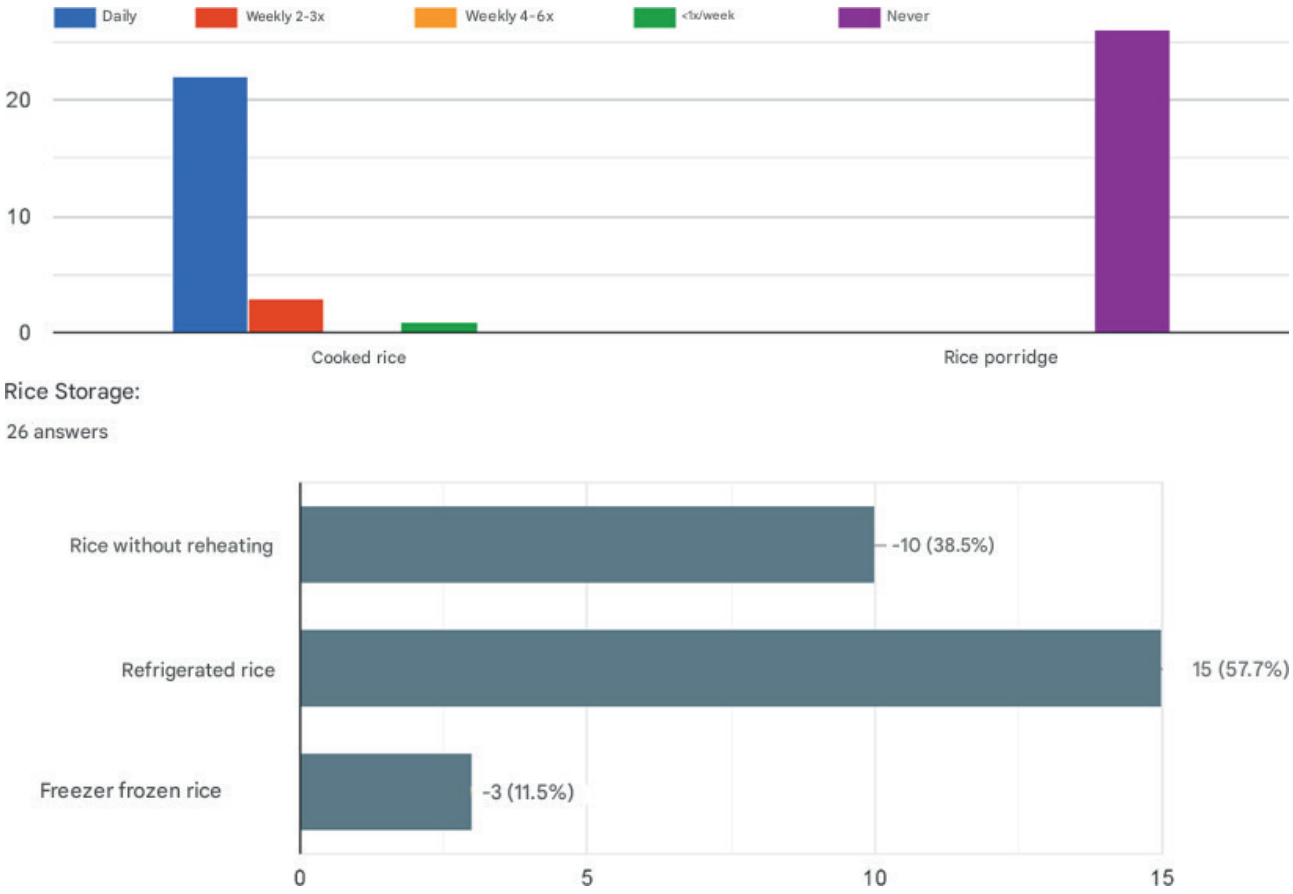
**Table 2 -** Clinical data of people with type 2 diabetes mellitus.

| **Alcoholism** | **n** | **%** |
|---|---|---|
| Alcoholic | 4 | 15,3 |
| Non-alcoholic | 22 | 84,6 |
| **Duration of diabetes (years)** | | |
| 1 a 5 | 7 | 26,9 |
| 5 a 10 | 4 | 15,3 |
| 10 a 20 | 9 | 34,6 |
| 20 a 30 | 1 | 3,8 |
| 30 a 40 | 3 | 11,5 |
| * 2 did not know how to respond | | |
| **Comorbidities** | | |
| Systemic Arterial Hypertension | 13 | 50,0 |
| Acute Myocardial Infarction | 1 | 3,8 |
| Stroke | - | |
| Heart Failure | 1 | 3,8 |
| Lower Limb Amputation | - | |
| None | 11 | 42,3 |
| **Complications** | | |
| Chronic Kidney Disease | 1 | 3,8 |
| Ischemic Event | - | |
| Diabetic Retinopathy | 4 | 15,3 |
| Lower Limb Ulcers | - | |
| None | 21 | 80,7 |

The foods with resistant starch (RS) most frequently consumed by the study participants were rice (84%), followed by whole wheat bread (62%) and black beans (54%).

