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Evaluation of postprandial glycemic response (index) in rats fed different carbohydrate sources

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Abstract

Diabetes mellitus is a metabolic disorder characterized by the presence of chronic hyperglycemia accompanied by greater or lesser impairment in the metabolism of carbohydrates, lipids and proteins, including defects in either insulin secretion or response. The function of pancreatic cells gradually declines before the onset of clinical hyperglycemia. Its prevalence is increasing everywhere, especially in the developing countries due to the consumption of unknown glycemic index (GI) foods. The objective was to determine the glycemic response of tropical fruits and the potential risk for chronic diseases. The present study aimed to determine the glycemic response of some fruits.4 fruits were investigated, water and a 5% Glucose solution: cantaloupe (*Cucumis melo*), Orange (*Citrus sinensis*), Grapes (*Vitis vinifera*) and Dates (*phoenix dactylifera*). In our Methods We had 36 Adult male Rats, weighing (170:180 g) were used in this Research. The 36 rats were divided into 6 groups and 6 rats for each group. Group 1 (control): Received 5% glucose solution, group 2 received water, group 3 received cantaloupe solution, Group 4 received orange solution, group 5 received Grape solution, group 6 received Date solution. In our Results Glucose shows us a rapid spike and Glucose has a high glycemic response because it is rapidly absorbed into the bloodstream, causing a sharp increase in blood sugar levels. This fast spike in blood glucose triggers a quick insulin response, which helps lower blood sugar levels but can also lead to fluctuations in energy and hunger. Pure fruits increase the glucose in blood sugar but not like the pure glucose and the artificial sugar. The results likely showed that glucose caused the highest glycemic response, leading to a rapid spike in blood sugar levels. The fruits, depending on their fiber and sugar composition, would have elicited lower and more gradual glycemic responses compared to pure glucose. The findings emphasize how whole fruits affect blood sugar

differently than pure glucose, likely to support the benefits of natural fiber and nutrient composition in glycemic regulation.

KEYWORDS: Glycemic response, Diabetes, Fruits, Metabolism, Insulin Response.

Introduction: The consumption of various meals lacking understanding their impact on blood glucose levels attitudes a significant burden on the management and inhibition of many metabolic diseases worldwide. Metabolic diseases affect one-third of the global population, with diabetes mellitus being one of the most dominant and life-threatening conditions. Non-communicable diseases (NCDs), such as diabetes, obesity, and cardiovascular disorders, are becoming increasingly common in both developed and developing nations (American Diabetes Association,2004). According to the World Health Organization (WHO, 2011), obesity and diabetes are among the most critical health challenges currently, profoundly affecting individuals and communities. Obesity is strictly linked to an increased risk of developing type 2 diabetes, one of the most common chronic diseases. These conditions have far-reaching effects on health, increasing the risk of heart disease, hypertension, kidney diseases, in addition to psychological and social consequences (Global Status Report on Noncommunicable Diseases 2010).

Since carbohydrates play a crucial role in affecting blood sugar levels, it is important to understand the relationship between carbohydrates and glucose. Sugar is a type of simple carbohydrate, and when used up, the body breaks down carbohydrates into simple sugars such as glucose and fructose, which aid as primary energy sources. The impact of carbohydrates in fruit on blood sugar levels hinge on the type of carbohydrates present. Fruits mainly contain natural sugars such glucose and fructose, along with dietary fiber, which impacts sugar absorption and metabolism (FAO/WHO, 1998).

- Natural Sugars: Fruits provide natural sugars that are progressively absorbed by the body. Although they contain sugar, the fiber in fruits reduce sugar absorption, preventing rapid spikes in blood glucose levels (FAO & WHO, 1998).

- Dietary Fiber: The fiber in fruit plays a key role in modifiable blood sugar levels by slowing down sugar absorption, thereby preserving glucose stability (Jenkins et al., 1981).

- Fruits with Reduced Sugar Levels: Certain fruits, like berries and strawberries, contain minor sugar levels compared to others like bananas and grapes, making their influence on blood

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sugar less significant (Foster-Powell et al., 2002).

