

Exploring the Ayurvedic view of rice- Impact of cooking & cooling on its nutritional composition & its potential relevance in Type II Diabetes management

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ABSTRACT

Rice is a staple food for majority of Indians. In today's era, there has been a debate on whether rice should be consumed by Diabetics due to its high GI & GL. According to Ayurveda, consuming warm rice may heighten the risk of diabetes. This study aims to address this uncertainty by examining the contemporary nutritional aspects and Ayurvedic properties of rice. Additionally, the study incorporates a comprehensive evaluation of the organoleptic characteristics, nutritional composition & starch content of 11 rice varieties commonly consumed in India. The rice was cooked by an ancient Ayurvedic method & two samples; freshly cooked and cooled post cooking (at RT) were analyzed. All the samples exhibited excellent organoleptic characteristics. 8 out of the 11 rice varieties exhibited increased protein and starch content in the cooled samples compared to freshly cooked ones, possibly due to protein denaturation and starch retro gradation, respectively. Studies have shown that retrograded starch resists intestinal enzymatic digestion thereby negligibly affecting blood sugar levels. It can thus be concluded that cooled rice after cooking (at RT) can be suggested to diabetics instead of freshly cooked which is in accordance with the Ayurvedic principle. This will ensure there is a steady rise of blood glucose. There is potential for further research to investigate the amylose and amylopectin content, GI and GL of various rice variety samples, providing insights into whether specific rice varieties are suitable for individuals with diabetes.

KEYWORDS: *Ayurveda, Diabetes, Health, Nutrition, Rice, Starch*

INTRODUCTION:

Rice (*Oryza sativa*) serves as a staple dietary food for over half of the global population, contributing to over 20% of the total calories consumed worldwide. Its significance is particularly observed in regions such as East and South Asia, the Middle East, the West Indies and Latin America. ⁽¹⁾ India holds a significant position as a major hub for rice cultivation. Some scholars believe that the word '*rice*' has been originated from a Tamil word '*arisi*'. ⁽²⁾ Rice is a staple crop of India & the varieties commonly consumed today include *Basmati*, *Kolam*, *Indrayani*, *Sona Masuri*, *Ambemohor*, *Mogra* (Jasmine rice), *Minimogra*, *Kali mooch*, *Jeerasal*, etc.

Rice can be categorized into different categories based upon the multilevel processing it undergoes- paddy rice (kernels enclosed in the husk), brown rice (husk removed), milled or white rice (bran layers removed), parboiled rice (subjected to a steam-pressure process before milling), precooked rice (cooked and dehydrated after milling to reduce cooking time) and enriched rice (a mixture comprising regular milled rice and a small proportion of fortified rice with slightly higher levels of vitamins and iron compared to brown rice).⁽⁵⁾

Among various rice categories, white rice or polished rice is predominantly consumed worldwide. It undergoes a sequence of mechanized procedures such as hulling and milling for its production & is majorly composed of starch.⁽⁶⁾ The process of milling and polishing of rice results into a significant loss of nutrients. Extensively milled white rice exhibits diminished levels of protein, minerals and lysine, with the zinc concentration being approximately half that of brown rice.⁽⁵⁾

In the contemporary world, there is uncertainty to whether rice can be consumed by the individuals having Type II Diabetes. Continuous ingestion of rice for long duration is believed to be associated with a higher risk of Type II Diabetes. The present research paper aims to shed light on this ambiguity by highlighting the contemporary nutritional characteristics as well as *Ayurvedic* properties of rice. Additionally, the study incorporates a comprehensive evaluation of the organoleptic characteristics, nutritional composition & starch content of 11 rice varieties commonly found in Indian markets, both when freshly cooked and after cooling, with the aim of determining the most suitable rice variety for individuals suffering from Type II Diabetes.

LITERATURE REVIEW

1. Nutritional Composition of Rice

Nutritionally, rice is a rich carbohydrate source and contains high-quality proteins.⁽³⁾ Starch is the major component of the milled rice. The rice starch granule predominantly comprises 99% of α -glucans, consisting two distinct glucose polymers known as amylose and amylopectin. Amylose is a linear molecule composed of α (1 $\rightarrow$ 4) linked D-glucopyranosyl units with minimal branching. In contrast, amylopectin exhibits a larger molecular weight and a highly branched structure, consisting of straight chains of D-glucopyranosyl units linked by α -(1 $\rightarrow$ 4) bonds, with branched chains attached via α -(1 $\rightarrow$ 6) bonds.⁽⁷⁾

