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Determination of the Percentage of Reducing and Non-Reducing Sugar in Whole Wheat Grain, Flour and Bran

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Abstract: ***The consumption of carbohydrates significantly influences long-term health outcomes, emphasizing the importance of quality over quantity. The Glycemic Index serves as a useful metric by assessing the rate at which foods elevate blood glucose levels, with pure glucose designated as the baseline score of 100. Reliance on high-GI foods, scoring 70 or above, substantially increases the risk of metabolic conditions such as cardiovascular disease and diabetes. Conversely, incorporating whole, unprocessed foods such as fresh produce and grains introduces natural fibre that moderates the metabolic process. This fibre effectively prevents rapid sugar combustion, thus avoiding energy surges and subsequent drops. By adopting such dietary choices, individuals provide their bodies with more consistent and dependable fuel, supporting sustained energy levels throughout the day. This approach mitigates rapid sugar metabolism, thereby reducing the likelihood of mid-afternoon energy declines and fatigue. Focusing on nutrient-dense foods not only satisfies satiation but also supplies the necessary stable fuel to maintain overall balance and health over time.***

Keywords: ***Carbohydrates, Reducing Sugar, Non-Reducing Sugar, Glycaemic Index (GI)***

Nomenclature:
GI: Glycaemic Index

I. INTRODUCTION

Consider carbohydrates the main fuel source that energises virtually all of our activities, from muscle movement to the constant metabolic processes within our bodies (Brito-Da-Silva et al., 2024) [1]. After consumption, our system determines precisely how this energy should be distributed. A portion is used immediately to sustain our daily functions. At the same time, the remainder is stored in our liver and muscle tissue as a reserve energy source, available for use when we require additional fuel (Chadt & Al-Hasani, 2020) [2]. When there is a considerable excess, the liver can convert this additional energy into fat for storage. Because our appetite is often linked to the amount of glucose our bodies require, the amount of carbohydrates we eat significantly influences our overall energy balance. after digestion, the process converts everything into glucose. Our system either utilises this sugar for immediate energy or stores it in our "muscle reserve" as a standby energy source for future needs (Adeva-Andany et al., 2016). Carbohydrates encompass a wide range of compounds, including sugars, fruits, vegetables, dietary fibre, and legumes. While they can be classified in various ways, only certain forms provide genuine nutritional benefits to humans. Chemically, carbohydrates are organic compounds featuring at least one chiral carbon atom and containing polyhydroxy aldehyde or ketone groups. Their hydrogen-to-oxygen ratio (2:1) resembles that of water, making them among the most abundant biomolecules in living organisms. (Régnier et al., 2023) [4].

The way each small component naturally finds its ideal position during plant growth is remarkable to observe. This process isn't simply chaotic; instead, there is a genuine, systematic pattern governing how all elements move and arrange themselves. Witnessing such self-organised behaviour truly demonstrates the intricate processes within a single tiny seed. (Schulz & Slavin, 2021) [5].

From a structural perspective, researchers commonly study glycans at three distinct levels of organisation: individual sugar units (monosaccharides), short sugar chains (oligosaccharides), and long sugar polymers (polysaccharides). The ability of sugar ring structures to change shape and adopt different configurations plays a vital role in biological processes, especially in essential biomolecules such as DNA and RNA, and in sugar pairs such as sucrose and starch. Researchers have dedicated significant effort to understanding the distribution of various sugars and starches within a developing wheat grain. When analyzing specific varieties such as PBW-343, it becomes evident that these kernels are far more complex than simple seeds. The manner in which each