• **Fruits with Elevated Sugar Levels** : certain fruits, including bananas and grapes, contain a higher concentration of natural sugars and may lead to a more rapid rise in blood glucose levels (Monro & Shaw, 2008).

Glucose and its Effect on glycemic index (GI)

Glucose is the most basic form of sugar and acts as the body's main energy source. Pure glucose has a GI of 100, as it is rapidly absorbed into the bloodstream, resulting in a swift increase in blood sugar levels (Jenkins et al., 1981). Foods rich in glucose or refined sugars, such as sugary beverages and processed sweets, can cause considerable fluctuations in blood sugar levels, raising the risk of insulin resistance and diabetes over time (WHO, 2011).

To improve the management and prevention of diabetes, the glycemic index (GI) has become a key instrument for assessing the impact of carbohydrate-rich foods on blood sugar levels. The GI concept was initially developed to categorize carbohydrate (CHO) sources according to their postprandial glycemic impact (Jenkins et al., 1981). The GI indicates the speed at which carbohydrates from various foods are digested and absorbed, affecting blood glucose levels.

• **Low-GI Foods**: These carbohydrates digest and absorb gradually, leading to a lower glycemic response (Foster-Powell et al., 2002).

• **High-GI Foods**: These carbohydrates digest and absorb rapidly, causing a higher glycemic response (AACC, 2001).

The glycemic response is described by the American Association of Cereal Chemists (AACC) as the variation in blood glucose levels resulting from the consumption of food (AACC, 2001). The postprandial glycemic response can be utilised to calculate the glycemic impact, GI, and glycemic load (GL) (Monro & Shaw, 2008), which aid in determining whether a food causes a gradual or rapid rise in blood glucose levels.

There is an increasing focus on GI research within both public health and industrial sectors. The Food and Agriculture Organization (FAO) and WHO (1998) advise that most dietary carbohydrates should have a low GI and be rich in non-starch polysaccharides (NSP). Several countries, including Australia, France, Sweden, Canada, and South Africa, have incorporated the GI concept into dietary recommendations. Furthermore, more food companies are developing and promoting low-GI products to encourage healthier eating habits (FAO & WHO, 1998).

• GI can also be applied as a useful dietary tool through glycemic load (GL), which considers both carbohydrate quality (GI) and quantity. The GL is determined by multiplying the glycemic index of a food by the amount of carbohydrates in a typical serving (Foster-Powell et al., 2002). Understanding the relationship between GI and GL is crucial for effective dietary planning.

• Balanced Meal Planning: Pairing foods with low GI and low GL supports stable blood sugar levels (Monro & Shaw, 2008).

• Optimized Meal Timing: Distributing meals across the day with low GI and GL options can assist in weight management, blood sugar regulation, and heart health enhancement (WHO, 2011).

The Effect of Orange, Cantaloupe, Grapes, and Dates on Blood Sugar and GI

Various fruits influence blood sugar levels depending on their glycemic index (GI), fiber amount, and natural sugar makeup.

• Oranges: Oranges are packed with vitamin C, fiber, and antioxidants. Although they contain natural sugars, their high fiber content aids in controlling blood sugar by slowing glucose absorption. With a low GI (~43-52), they are a suitable option for diabetes management (Foster-Powell et al., 2002).

• Cantaloupe: is a refreshing fruit rich in vitamins A and C. While it provides essential nutrients, its glycemic index (GI) is considered moderate (~55-60). It causes a gradual rise in blood sugar levels, reaching its peak after an hour and remaining slightly elevated for an extended period. This makes it a nutritious choice, but mindful consumption is recommended, especially for those keeping track of their blood sugar levels (Monro & Shaw, 2008).

• Dates: Dates are packed with nutrients, offering fiber, antioxidants, and key minerals like potassium and magnesium. Their GI ranges from moderate to high (~42-55, depending on the variety). Despite this, the fiber and natural polyphenols in dates help slow the release of glucose into the bloodstream, making them a healthier choice compared to refined sugar (FAO & WHO, 1998).