Based on glycemic index (GI) values, foods can be classified into three types: Low GI foods (GI <55), medium GI foods (GI ~ 56 to 69), and high GI foods (GI > 70). Foods are classified into three categories based on their glycemic load (GL): Low (GL $\leq$ 10), medium (GL >10 - <20) and high (GL $\geq$ 20).⁽⁸⁾ The glycemic index (GI) of rice is dependent upon its variety, with varietal impacts on GI primarily being influenced by the amylose content. Rice can be categorized based on its amylose content into waxy (0-2%), very low amylose (5-12%), low amylose (12-20%), medium amylose (20-25%) and high amylose (25-33%) types. The ratio of amylose to amylopectin plays a crucial role in determining starch digestion rates and consequently used to predict blood glucose and insulin responses to rice.⁽⁹⁾ Among various rice categories, white rice is considered to have high GI & GL. Research indicates that regular consumption of meals with elevated GI and GL levels over an extended duration is correlated with a higher risk of Type II Diabetes (due to insulin resistance & impairment of β -cell

function) along with other disorders like dyslipidemia, obesity, breast cancer, endothelial dysfunction, cardiovascular disease and a decline in cognitive functions. ⁽⁷⁾

Apart from being rich in starch, rice is also a fair source of essential minerals such as magnesium, manganese, iron, selenium and phosphorous, along with B-complex vitamins. Additionally, rice contains various bioactive compounds like γ -Oryzanol, tocopherol, tocotrienol, amino acids and dietary fiber. ^{(1), (4)} In addition to its nutritional richness, rice carries immense significance in India, possessing profound spiritual and ritual importance. According to Indian tradition, rice is highly revered as a powerful symbol of auspiciousness, prosperity and fertility, attributed to its life-sustaining qualities. ⁽³⁾

2. Impact of Cooking & cooling on the starch composition of rice

The starch composition of rice varies based upon the method used for cooking, cooking degree & the temperature at which it is consumed. The texture of freshly cooked rice is soft & elastic. When the rice is cooled or chilled for a few hours, it becomes hard & rigid. This could be attributed to the structural changes in the starch composition of rice. Upon cooking, the starch undergoes gelatinization and is rapidly digested by the small intestines. When the cooked rice is cooled, the gelatinized rice starch molecules are transformed into a structured crystalline state (retrograded starch) which withstand enzymatic breakdown in the small intestine thereby lowering the GI response. ⁽¹¹⁾ A study involving 32 individuals diagnosed with Type II Diabetes revealed that the consumption of cooled rice leads to a reduced spike in post-meal blood sugar levels. ⁽¹⁰⁾

3. Rice- An Ayurvedic Perspective

Ayurveda is an ancient medical science which aims to maintain optimal health and treat illnesses. ⁽¹³⁾ In Ayurveda, rice is referred to as '*Sali*' and comes under '*Sukadhanya*' (awned grains) category within the '*Dhanyavarga*' (section of grains). ⁽¹⁴⁾ The properties of various rice types, as mentioned in the ancient Ayurvedic text '*Bhojanakutuhalam*' by *Raghunathasuri* are as follows: sweet, astringent, unctuous, nourishing, light to digest, strength giving, produces hard stools in small quantities, stimulate appetite, improve voice, possess aphrodisiac properties and support growth. ⁽¹²⁾ Additionally, the text enumerates diverse rice varieties such as *krsnasali*, *raktasali*, *mahasali/sthulasali*, *gandhasali*, *tiriya*, *sashtikasali*, etc along with their respective properties.

3.1 Properties of various varieties of rice mentioned in the ancient Ayurvedic classic '*Bhojanakutuhalam*':

1. ***Krsnasali*** (Black rice): It is sweet, nourishing, enhances complexion & luster, strengthens the body, mitigates *tridosas*, alleviates burning sensations and exhibits aphrodisiac properties.
2. ***Raktasali*** (Red rice): It is sweet, light to digest, unctuous, strengthening, imparts a delightful taste, improves vision, diuretic and stimulates the digestive fire. It is considered beneficial for treating ailments related to *pitta*, burning sensations, *vata* and blood disorders, boosts semen quantity and effectively alleviates thirst and fever. Among the different types of rice, *raktasali* is acknowledged as the most superior.

