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Assessment of Germination Time for Siddi Rice (WGL–44)

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Abstract

Cereals are a significant part of the global diet and staple food in developing nations. The majority of developing nations rely heavily on rice as a staple food. The consumption of grains that sprouted is good for health as germination triggers the activation and synthesis of hydrolytic enzymes that improve nutrient absorption and digestibility for health benefits. The use of short duration rice varieties for value addition can also help in additional income generation to primary producers.

In the present study, the germination parameters of rice (WGL 44) were assessed. The findings showed that germinated percentage was highest at 48 hours with 98.00 ± 0.06% and a mean score of 68.28±7.84%. The non-germination percentage was highest for 6 hours with 91.32±0.06 and mean score of 31.71±7.84. The vitamin C content for 24 hours of germinated rice was highest with 78.25 ± 0.15 mg/100g at 24 hours and mean value of 35.6±4.03 mg/100g from 0 to 54 hours of germination. The milling yield of raw and 24 hours germinated rice were highest with 80.59±0.02 and 76.24±0.01% respectively.
Similarly, the husk percent of raw and 24 hours germinated were 19.41±0.02 and 23.63 ±0.01% respectively which was lowest among the various time intervals with significant differences at p<0.01 for milling yield and husk percentage at different intervals. The sensory parameters for cooked rice were best at 24 hours germinations and the best-accepted germination time was 24 hours. There was a statistically significant differences at p ≤ 0.01 for the sensory attributes at the different duration of germination after cooking.

Keywords: *Siddi, WGL – 44, milling yield, vitamin C, α – amylase, radical length, mean germination time, germination rate, radical length, shoot length, seed germination, cooking quality and sensory evaluation.*

Introduction

Rice (*Oryza sativa*) is a member of the grass family and one of the most important crops at the global level. It is used as a staple food in most countries around the world. It contributes about 60–70% of total calories and one-third of daily protein requirement in diets for Indians [1]. Rice is an essential crop for over half of the world's population providing 21.0% of global human per capita energy and 15.0% of per capita protein. The United Nations recognized the importance of this crop and declared 2004 as the 'International year of Rice' [2]. WGL – 44 commonly known as siddi is saline tolerant, fine grain type with the higher number of seeds in panicle, good cooking quality and resistance to gall midge which is a major endemic in rice during kharif season. The duration is 140-145 days [3]. Germination is a simple and economic method for improving grain quality and is gaining increased interest due to the health benefits of germinated grains. It is an inexpensive and effective method to improve the overall nutritional quality of food grains by enhancing their digestibility, free amino acids and total sugars as well as decreasing dry weight and starch content [2].

Germination plays an important role in increasing amino acid profile, protein digestibility and vitamins while decreasing anti-nutritional factors than in raw cereals and legumes [4]. Indigenous food processing methods like malting/germination increase the

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nutritional profile of cereals as these methods found to increase the bioavailability of desired nutrients [5]. The seeds germinate under favourable conditions like a suitable temperature range, adequate water supply and light atleast for some seeds [6]. The result was measured as final germination percentage attained and the speed with which the germination process ended [7]. The main objective of this study was to standardize time periods for optimum sprouting of (WGL–44) rice at constant soaking time of 24 hours and room temperature.

Materials and Methods

Sample preparation: The WGL-44 rice variety commonly referred to as Siddi was analysed in the present study which was procured from Krishi Vigyan Kendra, PJTSAU, Wyra, Khammam. The procured paddy sample was stored in jute bags and kept at room temperature till further analysis. The present study was carried out in the Post Graduate & Research Centre, and Central Instrumentation Cell, PJTSAU, Rajendranagar, Hyderabad.

The sprouting time of germinated rice standardized was at intervals of 6, 12, 18, 24, 36, 42, 48 and 54 hours with a constant soaking time of 24 hours and room temperature. The process of germination started with imbibition of water, radicle protrusion and elongation of the embryonic axis referred to as seedling establishment. The ability of rice grain to undergo germination was called as germination capacity and it depends on time and temperature.