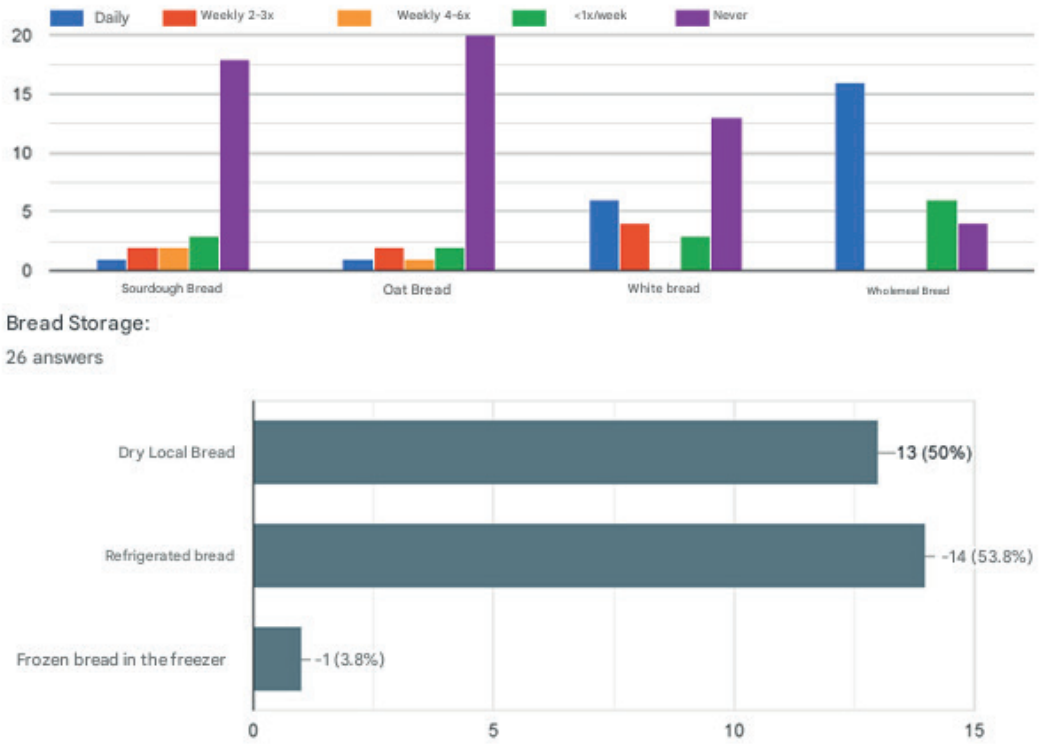
Among these, the cereal group was prominent, with cooked rice showing the highest prevalence of daily intake. Regarding storage methods, refrigeration was the method most used by more than 50% of participants, especially for rice (Figure 1).