• Grapes: Grapes contain fructose and glucose, simple sugars that are quickly absorbed and can cause a spike in blood sugar levels. Fresh grapes have a moderate glycemic index (GI), generally between 97.1 and 160.1, depending on the variety. Dried grapes (raisins) have a higher GI (~133.8 to 119.2) due to their higher sugar concentration (Journal of Nutrition, 2009).

Methods of Research and the tools used

A.Food Samples: Control Solution: 5% glucose solution (reference standard).

Fruits Tested: Cantaloupe (*Cucumis melo*), Orange (*Citrus sinensis*), Grapes (*Vitis vinifera*) and Dates (*Phoenix dactylifera*). Fruits were fresh, blended without water and obtain a uniform liquid form.

B.Animals

36 Adult male rats, weighing (170:180 g) were used in this study. Rats were housed in standard laboratory conditions. They had free access to water and a standard diet except during the fasting period.

C.Design of Experiment

The 36 rats were randomly divided into five groups (n = 6 per group):

Group 1 (Control): Received 5% glucose solution, Group 2: Received water, Group 3: Received cantaloupe solution , Group 4: Received orange solution , Group 5: Received grape solution ,Group 6: Received date solution.

Experimental Procedure

1 .Fasting and Administration: Rats were fasted for 12 hours before the experiment to standardize baseline glucose levels. Each rat received an oral dose of either glucose or fruit solution using a gavage tube.

2 .Blood Glucose Measurement: Blood samples were collected from the tail vein at 0 (baseline), 30-, 60-, and 120-minutes post-administration. Blood glucose levels were measured using a glucometer (Accu-Chek meters).

D. Statistical Analysis

Data obtained from the experiments are expressed as mean ± SE. Differences between the control and the treatments in the experiments were analyzed using ANOVA and Duncan's multiple range test, while values of $P \leq 0.05$ were considered significant.

Results of Research

Measurement of Blood Glucose Response

Blood glucose curves were constructed from blood glucose values of animals at time 0, after30, 60- and 120-minutes intervals after consumption of the glucose (control) and formulated food samples of each group.

(1) Analysis of Results by Time (for both Glucose and Water)

* Pre-control: Both the Glucose and Water groups start with very similar baseline values (99.0 ± 1.7 and 99.2 ± 1.2, respectively). This indicates that the initial measured parameter

is consistent across both groups before any treatment is administered.

*After 30 minutes Glucose: There is a substantial increase to 164.3 ± 1.4., which is expected as glucose is quickly absorbed into the bloodstream.

Water: There is a smaller increase to 119.5 ± 1.4. This increase is still statistically significant, it reflects a change in blood glucose or other factors due to water metabolism.

* After 60 minutes Glucose: The value decreases significantly to 90.8 ± 1.2. This indicates a regulatory response, likely the release of insulin, causing cells to take up glucose from the blood, lowering the level.

Water: The value increases slightly to 103.8 ± 1.7, although the change is not as pronounced as in the glucose group.

*After 120-minute Glucose: The value decreases further to 82.8 ± 1.2. This continues the trend of glucose levels falling, indicating a sustained regulatory response to the initial glucose administration.

*Water: The value rises slightly again to 106.5 ± 1.6. This suggests a possible return towards baseline or a continued mild effect of water.

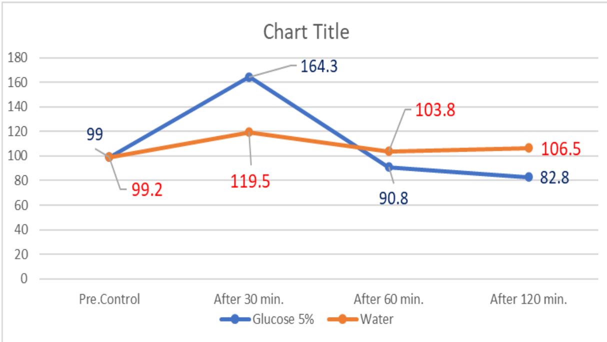
Table (1): Variation of blood glucose concentration (g/dl) of participants after consumption of glucose and water in rat model.