Profiling of sprouting parameters of rice

The sprouting parameters of rice profiled in the present study included germination capacity [8], seedling radical, shoot length, speed and degree of germination with time and extent of germination as vital consideration to determine the agronomic properties of procured grain [9]. The parameters used to assess the speed of germination were final germination percentage (FGP), mean germination time (MGT), first day of germination (FDG), last day of germination (LDG), time spread of germination (TSG), germination rate index (GRI) and coefficient of the velocity of germination (CVG) were analysed by using standard methods [10]. The degree of seed germination was carried out using the parameters like Timson index (T), Germination value (GV) and Maguire's index (T_{mod}) were calculated using standard formulae [11]. Vitamin C content [12] and α-amylase activity [13] activity in germinated rice samples were determined using standard protocols. Milled and husk percentages were analysed [14]. Titratable acidity [15], pH and Total soluble solids [16] were estimated during the germination of rice grains at various time intervals.

Cooking quality of germinated rice grains

The germinated, dehulled and polished rice (WGL 44) were cooked adding 150.0 ml water to a 30.0 g of sample before evaluating the sensory properties using a semi-trained panel of 15 members from PGRC, PJTSAU with 9-point hedonic scale for colour, texture, flavour, taste and overall acceptability for all time intervals of germination.

The samples were displayed in individual booths of the sensory evaluation laboratory on plates with three-digit codes. After evaluating each sample, the panellists rinsed their mouths. The evaluations were based on a hedonic scale of 1 to 9 with 1 denoting disliked extremely (very bad) and 9 denoting liked extremely (excellent) [17].

Results and Discussion

Germination results in increased grain digestibility as the hydrolytic enzymes are released making the nutrients fully available and are gaining popularity as "functional foods".

The enzyme inhibitors along with chemical and natural pesticides will be removed through soaking, rinsing and germination making them easier for the body to digest and assimilate.

Enzyme activity was employed to increase the availability of nutrients and add flavour during germination. The hydrolysis of complex components into simpler ones that can be digested easily and the breakdown of lipids into fatty acids to give energy are typically increased during germination [18].

Germination is a biological process that produces new molecules with beneficial properties through interconversion of complex molecules. There is considerable public interest in germination as it is a process that helps in developing foods that are natural, minimally processed and highly nutritious products that can lower many lifestyle disorders arising now-a-days [2].

Germination of rice was done with a constant soaking time of 24 hours and at room temperature for 6, 12, 18, 24, 36, 42 and 48 hours respectively. The results were statistically analysed and presented as germinated and non-germinated percentage parameters. Germination of rice was started at 6 hours of germination initially and continued till shoot and radical separated which was observed as 72 hours of germination. The various stages of germination of WGL 44 (Siddi) from 6 to 72 hrs were shown in Plate 1.

