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# STUDY OF FRUCTOSE-GLUCOSE RATIO IN DIFFERENT SAMPLES OF HONEY AVAILABLE IN SATARA REGION

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## ABSTRACT

The main objective of this project work was to determine fructose-glucose ratio in different honey samples. In this project, we tested 7 different samples of honey available in Satara region for its fructose-glucose ratio. The determination of fructose and glucose ratio ultimately gives the % by weight of glucose and fructose. As we know that sugar is unhealthy in excess to diabetes patients and hence comparison between regular sugars and honey must be done so that we can give a better alternative to regular sugar in a healthy way. Honey fructose and purified fructose plays different roles in our body in a very different way. By studying the percent reducing sugars in honey we are trying to conclude that how honey can be a good and healthy sweetener as that of other sweeteners which are causing hazardous effects on our body and health.

**KEYWORDS:** Honey, Fructose, Glucose, Fructose-Glucose ratio, Reducing sugars, and Honey Fructose.

## INTRODUCTION

### What Is Honey?

Honey is naturally occurring sweet fluid produced by the honeybees by enzymatic transformation of floral nectar ingested by them and deposited in the cells of hives or combs.

The Indian species of honeybees belongs to the genus *Apis* of which the common ones are *A. florea* (Family-Apidae). In commerce, Honey may be collected from naturally occurring hives in grooves and forests, by pressing and squeezing in the traditional method or may be centrifugation of the combs containing honey in artificially maintained apiaries. Both should be filtered before storage or use.[1]

**Synonyms**

Puspasava, Pusparasa, Ksaudra, Madhvika, Madhu.[1]

**Description**

A thick, syrupy, translucent, yellow to yellowish brown fluid; tastes sweet with a pleasant odour and flavor. When poured on to a tray as a thin layer, no impurities like mould, dirt, beeswax, insect fragments, plant debris or any other objectionable foreign matter should be visible to the naked eye in daylight.[1]

Honey has been ‘nature’s sweetener’ for centuries and is frequently marketed as ‘superior’ to sugar. Honey has been a traditional sweetener for thousands of years long before we discovered how to extract and refine sugar from sugar cane or sugar beet.

Today we consume over 40 times more sugar than honey yet it remains a favourite flavouring in foods like honey cakes, sauces, breakfast cereals, honey-coated nuts, yoghurts etc.

Sugar is 100 per cent sucrose, while honey is made up of around 75 per cent sugars, of which roughly half is glucose and half is fructose (these proportions may vary depending on the source of the nectar). The remaining 20 to 25 per cent is water with a trace of protein, a trace of fat and a trace of fibre, small amounts of plant acids, waxes, gums, pigments and volatile oils which have antioxidant and antibacterial properties. Honey also contains vitamin B and minerals but in very less quantity and not nutritionally significant.[4]

**Purpose of the Study**

The main purpose of this study to determine fructose-glucose ratio in honey of different brands available in satara region.

This will ultimately lead to the information about the honey, fructose-glucose ratio, advantages of honey over regular sugar and how to maintain a good and healthy diet.

**Research Questions**

During this study, many questions came in our way to find out importance of this study like,

- Is honey healthier than sugar?
- What are the honey health benefits?
- What is fructose- glucose ratio?
- Why it is so important?
- What is the role of fructose and glucose in our body?
- How fructose-glucose affects our health?

**Is Honey Healthier Than Sugar?**

Honey once described as 'nectar of the gods' and is often considered a 'natural', healthier sweetener than sugar but nutritionally its true advantages are minor.

As we said before sugar is 100 per cent sucrose, honey is made up of around 75 per cent sugars, of which roughly half is glucose and half is fructose. The remaining 20 to 25 per cent is water with a trace of protein, a trace of fat and a trace of fibre, which explains why honey has fewer 'sugars' or kilojoules/calories than sugar when you compare them weight for weight.

Comparison of sugar vs. honey:-

100g white sugar :- 1700kJ/406Cals.

100g of honey :- 1400kJ/334Cals.