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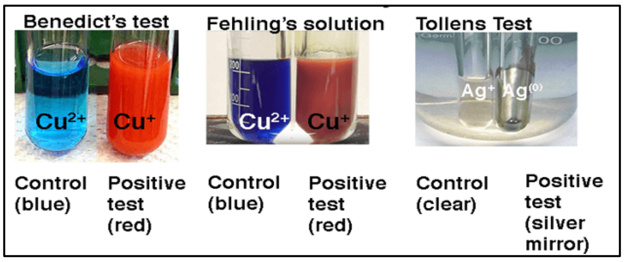
minute component allocates its optimal position during plant development is indeed extraordinary. This process is not merely a random arrangement; rather, it follows a genuine, systematic pattern that directs how all elements migrate and establish themselves. Observing such natural organization exemplifies the complex processes concealed within a single seed. (Xu et al., 2024) [6].This is more than just a chaotic structure; every part follows a specific biological blueprint, building an incredibly complex framework within the grain. It seems as though each kernel has a hidden growth strategy.

Reducing intake of added sugars and refined grains is essential as they provide minimal nutritional value and may contribute to health issues such as obesity and diabetes. When reducing sugar consumption, individuals may experience feelings of depression, restlessness, or irritability during the adjustment period. These sensations are correlated with dopamine levels, as shown in a study by Liu et al. (2023) [7].

II. METHODOLOGY

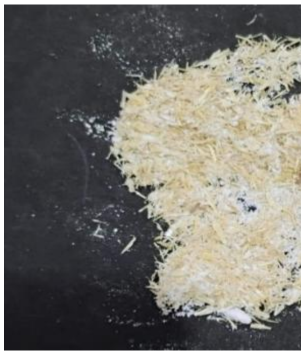
Whole-wheat grains were sought from a retail outlet. These grains were subsequently milled into flour. Sieves were employed to separate the bran from the ground wheat. This process enabled the analysis of sugar content in the different components: the grain, the flour, and the bran. Tests for reducing sugars were conducted using a copper-based assay, observing for a colour change as an indicator of their presence. Recognizing that certain sugars, such as sucrose, do not react in this manner, a small amount of acid was introduced to hydrolyze these non-reducing sugars. The testing procedure was then repeated for the whole-wheat grains, the flour, and the bran. By comparing sugar concentrations before and after acid treatment for each component, the non-reducing sugar content was determined. This methodology was adapted from the approach described by Shahid Qayoom and colleagues in 2021.[8]



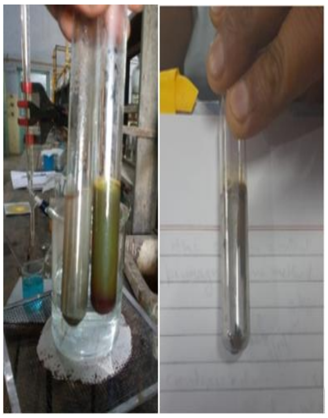
[Fig.1: Colour Test for Reducing Sugar with Different Reagents]

The amounts of reducing and nonreducing sugars in whole grain, flour, and bran were compared. The goal was to understand how the sugar profiles of grain, flour and bran changed the nutritional value of whole grain, flour and bran and affected things that were actually noticed, like how sweet whole grain, flour and bran tasted, the texture of whole grain, flour and bran or how well whole grain, flour and bran browned in the oven. Each test was run three times in the same way to ensure the data was reliable. This helped to maintain consistency and ensured that the findings on grain, flour and bran were reliable, following the process used by Sánchez-Siles and others in 2022 (Sánchez-Siles and others in 2022) [9].

[Fig.2: Sample of Wheat Flour]



[Fig.3: Sample of Wheat Bran]



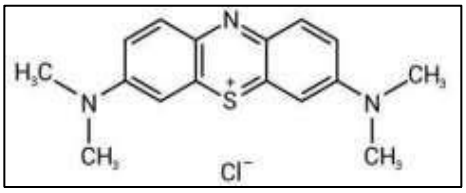
[Fig.3: Test for Reducing and Non-Reducing Sugar]

[Fig.4: Titration to Find out the Percentage of Reducing and Non-Reducing Sugar in Wheat Grain Flour and Bran]

To prepare Fehling's reagent, equal parts of Solution A and Solution B are required. First, 34.639 grams of copper sulphate pentahydrate, a relatively pure substance, was measured and dissolved in distilled water. Water was added gradually until the volume of Solution A reached 500 mL. Next, Solution B was prepared by mixing 173 grams of Rochelle salt with 15 grams of sodium hydroxide. Distilled water was then added to Solution B until it reached 500 mL.