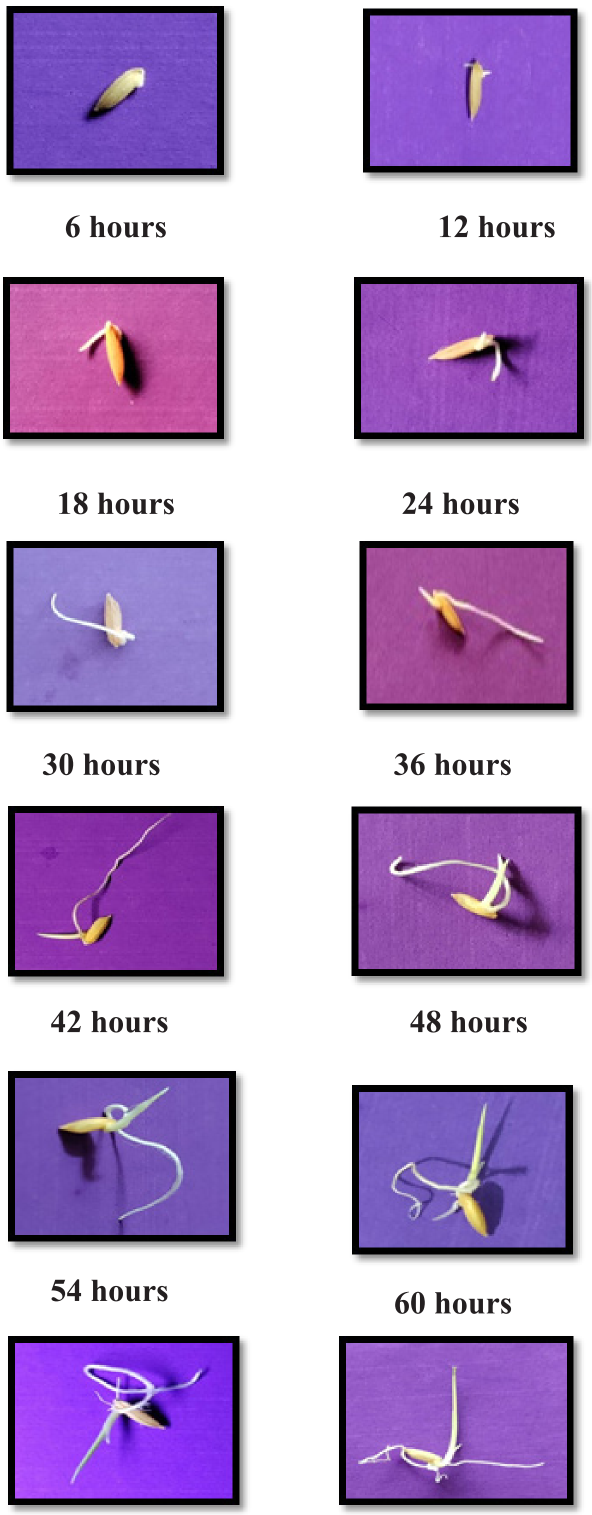

Plate 1: Germination of WGL 44 at different time interval

Germination capacity / germination percentage

The germinated percentage of rice (WGL 44) at constant soaking time of 24 hours and at room temperature were 8.68 ± 0.06, 18.34 ± 0.01, 80.67 ± 0.02, 88.00 ± 0.05, 90.00 ± 0.62, 94.33 ± 0.11 and 98.00 ± 0.06 % respectively for 6 to 48 hours at 6 hours' time interval with the mean score of 68.28 ± 7.84% as shown in Figure 1. The percentage of germination time was directly proportional to the increased time of germination. Similarly, the non-germinated rice percentage at the same temperature and time interval were 91.32 ± 0.06, 81.66 ± 0.01, 19.33 ± 0.03, 12.00 ± 0.05, 10.00 ± 0.62, 5.67 ± 0.12 and 2.00 ± 0.06% respectively with a mean score of 31.71±7.84 %. The results showed that germination time was inversely proportional to the non-germinated percentage due to the release of hydrolytic enzymes that acted on rice grains.

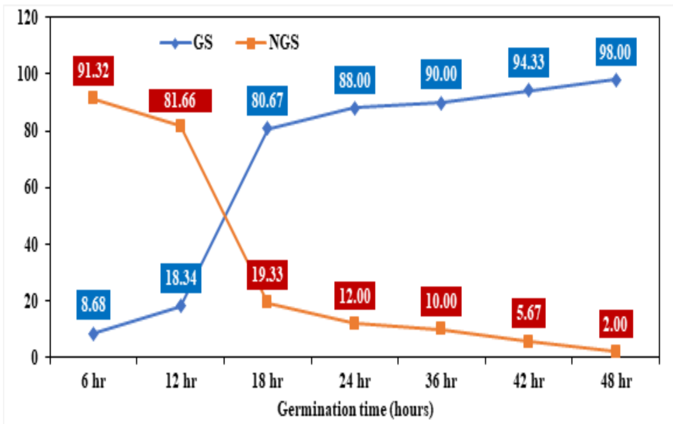

Figure 1: Germination percentage of rice (WGL 44) GS: Germination seeds; NGS: Non germination seeds

Radical and shoot length

The radical and shoot length of germinated rice (WGL 44) at constant soaking time of 24 hours and at room temperature for different time intervals of 6, 12, 18, 24, 36, 42 and 48 hours was measured and expressed as cm and depicted in Figure. 2

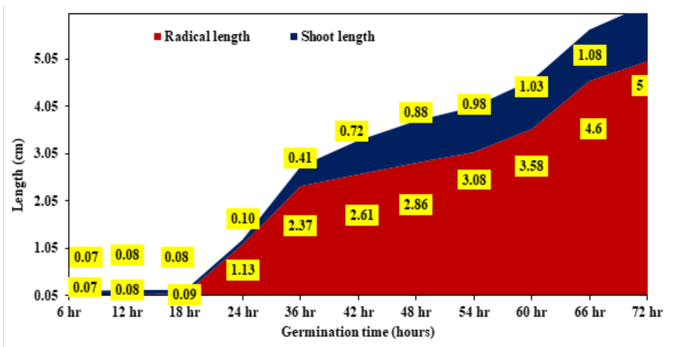

Figure 2: Radical and shoot length of germinated rice (WGL 44) at different time interval

The length of radicals was 0.07 ±0.00, 0.08 ± 0.00, 0.09 ± 0.00, 1.13 ± 0.02, 2.37 ± 0.03, 2.61 ± 0.02, 2.86 ± 0.03, 3.08 ± 0.03, 3.58 ± 0.06, 4.60 ± 0.10 and 5.0 ± 0.10 cm respectively with the mean score of 2.32 cm.