But in day-to-day life most of us we eat honey a teaspoon or a tablespoon not by its weight. And hence as the honey is denser than sugar 1 tablespoon of honey weighs 28g, whereas a tablespoon of sugar weighs only 16g. So, if you are taking one tablespoon of honey instead of sugar you are consuming more calories than regular sugar.[4]

**What Are the Honey Health Benefits?[2]**

- Useful in weight management
- Strengthens immune system
- Nourishes your skin and face
- Boosts your memory
- Home remedy for cough
- Natural home remedy for Dandruff

- Used for healing wounds
- Acts as natural sleeping aid
- Eases sinus issues
- Help with gum diseases
- Natural energy drink
- Prevents and helps control Eczema and many more.

**What Is Fructose-Glucose Ratio?**

Usually sugar contains Fructose and glucose in linked chain system, which has approximately half fructose and half glucose.

Glucose is simple sugar which is main energy source for body cells.

Fructose is a type of simple sugar that makes up 50% of table sugar (sucrose).

However, fructose needs to be converted into glucose by the liver before it can be used by the body. And hence limited quantity of fructose should be consumed to avoid its harmful effects.

Fructose-Glucose ratio gives the values of fructose and glucose so that we can determine its quantity and could take diet in appropriate measured quantities or could limit the diet in a healthy way.

**Why Fructose-Glucose Ratio Is Important?**

Basically fructose-glucose ratio calculated from fructose and glucose values present in the sample.

Fructose and glucose both are the simple sugars which provide quick energy and can be easily utilized by body cells for energy production.

Both sugars are good for health only in a safe and limited quantity but become very harmful when consumed in higher quantity.

As we have seen that glucose directly get absorbed in blood and raises the blood sugar level very quickly whereas fructose for absorption need to be metabolized by liver for absorption.

As the fructose is twice sweeter than glucose most of the sugary sweeteners and added sugars in soft drinks, desserts and in bakery sweet food products contains high fructose in it. Before the mass production of refined sugar, humans rarely consumed it in high amounts. While some sweet fruits and vegetables contain fructose, they provide relatively low amounts.

High glucose consumption is unhealthy and leads to the type 2 diabetes and heart diseases. While excessive fructose is undoubtedly unhealthy, its health effects are controversial.

And hence glucose and fructose levels must be within the safe range so the determination of fructose and glucose levels becomes very important when it came to the health.[3]

**What Is The Role Of Fructose And Glucose In Our Body?**

Where high fructose level leads to the various harmful diseases such as ……

Mal-absorption: - Some people do not absorb all the fructose they eat. This condition is known as fructose mal-absorption, which is characterized by excessive gas and digestive discomfort. All carbohydrates, even rapidly digestible sucrose, cause abdominal discomfort when consumed to excess. Some individuals may exceed their capacity for fructose absorption if large amounts are eaten. Under such circumstances, fructose may be associated with abdominal complaints, such as bloating and flatulence. In those with fructose mal-absorption, fructose acts as a fermentable carbohydrate and is categorized as a FODMAP.[3]

Appetite:-Fructose does not suppress appetite in the same way as other sugars, fructose does not cause rapid surges and dips in blood glucose levels, which is one factor thought to stimulate eating.[3]

And hence the determination of both fructose and glucose becomes very necessary.

Unlike glucose, fructose causes a low rise in blood sugar levels. Therefore, some health professionals recommend fructose as a “safe” sweetener for people with type 2 diabetes.

However, others are worried that excessive fructose intake may contribute to several metabolic disorders as follows.[3]

- Glucose and fructose are metabolized very differently by the body.
- While every cell in the body can use glucose, the liver is the only organ that can metabolize fructose in significant amounts.

- When people eat a diet that is high in calories and high in fructose, the liver gets overloaded and starts turning the fructose into fat.
- Impair the composition of your blood lipids. Fructose may raise the levels of VLDL cholesterol, leading to fat accumulation around the organs and potentially heart disease.
- Increase blood levels of uric acid, leading to gout and high blood pressure.
- Cause deposition of fat in the liver, potentially leading to non-alcoholic fatty liver disease.
- Cause insulin resistance, which can lead to obesity and type II diabetes.
- Fructose doesn't suppress appetite as much as glucose does. Thus, it might promote overeating.
- Excess fructose consumption may cause leptin resistance, disturbing body fat regulation and contributing to obesity.