**Figure 1 -** Rice consumption and consumption patterns among people with type 2 diabetes.



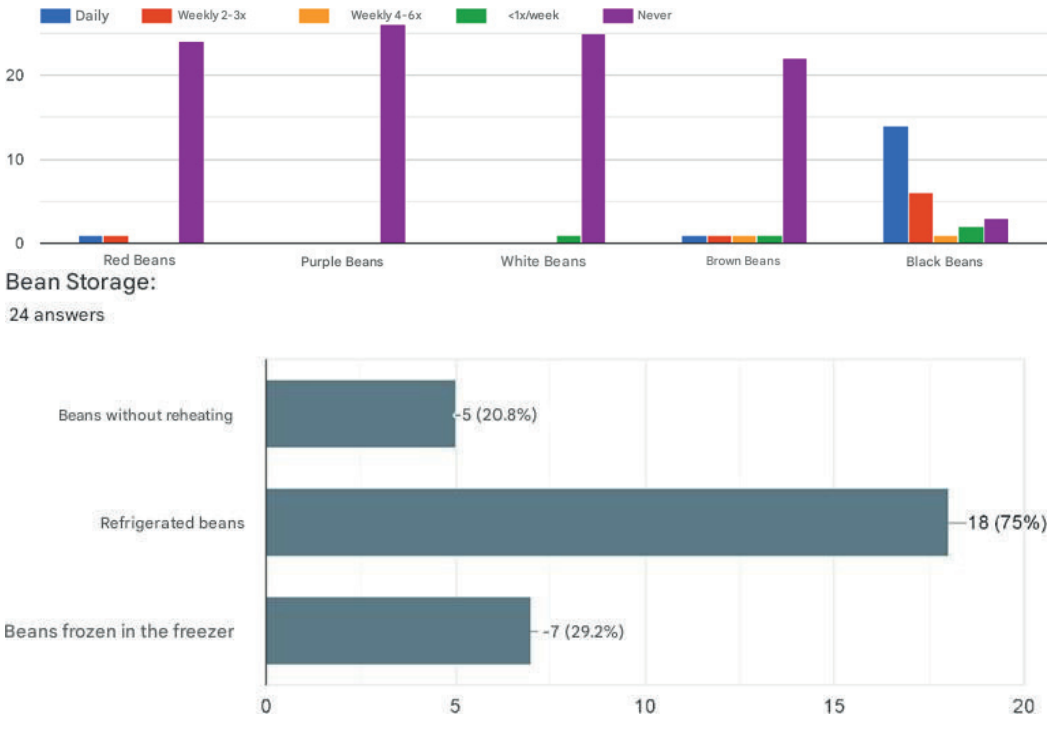

Whole wheat bread was the second most consumed food, with the highest frequency of daily intake among participants. It was observed that most participants prefer to store bread in the refrigerator (Figure 2).

**Figure 2** - Bread consumption and consumption patterns among people with type 2 diabetes.




Finally, among the most commonly consumed foods are vegetables, categorized as RS types 1 and 2. Most respondents with T2DM reported daily consumption of black beans. In addition, the predominant form of bean storage among the majority of participants is refrigerated beans (Figure 3).

**Figure 3** - Consumption and form of consumption of beans by people with type 2 diabetes.



The consumption of other foods with RS that are less preferred by the participants in this study was also observed. Among types 1 and 2 is oat bran, which a small portion of participants reported consuming daily, totaling 19.2% (n=5), followed by boiled peanuts 15.4% (n=4) and cashews and granola with daily consumption rates of 7.7% (n=2). Foods such as green bananas, raw sweet potatoes, oat flour and flakes, as well as pistachios, were consumed sporadically or were not part of the participants' diet. It is noteworthy that 73% (n=19) of individuals prefer to store these foods in dry environments.

In the type 3 RA category, it was observed that boiled potatoes were consumed daily by 15.4% (n=4) of participants. Next, lentils and boiled oats were consumed daily by 7.7% (n=2) of participants, while peas, green beans, and corn accounted for 3.8% (n=1) of daily intake. An interesting point was that no participant reported daily consumption of cooked pasta, although 26.9% (n=7) included it 2- 3 times a week in their diet. In addition, no participant consumed soy. Regarding storage practices, most subjects opted for the refrigerator, with 80.8% (n=21).

## DISCUSSION

When analyzing the data from this study, it was observed that individuals with T2DM in the central region of Rio Grande do Sul are composed of individuals over 60 years of age with low educational levels, among whom the largest portion of this sample has a long history of T2DM ranging from 10 to 20 years. This association of risk factors is a relevant finding. First, it is known that T2DM is an age-related disease. In this sense, Aguayo-Mazzucato *et al.* (2019) showed that cellular senescence, particularly of beta cells, leads to loss of function, which precedes the development and worsening of complications related to the disease. Second, low educational attainment also acts as a risk factor, given that literacy is a protective factor for successful aging, as highlighted by Kolcu *et al.* (2023), indicating that higher literacy is directly related to more effective disease management, as it promotes understanding of information, the development of relevant skills, and a positive attitude toward diabetes mellitus, resulting in greater autonomy and responsibility for older adults with T2DM in decisions related to their health. Finally, the presence of comorbidities such as systemic arterial hypertension identified in our sample constitutes an additional risk factor. Przezak, Bielka, and Pawlik (2022) demonstrate that the pathophysiology of both conditions correlate, indicating that proper management of diabetes and hypertension is crucial, since both conditions are components of metabolic syndrome.

Regarding food consumption, although this study did not measure specific intake in grams, it demonstrated a significant daily intake of foods containing resistant starch, particularly type 3. The preparation (cooking) and storage (refrigeration) methods observed in the participants' routines are essential for the formation of RS through the retrogradation process. Our findings corroborate previous studies that demonstrate the importance of storage in the formation of RS in various foods. For example, the study conducted by Basso *et al.* (2011) clarified the increase in RS in rice, beans,

and pasta after freezing for 60 days, raising their contents from 4.36% to 7.25% (rice), from 2.10% to 4.77% (beans), and from 2.50% to 5.45% (pasta), without altering their acceptability. To reinforce these findings, research by Sonia, Witjaksono, and Ridwan (2015) demonstrated that white rice cooked and cooled for 24 hours at 4 degrees Celsius and then reheated resulted in a higher RS content, as well as significantly reducing the glycemic response compared to control rice. Regarding bread, the study by Sullivan *et al*. (2017) showed that refrigeration accelerates the formation of RS, and Landa-Habana *et al*. (2004) point out that cooking and cooling beans for 30 days also increased the formation of type 3 RS. In this regard, regular intake of RS plays a protective role in health, contributing to the prevention of diet-related diseases such as diabetes mellitus through various mechanisms such as modulation of the intestinal microbiota, reduction of intestinal transit, greater glycemic control, reduction of body weight, and control of lipid metabolism (DRAKE *et al*., 2022; DOBRANOWSKI and STINTZI, 2021; LIU *et al*., 2020).