Speed of germination

Speed of germination with time and extent of germination as vital considerations to determine the agronomic properties of the procured grain.
Speed of germination of rice grains

The germination speed was considered to be the most important phenotypic feature of a seed to assess the rapidity of germination among different varieties of seeds or across the various treatments [18]. The germination speed of WGL 44 was assessed using the parameters viz. final germination percentage (FGP), mean germination time (MGT), first day of germination (FDG), last day of germination (LDG), time spread of germination (TSG), germination rate index (GRI) and coefficient of the velocity of germination (CVG) as presented in Table 1.

Table 1: Speed of germination of rice (WGL 44)

S. No.	Parameters	Values
1	Final germination percentage (FGP)	98.04 ± 0.07
2	Mean germination time per day	1.37 ± 0.01
3	Mean germination time per hour	32.88 ± 0.14
4	First day of germination (FDG)	6.15 ± 0.02
5	Last day of germination (LDG)	68.08 ± 0.35
6	Time spread of germination (TSG)	61.93 ± 0.01
7	Germination rate index (GRI)	68.28 ± 0.01
8	Germination rate per day	478.01 ± 1.00
9	Germination rate per hour	19.92 ± 0.17
10	Coefficient of velocity of germination (CVG)	127.50 ± 0.58

The final germination percentage of rice grain was 98.04 ± 0.07%. The higher values of FGP indicated the greater germination capacity of seed population. The MGT was calculated for day and hour. The MGT per day was 1.37 ± 0.01 and per hour was 32.88 ± 0.14 hours. The day on which the first germination occurred (FDG) and the day on which last germination occurred (LDG) are useful to understand the germination speed studies [10]. In the present study, the FDG of WGL 44 occurred at 6.15 ± 0.02 and LDG was 68.08 ± 0.35 at a constant soaking time of 24 hours and at room temperature after which sprouts separated as shoot and root.

The time in hours between the first and last germination events occurring in a seed lot is called as time spread of germination (TSG) and for WGL 44 was 61.93 ± 0.01 hours. The germination rate of rice grain was found to be 68.28 ± 0.01. The rate of germination per day was 478.01 ± 1.00 and rate of germination per hour was 19.92 ± 0.17 respectively.
The coefficient of the velocity of germination (CVG) gives an indication of the rapidity of germination and increases when the number of germinated seeds increases and the time required for germination decreases. In the present study, WGL 44 has 127.50 ± 0.58 on an average.

MGT represents the mean time required by seed lot to initiate and end germination [20]. The lower the MGT, the faster the population of seeds germinated indicating that seeds had good viability and were healthy. The higher the TSG, the greater was the difference in germination speed between the fast and slow-germinating seeds.

Degree of germination in WGL 44: The degree or rate of germination in WGL 44 was assessed using Timson index (T), germination value (GV) and Maguire's index (T_{mod}) as given in Table 2.

Table 2: Degree of germination of rice (WGL 44)

S. No.	Parameters	Values
1	Timson index (T)	478.0 **± 1.2**
2	Peak value of germination (PV)	49.0 ± 0.3
3	Mean daily germination (MDG)	68.3 **± 0.6**
4	Germination value (GV)	0.7 **± 0.0**
5	Maguire's index (T_{mod})	4.9 **± 0.0**

Timson index (T): The T index appeared to be the most comprehensive measurement parameter combining both germination percentage and speed (spread, duration and high/low' events). It magnified the variation among seed lots in this regard with an easily compared numerical measurement. The T value for WGL 44 was 478.0 ± 1.2 [11].

Germination value (GV): The GV is an expression of speed, the totality of germination and their interactions. The values of PV and MDG can be counter balanced, resulting in same GV values for samples or treatments with different behaviour in relation to the germination process [21]. In the present study, GV of WGL 44 was 0.7 ± 0.00 with PV 49.0 ±0.3 and MDG with 68.3 ± 0.6.