3. ***Sthulasali/Mahasali***: It is sweet, has a delightful taste and cooling properties. It treats vitiations of *pitta*, quickly alleviates persistent fever, hyperthermia and abdominal issues. It is suitable and nourishing for individuals of all ages, including children, youth and the elderly. Its consumption is recommended for everyone. It enhances digestive power, boosts strength and promotes virility.
4. ***Suksmasali***: It is sweet, light to digest, beneficial for ailments like *raktapitta* (bleeding disorders) and sensations of burning. It also enhances digestive power, aids in digestion and slightly alleviates ailments arising from *vata* aggravation.
5. ***Gandhasali***: It is sweet, aphrodisiac, galactagogue, treats *pitta* vitiation, relieves exhaustion, improves appetite, alleviates burning sensations, supports embryo growth, enhances strength, mildly vitiates *kapha* and contributes to overall strength.
6. ***Tiriya***: The rice that matures in 3 months is called *Tiriya*. It is sweet, possesses a soothing quality and cooling effect. It is effective in treating burning sensations and vitiations of *pitta*. Additionally, it has the capability to alleviate vitiations of all three *doshas*, enhances taste, is wholesome and serves as a remedy for various ailments.
7. ***Sastika***: This rice variety takes 60 days or two months to reach maturity. It comes in two varieties - white and black. The white variant adds flavor, possesses a cooling effect, treats imbalances in the *dosas*, enhances strength, wholesome, boosts digestive fire and supports virility. The black variety is slightly less superior compared to the white one.

3.2 Properties of warm (freshly cooked) rice according to *Ayurveda*:

In *Ayurveda*, freshly cooked warm rice is called as '*Ushnodana*'. Given below are the properties of such rice mentioned in the ancient Ayurvedic classic '*Bhojanakutuhalam*':

उष्णदिनगुणाः

उष्णोदनो भ्रममदात्ययरक्तपित्तमेहप्रदः क्रिमिहरः कसनार्तिनिघ्नः ।

आध्यानगुल्मपवनक्षयकारहिक्काश्वासापहृश्च कफकृल्लघुदीपनश्च॥⁽¹²⁾

Cooked rice leads to dizziness, intoxication, bleeding and urinary disorders. It's effective in eliminating worms, treating coughs, abdominal distention, *gulma*, reduced *vata dosha* functioning, hiccups and dyspnea. It aggravates *kapha dosha*, is light to digest & boosts digestive fire.⁽¹²⁾

AIM OF THE STUDY:

The aim of this research was to assess the nutritional properties of 11 commonly consumed Indian rice varieties (freshly cooked and cooled post cooking {at RT}) with respect to dietary management of diabetes.

OBJECTIVES OF THE STUDY:

- To study the properties of rice from *Ayurveda* & Contemporary Nutritional Science.
- To compare the rice varieties with their *Ayurvedic* counterparts.
- To cook the rice by the traditional method mentioned in the ancient Ayurvedic manuscript '*Bhojanakutuhalam*'.

- To determine whether freshly cooked or cooled post-cooking rice is more advisable for individuals with diabetes.

MATERIALS & METHODS:

Raw materials procurement-

Eleven varieties of rice commonly consumed in India were procured from the local supermarkets of Pune. These included: *Sela Basmati*, Red rice, Brown rice, *Ambemohor*, *Kalimuch chinari* & 2 sub varieties of *Kolam* (*Jeerasal* & *Surati*), *Indrayani* (*Sugandhi* & *Maval*) & *Mogra* (*Minimogra* & *Mogra*) each.

Methodology:

An extensive literature review of contemporary nutritional perspectives on rice was conducted by thoroughly examining numerous research and review papers accessible through various scientific databases such as Google Scholar, PubMed, Research Gate, etc. Moreover, references related to various rice types were collected by conducting a thorough literature review of an ancient Ayurvedic text called '*Bhojanakutuhalam*'. The rice varieties were then classified into different groups according to their resemblance to the characteristics of their *Ayurvedic* counterparts. Furthermore, these rice varieties were cooked by the traditional procedure mentioned in the ancient *Ayurvedic* text '*Bhojanakutuhalam*'. 100g of raw rice was cooked in five times quantity of water in an open vessel without lid. Two different samples from each cooked rice variety were prepared, one sample was cooked & maintained at the 50°C temperature and the second sample was cooled for 6 hours post cooking. The rice samples were examined for the organoleptic attribute i.e. overall acceptability by 10 semi-trained panelists selected randomly. Furthermore, these samples were analyzed for their nutritional composition -carbohydrates (available), protein, total fat, crude fiber & starch content.

Stepwise execution of the research study

Literature review of rice from Contemporary Nutritional Science & collection of references from an ancient Ayurvedic classical text '*Bhojanakutuhalam*'.