A: Preparation of the indicator

To prepare a 0.1% methylene blue solution, 0.1 g of methylene blue was mixed in a 95% ethanol-5% distilled water solution. This liquid was continued to be added until a total of 100 mL had been obtained



Initially, Carriz Solution I was prepared by combining 21.9 grams of zinc acetate with 3 mL of acetic acid, then adding water to achieve a final volume of 100 mL. Subsequently, Carriz Solution II was prepared by dissolving 10.6 grams of potassium ferrocyanide in water, then precisely measuring a total volume of 100 mL using a volumetric tool. It was now intended to determine the Fehling Factor (0.99) of the methylene blue indicator and the clarifying reagents,

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specifically focusing on the Fehling Factor. To standardize the process, 0.2 g of dextrose was dissolved in distilled water, and the volume was made up to 250 ml. A 5 ml portion was then taken and titrated against a mixture of Fehling A and B, using methylene blue as an indicator. It was known that the endpoint had been reached when a clear, brick-red precipitate had appeared.

Calculation of the Fehling factor-

$$\frac{\text{Titre value* wt of the sample(2g)}}{\text{Volume makeup(250mL)}}$$

For the actual sugar analysis, a 2 g sample was placed in a 250 ml flask, 5 ml each of Carriz 1 and Carriz 2 were added, and the flask was filled to the mark with water. After a quick filtration, the filtrate was used to measure both reducing (Part-1) and non-reducing sugar levels (Part-2).

PART -1

For the reducing sugar test in Part-1, the prepared sample was transferred to a burette. Meanwhile, 5 mL each of Fehling A and Fehling B were mixed in a conical flask and heated in a water bath for about 30 minutes. Methylene blue was used to track the progress, and as soon as that brick-red precipitate had appeared, it was known that the reaction had reached its endpoint.

Calculation for Reducing Sugar

$$= \frac{\text{Fehling factor} * 100 * 250}{\text{Sample wt.} * (2g/5mL) * \text{Titre value}}$$

PART -2

Approximately 5–7 mL of concentrated HCl was added to break down the non-reducing sugars. After the mixture had been left in a water bath for half an hour, the characteristic brick-red precipitate began to form. Once it had cooled, it was topped up to 100 mL with distilled water and neutralised with 50% NaOH. To measure total sugar, 50 mL of the filtrate was poured into a beaker. In a separate flask, a 50 mL mixture of Fehling A and B solutions was heated. Once boiling, a little methylene blue was added, and as soon as the brick-red colour appeared, it was known that the endpoint had been reached.

$$For\ total\ sugar = \frac{Fehling\ factor * 100(II\ volume\ make\ up) * 100 * 250\ (I\ volume\ make\ up)}{50\ (aliqyot\ filterate) * filter\ volume * sample\ weight\ (2g/5mL)}$$

$$\text{Non Reducing Sugar} = \text{Total sugar} - \text{Reducing sugar}$$

A. Observations

Table I: Percentage of Reducing and Non-Reducing Sugar in Whole Wheat Grain, Flour and Bran at 65% Moisture in Whole Wheat Grain as follows:

Source of Carbohydrate	Percentage of Reducing Sugar	Percentage of Non-Reducing Sugar	T-Test Value
whole wheat grain	4.5	6.3	5.24
flour	3.9	5.2	9.47
bran	5.8	9.0	11.34

B. Importance of the t-test

The t-test was used to determine whether the difference between the two group averages was meaningful or a coincidence. A hypothesis that the two groups were the same was initially proposed. The alternative hypothesis said there was a difference between the two groups. To obtain the results, what Mishra, Prabhakar, and the rest of the team said to do in 2019 was followed to calculate our numbers [10]. The t-test is usually broken down into three parts: the one-sample t-test, the independent samples t-test and the paired samples t-test. We did this to make sure our t-test results were correct. The t-test helps us determine whether the difference between two group averages is statistically significant.