Parameters	Pre. control	After 30 min.	After 60 min.	After 120 min.	p-value
Glucose 5%	$99.0^{a} \pm 1.7$ (6)	$164.3^{b} \pm 1.4$ (6)	$90.8^{c} \pm 1.2$ (6)	$82.8^{d} \pm 1.2$ (6)	0.000
Water	$99.2^{a} \pm 1.2$ (6)	$119.5^{b} \pm 1.4$ (6)	$103.8^{a} \pm 1.7$ (6)	$106.5^{a} \pm 1.6$ (6)	0.000

Values represent the mean ± S.E.M. with number of animals between parentheses.

*: Significance between groups at p value < 0.05

Statistically significant means (P value < 0.05) are given different letters and statistically non-significant means are given the same letter.



(2) Analysis of Results by Time (for both Glucose and cantalupensis (Cucumis melo var))

* Pre-control: Both start with very similar baseline values, indicating consistency before treatment.

* After 30 minutes: Both show an increase, but the glucose level rises much more dramatically, suggesting a rapid absorption and impact on the measured parameter.

Cantalupensis (Cucumis melo var) also shows an increase, but it's considerably smaller.

*After 60 minutes: Here, we see a striking difference. Glucose levels are actively dropping, likely due to insulin response. Canta levels continue to climb, suggesting a different mechanism or slower absorption.

* After 120 minutes, Glucose: 82.8 ± 1.2 (Further decrease),Canta: 117.8 ± 0.8 (Slight decrease, but remains above baseline)

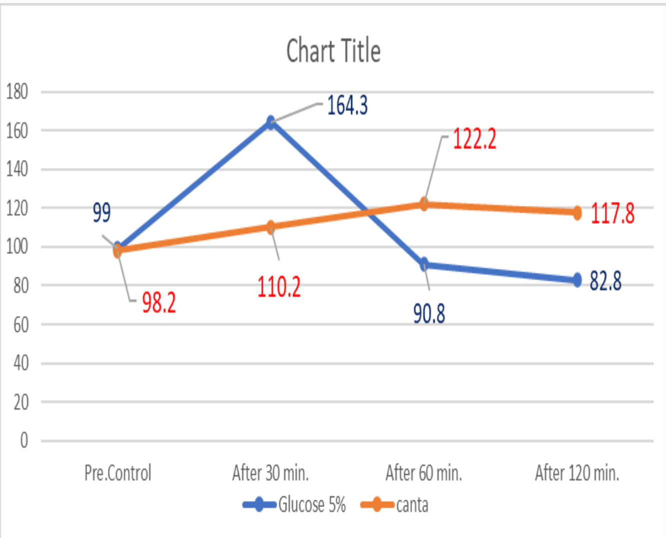
Table (2): Variation of blood glucose concentration (g/dL) of participants after consumption of glucose and Cantalupensis (Cucumis melo var) in rat model.

Parameters	Pre. control	After 30 min.	After 60 min.	After 120 min.	p-value
Glucose 5%	99.0^{a} ±1.7 (6)	164.3^{b}±1.4 (6)	90.8^{c}±1.2 (6)	82.8^{d}±1.2 (6)	0.000
Canta.	98.2^{a} ±1.8 (6)	110.2^{b}±1.6 (6)	122.2^{c}±1.9 (6)	117.8^{c}±0.8 (6)	0.000

Values represent the mean ± S.E.M. with number of animals between parentheses.

*: Significance between groups at p value < 0.05

Statistically significant means (P value < 0.05) are given different letters and statistically non-significant means are given the same letter.



(3) Analyze of Results Over Time (Glucose \ Orange)

*Pre-control (Baseline) :The starting values are very similar, indicating a good baseline.

* After 30 minutes :Both show an increase, but glucose shows a much larger and more rapid increase. This suggests that glucose is absorbed into the system more quickly and has a more immediate impact on the measured parameter.