Raw rice sample collection from the local supermarkets of Pune



Cooking of 100g raw rice according to the traditional method as mentioned in the Ayurvedic text '*Bhojanakutuhalam*'- Without lid using 5 times quantity of water



Preparation of samples- First sample was cooked & maintained at 50°C and the second sample was cooled for 6 hours post cooking.



Conduction of organoleptic evaluation, nutritional analysis - Carbohydrates (available), protein, total fat, crude fiber & starch content of the prepared samples.

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Protocol writing

RESULTS & DISCUSSION:

The rice types examined in this research were evaluated against their Ayurvedic equivalents, focusing on similarities in physical attributes as described in Ayurveda. This comparison is detailed in Table 1 given below.

Table 1: Comparison of Frequently Consumed Indian Rice Varieties with Ayurvedic Considerations

Commonly consumed Indian Rice Varieties examined in the current research	Consideration with Ayurvedic Rice Varieties
<i>Sela Basmati, Surti Kolam</i>	<i>Shulashali/Mahashali</i>
<i>Sugandhi Indrayani, Maval Indrayani, Ambemohor</i>	<i>Gandhashali</i>
Red rice	<i>Rakta shali</i>
<i>Minimogra, Mogra, Kalimuch chinar, Jeerasal Kolam, Brown rice</i>	<i>Sukshmashali</i>

Organoleptic evaluation

Mean score of the overall acceptability of the rice samples is depicted in Table 2. All the rice samples (both freshly cooked & cooled after cooking) exhibited excellent overall acceptability, *Kalimooch chinar* (At RT) being the highest & *Mogra* (At 50°C) the lowest.

Table 2: Mean score of the organoleptic attribute (Overall acceptability) of the rice samples

Sr. No.	Rice variety	Overall acceptability
1.	<i>Sela Basmati</i> (At 50°C)	4.6
2.	<i>Sela Basmati</i> (At RT)	4.5
3.	<i>Kalimooch chinar</i> (At 50°C)	4.5
4.	<i>Kalimooch chinar</i> (At RT)	5
5.	<i>Jeerasal Kolam</i> (At 50°C)	4.4
6.	<i>Jeerasal Kolam</i> (At RT)	4.5
7.	<i>Surati Kolam</i> (At 50°C)	4.6
8.	<i>Surati Kolam</i> (At RT)	4.6
9.	<i>Sugandhi Indrayani</i> (At 50°C)	4.4
10.	<i>Sugandhi Indrayani</i> (At RT)	4.9
11.	<i>Maval Indrayani</i> (At 50°C)	4.4
12.	<i>Maval Indrayani</i> (At RT)	4
13.	Red rice (At 50°C)	4.4

14.	Red rice (At RT)	4.1
15.	<i>Mini mogra</i> (At 50°C)	4.2
16.	<i>Mini mogra</i> (At RT)	4.2
17.	<i>Mogra</i> (At 50°C)	3.8
18.	<i>Mogra</i> (At RT)	4.6
19.	Brown rice (At 50°C)	4.3
20.	Brown rice (At RT)	4.2
21.	<i>Ambemohor</i> (At 50°C)	4.5
22.	<i>Ambemohor</i> (At RT)	4.5