**Note: -** It's important to realize that all of this does not apply to whole fruit.

Fruits aren't just watery bags of fructose; they are real foods with a low-calorie density and lots of fiber. They're hard to overeat on and you would have to eat very large amounts to reach harmful levels of fructose. In general, fruit is a minor source of fructose in the diet compared to added sugars.

The harmful effects of fructose apply to a Western diet supplying excess calories and added sugars. It does not apply to the natural sugars found in fruits and vegetables.[3]

**How Fructose And Glucose Affects Our Health?**

Many soft drinks, desserts, beverages, high fructose corn syrup and bakery food products use high amounts of fructose in it.[20]

Some have suggested that a rise in the use of HFCS in the United States (US) over the past 30 years could explain the rise in obesity and type II diabetes, and that this is due to increased fructose consumption.[5,20]

A recent study claimed that High-Fructose Corn Syrup (HFCS) causes obesity while sucrose does not, this study was thoroughly unconvincing. Over 8 weeks, rats with 24-hour access to control chow, sucrose, or HFCS had no difference in body weight. Rats with 12-hour access to HFCS had increased body weight, and rats with 12-hour access to sucrose did not. They didn't restrict any of the control rats to 12-hour access.

Their main finding was that over seven months, female rats with 24-hour access to HFCS had increased abdominal and uteral fat and increased blood levels of triglycerides, but rats with 12-hour access to sucrose or HFCS did not.

Speaking of honey, however, research suggests that the fructose in honey doesn't behave anything like the fructose in refined sweeteners. Isn't that a sweet surprise!

Researchers fed weanling rats for two weeks on diets that were 65% (by weight of dry matter) starch, honey, or purified glucose and fructose purchased from Sigma. They provided glucose and fructose at the same ratio at which they occur in honey.[5]

And the findings were surprising such as[5] ….

- Purified fructose increased triglyceride levels, as expected. Honey seemed to increase triglyceride levels, but the increase was not statistically significant.
- Purified fructose, but not honey fructose, decreased blood levels of vitamin E. This suggests that it promoted oxidative stress.
- Purified fructose, but not honey, seemed to promote inflammation. Nitric oxide is very important to blood vessel function in small amounts, but large increases are usually a sign that immune cells have been activated to create an inflammatory state. Honey fructose just doesn't seem to promote inflammation the way purified fructose does.
- After all this they took some heart tissue and mixed it with iron sulfate and vitamin C. The combination of high doses of iron and vitamin C can create oxidative stress. This test shows how susceptible the heart tissue would be to suffering damage in the face of oxidative stress. Once again, purified fructose poses harm while honey fructose does not.[5]

## MATERIALS AND METHOD

### Methodology for Study of Fructose-Glucose Ratio in Different Honey Samples

### Determination of Total Reducing Sugars

### Total Reducing Sugars[1]

### Reagent

**Soxhlet modification of Fehling's solution –** Prepare by mixing equal volumes of solution A and solution B immediately before using.

**Copper Sulphate solution (Solution A) –** Dissolve 34.639 g of copper sulphate crystals in water, dilute to 500 ml and filter through glass wool or filter paper.

**Standardization of copper sulphate solution –** Using separate pipettes, pipette accurately 5 ml of Solution A and 5 ml of solution B into a conical flask of 250 ml capacity. Heat this mixture to boiling on an asbestos gauze and add standard inverted sugar solution from a burette, about one milliliter less than expected volume which will reduce the fehling solution completely 48 ml. Add one ml of methylene blue indicator while keeping the solution boiling. Complete the titration within 3 minutes, the end point being indicated by change of color from blue to red. From the volume of invert sugar solution used, calculate the strength(S) of the copper sulphate solution by multiplying the titre value by 0.001 (mg/ml of standard invert sugar solution). This would give the quantity of invert sugar required to reduce copper in 5ml copper sulphate solution.