* After 60 minutes Orange: 106.3 ± 1.8 (Slight decrease, remains above baseline)

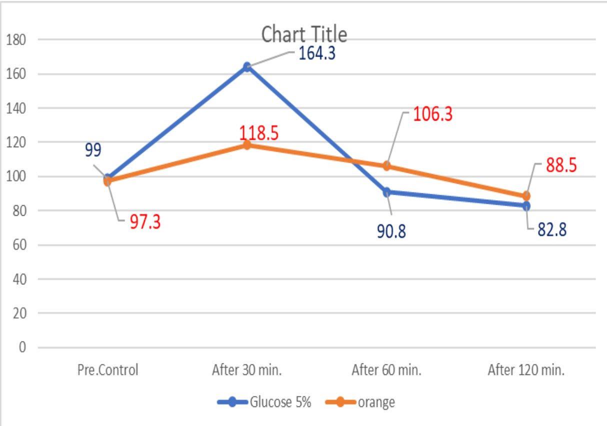
Here, we see a key difference. Glucose levels are dropping significantly, likely due to insulin response. Orange levels also decrease slightly but remain high compared to the baseline.

* After 120 minutes, Glucose levels continue to fall, showing a sustained regulatory response. Orange levels are also decreasing and getting closer to the baseline of glucose.

Table (3) Variation of blood glucose concentration (g/L) of participants after consumption of glucose and orange in rat model.

Parameters	Pre. control	After 30 min.	After 60 min.	After 120 min.	p-value
Glucose 5%	99.0^{a} ±1.7 (6)	164.3^{b}±1.4 (6)	90.8^{c}±1.2 (6)	82.8^{d}±1.2 (6)	0.000
orange	97.3^{a} ±1.3 (6)	118.5^{b}±1.4 (6)	106.3^{c}±1.8 (6)	88.5^{d}±0.8 (6)	0.000

Values represent the mean ± S.E.M. with number of animals between parentheses.
*: Significance between groups at p value < 0.05
Statistically significant means (P value < 0.05) are given different letters and statistically non-significant means are given the same letter.



(4) Analysis of Results Over Time (Glucose and Grapes)

*Pre-control (Baseline): The starting values are very close, its very similar to glucose.

* After 30 minutes :Both show a significant increase, but glucose shows a slightly larger increase. This suggests that glucose might be absorbed slightly faster than the sugars in grapes, or that other components in grapes might be slowing down sugar absorption slightly.

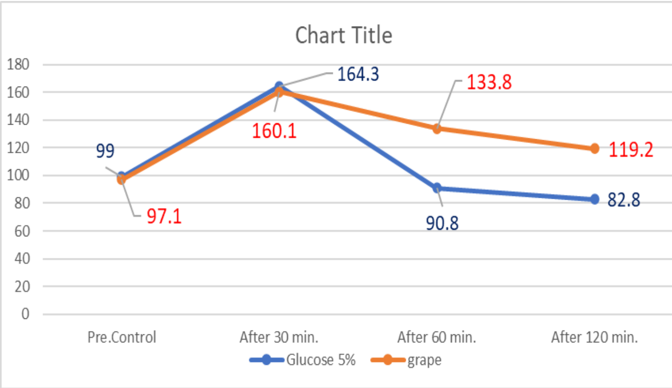
* After 60 minutes :Here, we see a key difference. Glucose levels are dropping significantly, likely due to insulin response. Grape levels also decrease but remain much higher than the baseline and much higher than glucose levels.

* After 120 minutes: Glucose levels continue to fall, showing a sustained regulatory response. Grape levels are also decreasing but are still high compared to the baseline

Table (4): Variation of blood glucose concentration (g/L) of participants after consumption of glucose and grapes in rat model.

Parameters	Pre. control	After 30 min.	After 60 min.	After 120 min.	p-value
Glucose 5%	99.0^{a} ±1.7 (6)	164.3^{b}±1.4 (6)	90.8^{c}±1.2 (6)	82.8^{d}±1.2 (6)	0.000
grape	97.1^{a} ±1.4 (6)	160.1^{b}±1.9 (6)	133.8^{c}±1.7 (6)	119.2^{d}±1.8 (6)	0.000

Values represent the mean ± S.E.M. with number of animals between parentheses.
*: Significance between groups at p value < 0.05
Statistically significant means (P value < 0.05) are given different letters and statistically non-significant means are given the same letter.



<u>(5) analyze the differences between the effects of glucose and date.</u>

*Pre-control: as starting value they similar value but glucose show more significant.