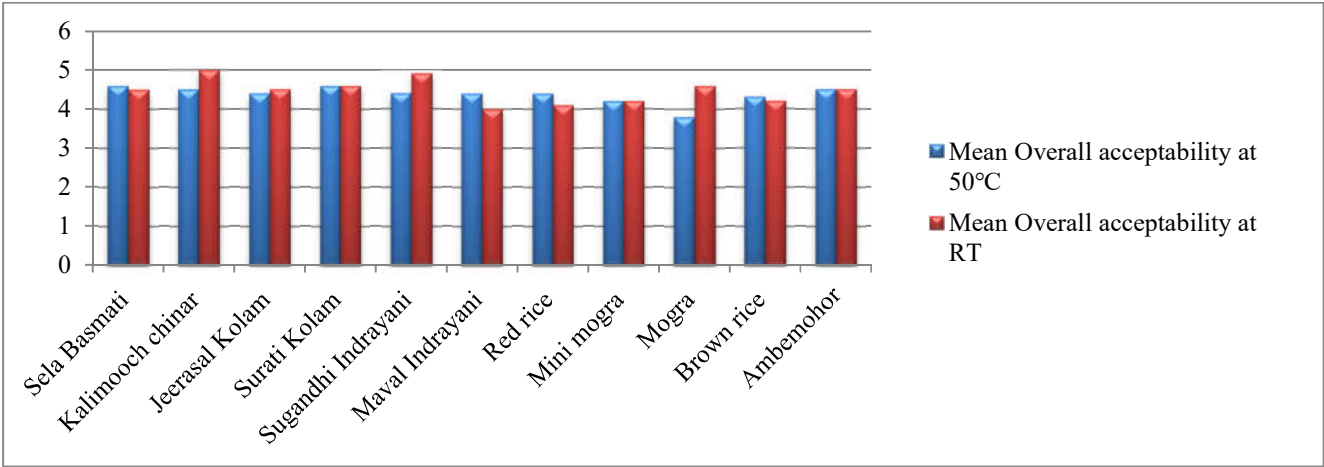


Fig 1: Mean overall acceptability scores of various rice samples

Nutritional Analysis

The rice samples exhibited carbohydrate levels ranging from 13 to 29g/100g. It has been observed that the carbohydrate levels in room temperature rice exceeded those in their freshly cooked counterparts, with the exception of *Jeerasal kolam*, *Maval Indrayani*, *Mini Mogra*, and *Mogra* varieties. There was negligible change in the carbohydrate content of the *Surti Kolam* rice variety.

Protein content varied between 1 to 5g/100g in the samples. Notably, 8 out of 11 cooled samples (at RT) showed a distinct pattern of increased protein content compared to their freshly cooked counterparts, possibly due to protein denaturation. The protein levels in the *Maval Indrayani* and red rice varieties decreased when stored at room temperature, whereas there was no change in the protein content of the *Mogra* rice variety in both samples.

There was negligible change in the fat content of both the samples. All the rice samples contained <0.1g/100g of crude fiber. Starch content ranged from 12 to 26g/100g in the rice samples, *Sela Basmati* (At RT) being the highest (26g/100g) & *Mini Mogra* (At RT) the lowest (12.99). 8 out of 10 samples showed higher starch content in the cooled (RT) samples compared to the freshly cooked ones which might be likely attributed to starch retro gradation. The amount

of starch in the *Mini Mogra* and *Mogra* rice varieties decreased when stored at room temperature. Similarly, there was a minor decrease (15.99 - 15.59g/100g) in the starch content of the *Surati Kolam* rice sample when cooled to room temperature. (Please refer Table 3)

Table 3: Proximate & starch content of the prepared rice samples

Sr.No	Rice variety	Carbohydrate (g/100g)	Protein (g/100g)	Total fat (g/100g)	Crude Fiber (g/100g)	Starch (g/100g)
1.	<i>Sela Basmati</i> (At 50°C)	21.11	2.79	0.57	<0.1	18.24
2.	<i>Sela Basmati</i> (At RT)	28.59	4.90	0.62	<0.1	26
3.	<i>Kalimooch chinar</i> (At 50°C)	18.83	1.82	0.7	<0.1	16.24
4.	<i>Kalimooch chinar</i> (At RT)	18.86	3.33	0.68	<0.1	17.75
5.	<i>Jeerasal Kolam</i> (At 50°C)	22.38	2.56	0.82	<0.1	16.85
6.	<i>Jeerasal Kolam</i> (At RT)	19.32	3.05	0.77	<0.1	18.03
7.	<i>Surati Kolam</i> (At 50°C)	16.60	2.88	<0.5	<0.1	15.99
8.	<i>Surati Kolam</i> (At RT)	16.42	5.00	0.55	<0.1	15.59
9.	<i>Sugandhi Indrayani</i> (At 50°C)	17.35	1.86	<0.5	<0.1	16.02
10.	<i>Sugandhi Indrayani</i> (At RT)	22.24	3.04	0.59	<0.1	20.93
11.	<i>Maval Indrayani</i> (At 50°C)	25.65	3.02	0.66	<0.1	21.74
12.	<i>Maval Indrayani</i> (At RT)	24.83	2.81	0.71	<0.1	23.16
13.	Red rice (At 50°C)	18.53	4.22	0.75	<0.1	17
14.	Red rice (At RT)	25.71	2.81	0.58	<0.1	23
15.	<i>Mini mogra</i> (At 50°C)	18.23	2.70	0.67	<0.1	17.68
16.	<i>Mini mogra</i> (At RT)	13.70	3.91	0.52	<0.1	12.99
17.	<i>Mogra</i> (At 50°C)	21.91	2.33	0.65	<0.1	19.16
18.	<i>Mogra</i> (At RT)	20.58	2.33	0.6	<0.1	18.40
19.	Brown rice (At 50°C)	19.56	2.61	0.62	<0.1	17.49
20.	Brown rice (At RT)	21.29	3.58	0.68	<0.1	19.88
21.	<i>Ambemohor</i> (At 50°C)	19.41	2.53	1.75	<0.1	18.94
22.	<i>Ambemohor</i> (At RT)	26.75	4.60	0.5	<0.1	25.64