The main food sources of RS, according to the study results, were rice, black beans, and whole wheat bread. This consumption pattern is found in data from the National Food Surveys, which indicate that these items remained the main components of the Brazilian diet between 2008 and 2018, as reported by Rodrigues *et al*. (2021). Although the intake of RS in the participants' routine is relevant, there are currently no official recommendations on the ideal amount for health, nor is it included in food composition databases or national surveys (LOCKYER and NUGENT, 2017). The literature presents conflicting recommendations, ranging from 6 grams per meal to 20 grams per day. Some researchers indicate that 6 to 12 grams in a single meal can benefit postprandial glucose and insulin levels, while other studies suggest that daily supplementation of 15 to 30 grams may be beneficial (BIRT *et al*., 2013; ASHWAR *et al*., 2016; FUENTES-ZARAGOZA *et al*., 2011; MAZIARZ *et al*., 2017; MIKETINAS *et al*., 2020).

Another important point was the refrigeration used by most study participants as a storage method for foods containing resistant starch. This method induces starch retrogradation. This process leads to an increase in type 3 resistant starch, which may offer health benefits. In support of this observation, research by Strozyk *et al*. (2022) demonstrated that consuming cooked rice that has been refrigerated for 24 hours increases the resistant starch content, leading to lower postprandial blood glucose levels and a reduced time to reach the glycemic peak, without altering the organoleptic properties of the food. To consolidate these findings, after consuming baked and subsequently cooled potatoes, women with high fasting blood glucose and serum insulin levels experienced a decrease in these levels, which had a beneficial impact on their glycemic response (PATTERSON *et al*., 2019). Overall, the five types of resistant starches (RS1, RS2, RS3, RS4, and RS5) have potential hypoglycemic mechanisms, according to a review of the last 15 years by Liu *et al*. (2022).

Another relevant finding in this study is that the specific sample presents a consumption pattern characterized by limited variability and dietary diversity. This is evident in relation to the items

classified as "other foods" in RS types 1, 2, and 3, where the frequency attributed to the category "never" presented the highest rates. This suggests a tendency toward monotony in the food choices of the subjects in this sample, which in turn may reflect restrictive dietary preferences or limited availability of options, in parallel with the income and limited knowledge of the population studied. This consumption pattern may have unsatisfactory implications for nutritional health, given that the Food Guide for the Brazilian Population emphasizes in its recommendations the importance of a varied and balanced diet as one of the fundamental principles, including different types of foods to ensure a broad supply of nutrients necessary for health (MINISTRY OF HEALTH, 2014).

The present study has some limitations inherent to its cross-sectional design, which makes it impossible to infer causality. In addition, the use of convenience sampling and the small sample size restrict the generalization of the findings to a broader population. Another limiting aspect lies in the nature of the food frequency questionnaire, since it does not measure the exact amount of consumption (in grams or servings) and still depends on the individual's memory to report their consumption, making it difficult to directly correlate the consumption of foods with resistant starch and possible clinical outcomes.

Despite the limitations, the results obtained in this study provide an important basis for future research, especially in the field of resistant starch consumption analysis and its effects. The scarcity of previous research on the subject highlights a gap in the literature, reinforcing the relevance of this study as a starting point. These findings can serve as a basis for the creation of food education strategies for populations with T2DM, highlighting the importance of consuming foods that contain resistant starch and methods of preparation that optimize its benefits.

## CONCLUSION

This study sheds new light on the daily consumption of foods that are sources of resistant starch in the diets of the individuals evaluated, with emphasis on rice, whole wheat bread, and black beans. It was also observed that refrigeration was the main form of storage, a condition that favors the formation of type 3 resistant starch. This finding suggests that this dietary pattern may contribute to the habitual incorporation of resistant starch into the diet, representing a possible complementary nutritional strategy in the management of type 2 diabetes mellitus. Furthermore, the low dietary variability identified among participants points to the need for educational strategies that increase dietary diversity and strengthen autonomy in self-care. Despite the limitations inherent in the cross- sectional design and sample size, the results presented provide support for future investigations that further explore the relationship between resistant starch consumption patterns and clinical outcomes in people with diabetes.

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## SUPPLEMENTARY MATERIAL

Flyer with information on the treatment of type 2 diabetes.