* After 30 minutes: The glucose increase to 164.3 ± 1.4. This indicates a rapid and significant rise parameter compare between date , date increase but not same glucose.

*After 60 minutes: The value drops significantly to 90.8 ± 1.2. This suggests a regulatory response, likely the release of insulin to counteract the initial spike in glucose , but date increase by high way .

* After 120 minutes: The value is 82.8 ± 1.2, slightly lower than the 60-minute mark. This indicates a continued trend toward baseline levels, date show high value of glucose this clear this type of date low absorption in our body.

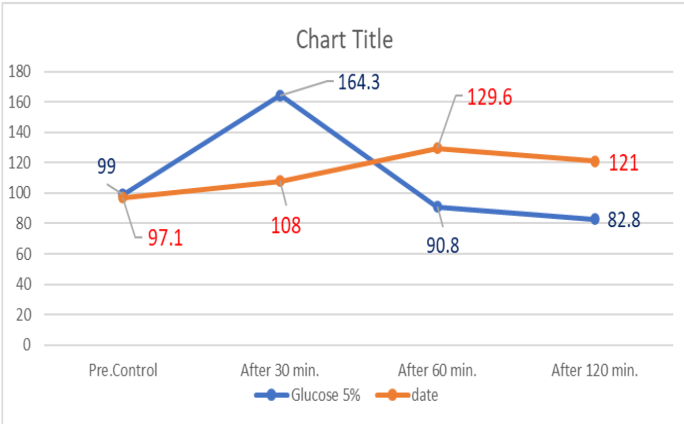
Table (5): Variation of blood glucose concentration (g/L) of participants after consumption of glucose and date in rat model.

Parameters	Pre. control	After 30 min.	After 60 min.	After 120 min.	p-value
Glucose 5%	99.0^{a} ±1.7 (6)	164.3^{b}±1.4 (6)	90.8^{c}±1.2 (6)	82.8^{d}±1.2 (6)	0.000
date	97.1^{a} ±1.9 (6)	108.0^{b}±1.3 (6)	129.6^{c}±2.0 (6)	121.0^{d}±1.5 (6)	0.000

Values represent the mean ± S.E.M. with number of animals between parentheses.

*: Significance between groups at p value < 0.05

Statistically significant means (P value < 0.05) are given different letters and statistically non-significant means are given the same letter



* Overall: Glucose shows a rapid spike and subsequent drop, indicative of a quick surge in energy followed by a regulatory response to restore balance.

* the pure fruit increase the glucose in blood sugar but not like the pure glucose and artificial sugar.

Discussion

Discussion: The nutrition transition is marked by a rise in the intake of high-fat, energy-dense, and processed foods high in sugar, animal-based food products, and decrease in The consumption of foods from plant sources, including fruits, vegetables, and whole grains (WHO, 2000; Popkin, 2001; Popkin 2006, 2009; Astrup et al. 2008).Indication has shown that nutritional transition is negatively accompanying with health status, and it has been involved as the major factors responsible for the increases in occurrence of diet-related diseases, such as obesity, diabetes and cardiovascular diseases worldwide (WHO/FAO, 2002; Popkin 2004, 2006, 2009; Astrup et al. 2008). Epidemiological study established that rise in refined sugar intakes, which is characterized with high glycemic index, has switched traditional plant-based foods (Brand-Miller, 2004). Refined sugar intakes have been implicated in the etiology of many chronic diseases like diabetes and cardiovascular diseases (Brand-Miller, 2004; Ludwig 2000; Jenkins et al., 2006; Ma et al., 2006).

Its purpose is an attempt to characterize foods according to their postprandial glycemic response instead of their chemical composition (Jenkins et al., 1981.).