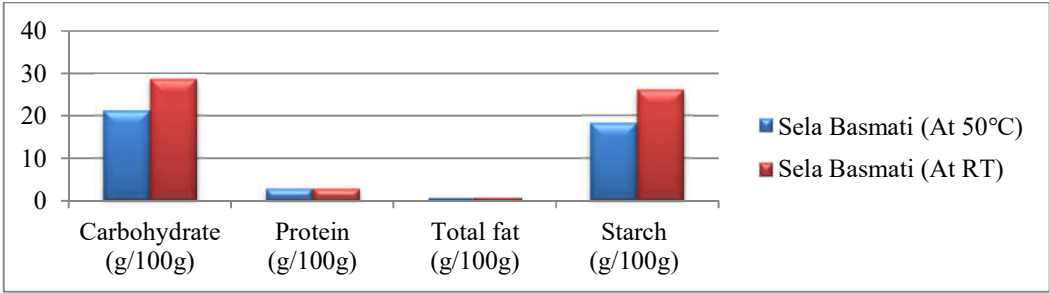


Fig 2: Proximate & starch content of *Sela Basmati*

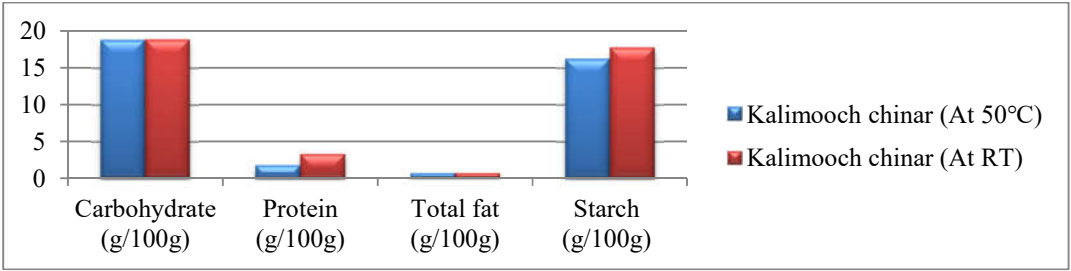


Fig 3: Proximate & starch content of *Kalimooch chinar*

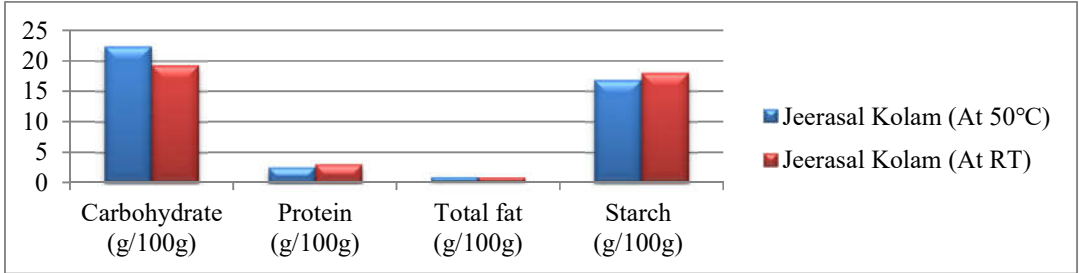


Fig 4: Proximate & starch content of *Jeerasal kolam*

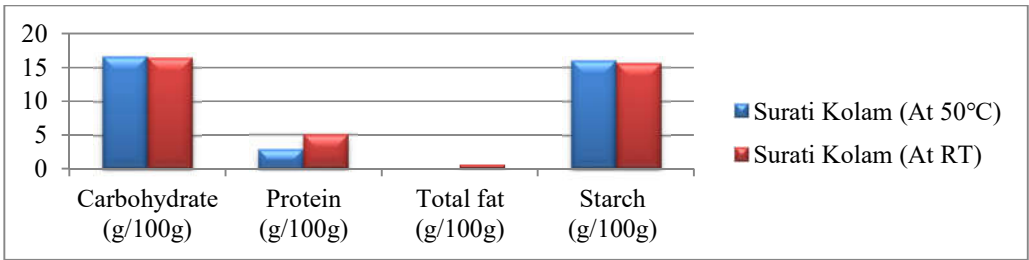


Fig 5: Proximate & starch content of *Surti Kolam*

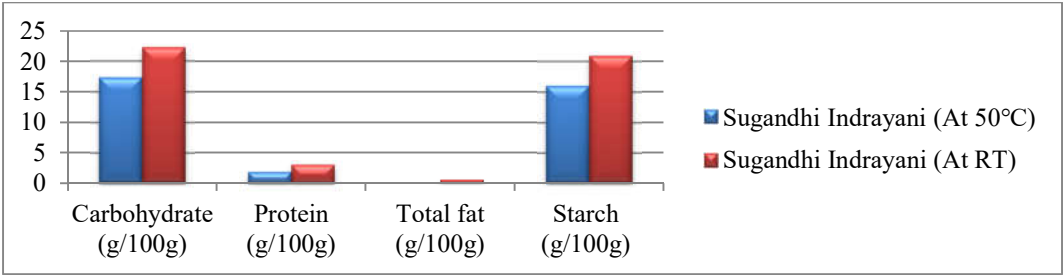


Fig 6: Proximate & starch content of *Sugandhi Indrayani*

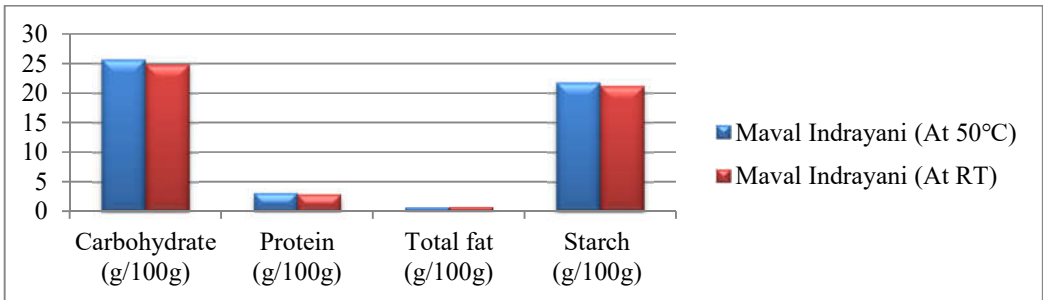


Fig 7: Proximate & starch content of *Maval Indrayani*

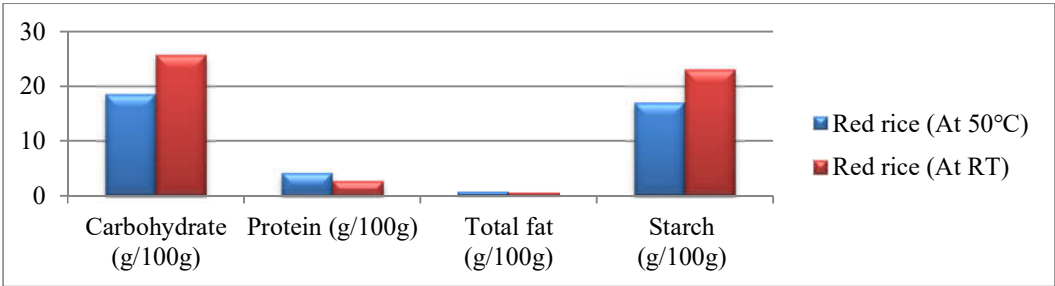


Fig 8: Proximate & starch content of *Red rice*