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}} \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Since the t-value we calculated was much higher than the table value for four degrees of freedom, the difference between the averages for reducing and non-reducing sugars is significant. This confirms that bran sugar percentages are more affected than flour sugar percentages. The sugar percentages in bran are significantly affected. The difference is mainly due to reducing and non-reducing sugars. Bran and flour react differently to sugar percentages.

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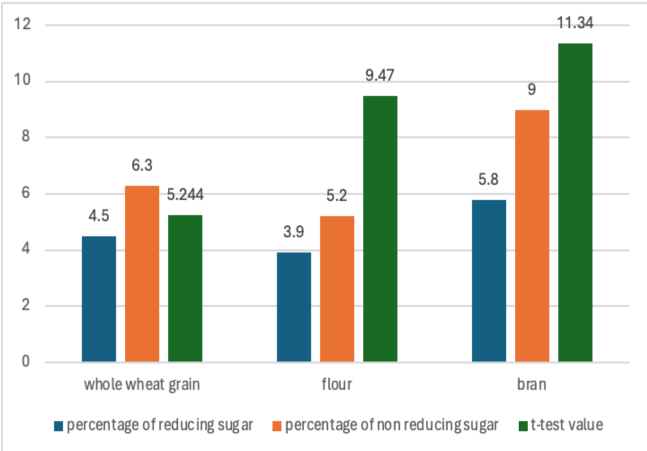

[Fig.5: A Comparative Analysis of Reducing and Non-Reducing Sugars in Whole Wheat Grain, Flour, and Bran, Visualized with a bar Diagram]

III. RESULTS AND DISCUSSION

By measuring sugar levels, it was seen how they varied across the grain. This gave information about the quality of the wheat. It was found that sugars such as glucose, fructose, and maltose added sweetness and energy. They were called reducing sugars. Sucrose was a non-reducing sugar. Reducing sugars affected taste and energy. Non-reducing sugars like sucrose contributed to the structure of wheat. They were important in different parts of the wheat. Whole wheat, flour, and bran had distinct sugar profiles. This affected how they behaved in recipes.

IV. CONCLUSION

Measuring the levels of reducing and non-reducing sugars in wheat, flour and bran is important. It helps to understand the nutritional value of whole wheat, flour, and bran, and how they behave when used. Analysing the sugar content of wheat, flour and bran provides valuable insights into how wheat products affect blood sugar levels. Understanding the sugar content of wheat, flour and bran is essential for improving food processing and making wheat products healthier. Moving forward, we need to research how the sugar content of whole wheat, flour and bran affects taste and long-term health. This information is crucial for providing dietary advice. Investigating reducing and non-reducing sugars in wheat, flour, and bran is vital for improving health, advancing food technology, and addressing public health problems. Measuring the sugar content of wheat, flour, and bran is important for improving nutrition. Our findings show that whole wheat grain contains reducing and non-reducing sugars. On the other hand, wheat flour has more reducing sugars, probably because of the way it is processed. But bran is different; it contains both kinds of sugar. Non-reducing sugars are good for us because they do not make our blood sugar go up and down a lot. This helps prevent spikes in blood sugar. If we know where these sugars are in wheat, we can make better choices about what we eat. This is especially important for people with diabetes or those who want to stay healthy. What we learned confirms that eating grains is a good way to control blood sugar. The best way to be healthy is to eat minimally processed foods. Whole wheat grain is an example of a food that is good for us because it has a lot of non-reducing sugars. Eating wheat grain and other whole grains can really help us stay healthy.

DECLARATION STATEMENT

As the article's author, I must verify the accuracy of the following information after aggregating input from all authors.

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- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

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