Our conduct experiment was conducted to estimate blood glucose responses under controlled conditions. Blood glucose levels were measured at specific time intervals (0, 30, 60, and 120 minutes) following the consumption of glucose (control) and various formulated food samples: cantaloupe (*Cucumis melo*), Orange (*Citrus sinensis*), Grapes (*Vitis vinifera*) and Dates (*phoenix dactylifera*) in the rat model. The study compared the influences of pure glucose with natural sugar sources, including fruit-based alternatives, to evaluate differences in glucose absorption and metabolic regulation. The conclusions viewed that the glucose group presented a rapid spike in blood sugar levels within the first 30 minutes, followed by a sharp drop due to insulin regulation. In contrast, fruit-based sugars such as grapes appeared a more gradual increase, with glucose levels remaining higher for a longer period before gently decreasing. Dates, in particular, showed a moderate increase and a delayed peak, representing a slower absorption rate. But oranges and cantaloupe were revealed through the analysis that a low glycemic response.

Wolever et al. (2003) discovered that glucose level reached peaks greater than 200 mg/dL within first 45 minutes after intake of the glucose solution, showing an increase of more than 100% in relation to their fasting blood glucose level.

This suggests that natural fruit sources, those particularly with slower glycemic responses, It may be better suited for those who require stable blood sugar regulation , as they prevent sharp variations , Enhance glucose tolerance in both healthy individuals and those with diabetes, offering a more prolonged energy release compared to pure glucose (Jenkins et al., 1988).

Foods that are categorized as low GI trigger a more favorable response to postprandial glucose, leading to a modest rise in circulating insulin and gastrointestinal hormones; as a result, satiety is enhanced, and voluntary food consumption is lowered (Bornet et al., 2007; Jenkins et al., 2002). Conversely, elevated insulin secretion induced by high GI foods results in postprandial hyperinsulinemia, which, in turn, promotes both increased hunger and voluntary food intake (Aller et al., 2011).

postprandial glucose peaks play a role in the onset of chronic diseases, especially atherosclerosis, and are considered an independent risk factor for cardiovascular disease. Even within the normal range, blood glucose spikes after meals may directly elevate increase oxidative stress and trigger an inflammatory response (Brand–Miller et al., 2009a).

This means high GI foods rapidly digest and increase the blood glucose level, while low–GI foods undergo slower but gradual release of glucose into the blood stream. The fundamental health benefits of low glycemic index and glycemic load foods is that, these foods produce a lesser increase in the plasma glucose concentration as a result of slower rates of gastric emptying and digestion of carbohydrate in the intestinal lumen and subsequently, a slower rate of absorption of glucose into the portal and systemic circulation (Jenkins et al., 1981; Wolever et al., 1991).

Scientific research has shown that the glycemic index of a food in humans is affected by various factors, such as the rate of digestion, gastric emptying, and absorption (FAO/WHO report, 1997; Liljeberg and Bjorck, 1998; Jenkins et al., 2002), the type of starch or carbohydrate granules, and the method of food processing (John and Vladimir, 2004).

Brand–Miller et al. (2014) discovered that other factors, such as acidity, can influence glycemic responses by delaying gastric emptying, which slows down digestion and subsequently reduces the glycemic response. It is therefore plausible that the acidity found in many of the fruits examined played a role in the results of the current study (Brand–Miller et al., 2003; Novotni et al., 2011; Brand–Miller et al., 2014)

conclusion:

Based on the data mentioned above, we can infer that the composition of different foods like fruits had a different response in our body such as glycemic response, glucose and insulin levels in plasma. Therefore, its essential to have a thorough understanding of the ingredients of different foods and their studies in terms of their effect on blood sugar and its glycemic index and curve. All this helps to maintain the general health of people and stay away from chronic diseases related to diabetes, insulin resistance and other diseases.

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Reference

1. Aller, E. E., Abete, I., Astrup, A., Martinez, J. A., & Van Baak, M. A. (2011). Starches, sugars and obesity. Nutrients, 3(3), 341–369.

2. American Association of Cereal Chemists. (2001). "The definition of dietary fiber." Cereal Foods World, 46(3), 112–126.

3. American Diabetes Association.Diagnosis and classification of diabetes mellitus . Diabetes care,2004,27(1):s(5)_s(10).

4. Astrup, A., Dyerberg, J., Selleck, M., & Stender, S. (2008). Nutrition transition and its relationship to the development of obesity and related chronic diseases. Obesity Reviews, 9(S1), 48–52.

5. Brand–Miller, J. C. (2004). Postprandial glycemia, glycemic index, and the prevention of type 2 diabetes. Nutrition Reviews, 62(s1), S32–S39.