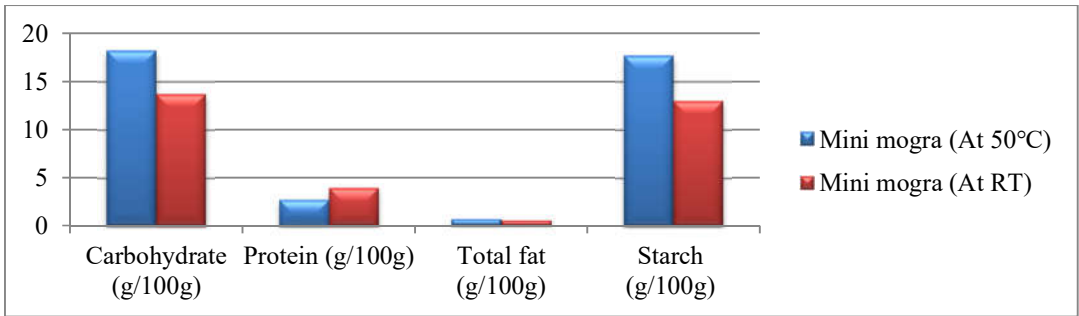


Fig 9: Proximate & starch content of *Mini mogra*

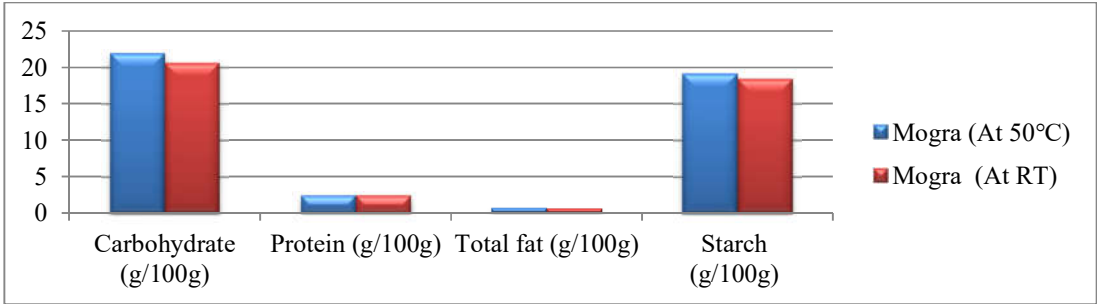


Fig 10: Proximate & starch content of *Mogra*

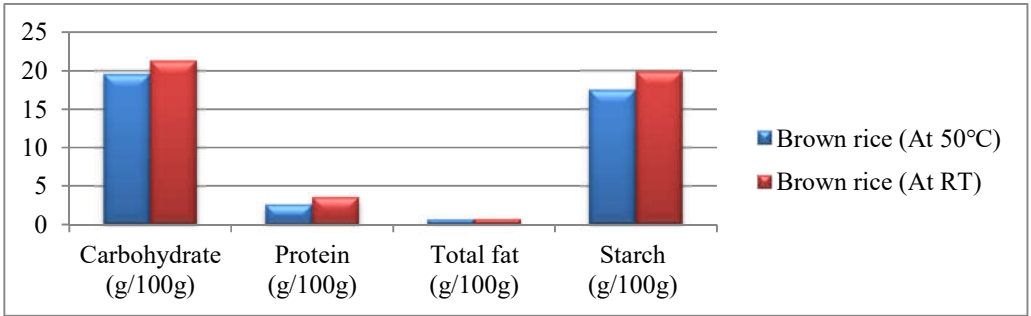


Fig 11: Proximate & starch content of *Brown rice*

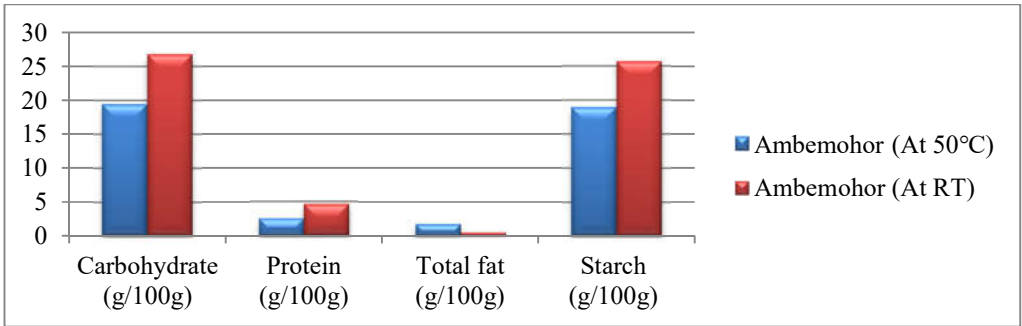


Fig 12: Proximate & starch content of *Ambemohor*

CONCLUSION:

Freshly cooked warm rice contains high amounts of rapidly digesting starch (RDS) which causes a quick rise in the blood glucose. This aligns with the Ayurvedic belief that consuming hot rice may lead to diabetes. Therefore, incorporating cooled post cooking rice (at RT) may be recommended for individuals with diabetes due to its high content of resistant starch, which remains undigested in the small intestine. Additionally, the protein levels in such rice are higher compared to freshly cooked rice of the same variety, potentially favoring a steady rise in blood glucose levels.

There is potential for further research to investigate the amylose and amylopectin content, glycemic index (GI) and glycemic load (GL) of various rice variety samples, providing insights into whether specific rice varieties are suitable for individuals with diabetes.

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