**Potassium sodium tartrate (Rochelle Salt) solution (solution B) -** Dissolve 173g of potassium sodium tartrate and 50 g of sodium hydroxide in water, dilute to 500 ml. let the solution stand for a day and filter.

**Hydrochloric acid: –** specific gravity 1.18 at 20’C (approximately 12 N).

**Standard invert sugar solution**

1. Weigh accurately 0.95 g sucrose and dissolve it in 500 ml water.
2. Add 2 ml of concentrated hydrochloric acid. Boil gently for 30 minutes and keep aside for 24 hours.
3. Neutralize with sodium bicarbonate and make the final volume to 1000 ml; 50 ml of this solution contains 0.05 g invert sugar.

**Methylene blue indicator: –** 0.02% in water.

**Procedure**[1]

1. Place accurately weighed about 1 gram (W) of prepared sample of honey into a 250 ml volumetric flask and dilute with about 150 ml of water.
2. Mix thoroughly the contents of the flask and make up volume to 250 ml with water.
3. Using separate pipettes, take accurately 5 ml of solution A and solution B, in a porcelain dish.

4. Add about 12 ml of honey solution from a burette and heat to boiling over an asbestos gauze.
5. Add 1 ml methylene blue indicator and while keeping the solution boiling complete the titration, within 3 minutes.
6. The end point being indicated by change of color from blue to red.
7. Note the volume (H) in ml of honey solution required for the titration.[1]

**Calculations**

A. Total reducing sugar % by mass = $\frac{250 \times 100 \times S}{H \times M}$

Where,

S = strength of copper sulphate solution,

H = volume in ml of honey solution required for titration, and

M= mass in gm of honey.

**Fructose-Glucose Ratio[1]**

**Reagents**

**Iodine solution: –** 0.05 N.

**Sodium hydroxide solution: –** 0.1 N.

**Sulphuric acid: –** concentrated.

**Standard sodium thiosulphate solution: –** 0.05 N.

**Procedure[1]**

1. Pipette 50 ml of honey solution in a 250ml stoppered flask.
2. Add 40 ml of iodine solution and 25ml of sulphuric acid.
3. Stopper the flask and keep in dark for 20 minutes.
4. Acidify with 5ml of sulphuric acid and titrate quickly the excess of iodine against standard sodium thiosulphate solution.
5. Conduct a blank using 50ml of water instead of honey solution.[1]

**Calculations**

A. Approximate glucose,

% by mass (w) = $\frac{(B-S) \times 0.004502 \times 100}{a}$

Where,

B = volume of sodium thiosulphate solution required for the blank,

S = volume of sodium thiosulphate solution required for the sample, and

a = mass of honey taken for test.

B. Approximate fructose,

$$\% \text{ by mass (x)} = \frac{\text{Approximately total reducing sugars, \% - w}}{0.925}$$

C. True glucose, % by mass(y) = $w - 0.012\ x$

D. True fructose %

$$\text{By mass (z)} = \frac{\text{Approximate reducing sugars, \% - y}}{0.925}$$

E. True reducing sugars, % by mass = $y + z$

F. Fructose – Glucose Ratio = $\frac{\text{True Fructose, \% by mass (z)}}{\text{True Glucose, \% by mass (y)}}$

**OBSERVATIONS AND READINGS**

**Readings for Total Reducing Sugars**

| Sr. No. | Sample code | Readings (ml) | | | Mean (ml) |
|---|---|---|---|---|---|
| 1 | A | 15 | 14.7 | 15 | 15 |
| 2 | B | 17.7 | 17.7 | 17.8 | 17.7 |
| 3 | C | 16.2 | 16 | 16.2 | 16.2 |
| 4 | D | 16.6 | 16.8 | 16.7 | 16.7 |
| 5 | E | 17 | 17 | 17.1 | 17.0 |
| 6 | F | 16.7 | 17.1 | 16.9 | 16.9 |
| 7 | G | 16.7 | 16.7 | 16.7 | 16.7 |

From the formula given for determination of total reducing sugars calculated are as follows:

- Strength of Copper Sulphate was found to be = 0.055 mg/ml.
- Calculation Results for Total Reducing Sugar in different samples is as follows: -

1. Total Reducing Sugar % by Mass of sample A = 91.66
2. Total Reducing Sugar % by Mass of sample B = 77.68
3. Total Reducing Sugar % by Mass of sample C = 84.87
4. Total Reducing Sugar % by Mass of sample D = 82.33
5. Total Reducing Sugar % by Mass of sample E = 80.88

6. Total Reducing Sugar % by Mass of sample F = 81.36
7. Total Reducing Sugar % by Mass of sample G = 82.33

**Readings for Fructose-Glucose Ratio**

| Sr. No. | Sample code | Readings (ml) | | | Mean (ml) |
|---|---|---|---|---|---|
| 1 | A | 93.9 | 94.5 | 94.2 | 94.2 |
| 2 | B | 112.3 | 112 | 112 | 112 |
| 3 | C | 97 | 96.5 | 97 | 97 |
| 4 | D | 96.5 | 97.1 | 96.8 | 96.8 |
| 5 | E | 100 | 100.5 | 100.5 | 100.5 |
| 6 | F | 97 | 97 | 97 | 97 |
| 7 | G | 98.2 | 98.2 | 98.3 | 98.2 |

- Sodium Thiosulphate require for Blank was (B) = 120ml.

By above given formulas % Glucose, % Fructose, True Glucose, True Fructose and Fructose-Glucose ration is calculated and mentioned in results.

## RESULTS AND DISCUSSION

Here in this project I perform the experimental work by process given above and it is the standard procedure for determination of fructose- glucose ratio in honey referred from the Aayurvedic Pharmacopeia.

**Standard Values**

Reducing sugars: – not less than 65% by wt.

Fructose-Glucose ratio: - not less than 1% by wt.

I took different 7 samples of honey from different store in Satara region.

By performing the given standard procedure, the obtained results and readings after calculating are enlisted in table given below….

**Table 1: Fructose-Glucose ratio and other sugars in honey.**

| Parameters | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| Total reducing sugar | 91.66 | 77.68 | 84.87 | 82.33 | 80.88 | 81.36 | 82.33 |
| Glucose% (y) | 45.87 | 13.58 | 40.85 | 41.25 | 34.52 | 40.90 | 38.69 |
| Fructose % (z) | 49.49 | 69.29 | 47.58 | 44.40 | 50.11 | 43.71 | 47.16 |
| y + z | 95.37 | 82.87 | 88.43 | 85.66 | 84.63 | 84.64 | 85.86 |
| Fructose-Glucose ratio | 1.07 | 5.10 | 1.16 | 1.07 | 1.45 | 1.06 | 1.21 |

In this project the final results and ranges of % of fructose, glucose and reducing sugars in different honey samples found to be within the standard values and limits.

There were no adulterations found in honey samples.

As honey contains sugar level in limited quantity and hence won't show more harmful effects as that of the regular sugar.

Honey contains sugars along with various plant metabolites, antioxidants and other various enzymes hence it provides sweetness in a healthy way.

**Variables**

- Fructose-glucose ratio also depends on types of honey.
- Honey can be obtained by honeycomb but bee's collects honey from various flowers and hence exact and only specific flower nectar can't be obtained in honey.
- Honey of marketed products can be adulterated and hence the sugar levels may vary.
- Other formulation processes of honey in industry like pasteurization may affect the heat sensitive compounds and hence will affect in proportions.

**CONCLUSION**

- Fructose – Glucose ratio in different samples of honey available in Satara region is within normal range and limits.
- Total reducing sugars in different samples of honey are within standard limits.
- As honey contains sugars in limited quantity and also contains other plant metabolites, enzymes etc. it gives additional healthy effects along with the sweetness.[4]
- Honey fructose does not give same side effects as that of the purified fructose and hence become a better choice of sweetener than the regular sugars.[5]

**Future of project**

As we have concluded that honey can be a better option for sweetness than that of the regular sugars and various sweeteners available in market. But exactly how honey is beneficial? Why honey fructose does not gives same side effects as that of the purified fructose is the big question?

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