6. Brand–Miller, J. C., Atkinson, F., Petocz, P., & Stockmann, K. (2014). Glycemic index, glycemic load and chronic disease risk–a meta–analysis of observational studies. British Journal of Nutrition, 112(3), 457–471.

7. Brand–Miller, J. C., Stockmann, K., Atkinson, F., Petocz, P., & Denyer, G. (2009a). Glycemic index, postprandial glycemia, and cardiovascular disease. The American Journal of Clinical Nutrition, 89(1), 257S–261S.

8. Bornet, F. R., Jardy–Gennetier, A. E., Jacquet, N., & Stowell, J. (2007). Glycaemic response to foods: impact on satiety and long–term weight regulation. Appetite, 49(3), 535–553.

9. Centers for Disease Control and Prevention (CDC). (n.d.). How Fiber Helps Control Blood Sugar.

10. FAO/WHO. (1998). Carbohydrates in Human Nutrition: Report of a Joint FAO/WHO Expert Consultation. FAO Food and Nutrition Paper 66.

11. Foster–Powell, K., Holt, S. H. A., & Brand–Miller, J. C. (2002). "International table of glycemic index and glycemic load values: 2002." The American Journal of Clinical Nutrition, 76(1), 5–56.

12. Food and Agriculture Organization (FAO) and World Health Organization (WHO), 1998.

13. Jenkins, D. J. A., Wolever, T. M. S., Taylor, R. H., Barker, H., Fielden, H., Baldwin, J. M., Bowling, A. C., Newman, H. C., Jenkins, A. L., & Goff, D. V. (1981). "Glycemic index of foods: a physiological basis for carbohydrate exchange." The American Journal of Clinical Nutrition, 34(3), 362–366.

14. Jenkins, D. J., Kendall, C. W., Augustin, L. S., Franceschi, S., Hamidi, M., Marchie, A., ... & Axelsen, M. (2002). Glycemic index: overview of implications in health and disease. The American Journal of Clinical Nutrition, 76(1), 266S–273S.

15. John, E. & Vladimir, V. (2004). Influence of food processing on glycemic response. Journal of Food Science, 69(3), 123–130.

16. Ludwig, D. S. (2000). Dietary glycemic index and obesity. The Journal of Nutrition, 130(2S Suppl), 280S–283S.

17. Liljeberg, H. G., & Björck, I. M. (1998). Delayed gastric emptying rate may explain improved glycaemia in healthy subjects to a starchy meal with added vinegar. European Journal of Clinical Nutrition, 52(5), 368–371.

18. Ma, X. Y., Liu, J. P., & Song, Z. Y. (2006). Glycemic load, glycemic index and risk of cardiovascular diseases: meta-analyses of prospective studies. Atherosclerosis, 191(1), 46–52.

19. Monro, J. A., & Shaw, M. (2008). "Glycemic impact, glycemic glucose equivalents, glycemic index, and glycemic load: definitions, distinctions, and implications." The American Journal of Clinical Nutrition, 87(1), 237S–243S.

20. Popkin, B. M. (2001). The nutrition transition and obesity in the developing world. Journal of Nutrition, 13(3), 871S–873S.

21. Popkin, B. M. (2004). The nutrition transition: worldwide obesity dynamics and their determinants. International Journal of Obesity, 28(S3), S2–S9.

22. Popkin, B. M. (2006). Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. The American Journal of Clinical Nutrition, 84(2), 289–298.

23. Popkin, B. M. (2009). Global changes in diet and activity patterns as drivers of the nutrition transition. Nestle Nutrition Workshop Series. Pediatric Program, 63, 1–10.

24. WHO (2000). World Health Organization. Obesity: preventing and managing the global epidemic. WHO Technical Report Series, No. 894.

25. WHO/FAO (2002). Diet, nutrition and the prevention of chronic diseases. Report of a

Joint WHO/FAO Expert Consultation. **WHO Technical Report Series No**. **916**.

26. **World Health Organization**. (**2011**). **Global Status Report on Noncommunicable Diseases 2010**. **WHO Press**.