T_{mod}: Maguire's index was time-weighted cumulative germination that measured the speed of germination to quantify the seedling vigour and found to be 4.9 ± 0.0. The higher the T_{mod}, the better the seed germination [21].

Vitamin C content and α-amylase activity of germinated WGL 44 at different time intervals

Germination usually increases the Vitamin C content. The non-germinated rice grains contained vitamin C of 10.02 ± 0.61 sample. The vitamin C content at 6, 12, 18, 24, 36, 42, 48 and 54 hours of germination were 27.33 ± 0.20, 30.56 ± 0.07, 43.39 ± 0.19, 43.39 ± 0.19, 78.25 ± 0.15, 62.17 ± 0.30, 26.53 ±0.23, 21.82 ± 0.11 and 21.07 ± 0.18 mg/100g respectively with the mean of 35.68 mg/100g. The results showed that at 24 hours germination has the highest vitamin C content with slow increase in values up to 24 hours and then decreased with an increase in time up to 54 hrs of germination.

The non-germinated WGL 44 rice contained α-amylase of 0.60 ± 0.01 µg/100 g sample and germinates contained 0.84 ± 0.01, 1.02 ± 0.09, 1.81 ± 0.00, 1.63 ± 0.00, 1.22 ± 0.00, 1.13 ± 0.06, 0.87 ± 0.00 and 0.57 ± 0.00 µg/100 g sample respectively with the mean value of 1.08 µg/100 g at different time intervals as tabulated in Table 3. The non-germinated grain contained lesser α-amylase content compared to germinated ones as germination enhances the α-amylase activity of grains up to a certain point and thereafter declined with an increase in the germination period.

Table 3: α-amylase activity and Vitamin C content of germinated WGL 44 rice variety

Germination time (hr)	α- amylase activity (µg /100g)	Vitamin C content (mg/100g)
0.0	0.60 ± 0.01	10.02 ± 0.61
6.0	0.84 ± 0.01	27.33 ± 0.20
12.0	1.02 ± 0.09	30.56 ± 0.07
18.0	1.81 ± 0.00	43.39 ± 0.19
24.0	1.63 ± 0.00	78.25 ± 0.15
36.0	1.22 ± 0.00	62.17 ± 0.30
42.0	1.13 ± 0.06	26.53 ± 0.23
48.0	0.87 ± 0.00	21.82 ± 0.11
54.0	0.57 ± 0.00	21.07 ± 0.18
Grand Mean	1.08	35.68
SE of Mean	0.07	4.03
CD	0.11	0.81
% CV	6.26	1.33

Note: Values are expressed as mean ± standard deviation of three determinations.

Physical parameters of raw and germinated rice

The physical parameters analysed included milling percentage, husk percentage titratable acidity, pH and Total soluble solids (TSS) for raw and germinated rice grain at time intervals of 6, 12, 18, 24, 36, 42 and 48 hours at a constant soaking time of 24 hours and at room temperature as shown in Table 4.

The milling of raw and germinated rice grain yielded milled grains of 80.59 ± 0.02, 71.68 ± 0.06, 72.63 ± 0.06, 74.37 ± 0.02, 76.24 ± 0.01, 68.47 ± 0.07, 64.47 ± 0.18, 58.17 ± 0.09 and 56.66 ± 0.01% respectively. Similarly, the husk percent of raw and germinated rice grains were 19.41 ± 0.02, 28.32 ± 0.05, 27.37 ± 0.06, 25.63 ± 0.02, 23.76 ± 0.01, 31.53 ± 0.07, 35.60 ± 0.12, 41.83 ± 0.09, 43.34 ± 0.0 % respectively.

Titratable acidity of raw and germinated WGL 44 was 4.03 ± 0.01, 4.05 ± 0.02, 4.11 ± 0.01, 4.23 ± 0.01, 4.49 ± 0.00, 4.65 ± 0.02 ,4.70 ± 0.05, 4.76 ± 0.03 and 4.81 ± 0.00% with a mean value of 4.42 ± 0.05%. The pH of raw and germinated rice (WGL 44) was 6.70 ± 0.00, 6.66 ± 0.00, 6.66 ± 0.01, 6.44 ± 0.22, 6.62 ± 0.01, 6.61 ± 0.01, 6.60 ± 0.00 and 6.60 ± 0.00 respectively with a mean value of 6.61 ± 0.02.

The TSS of raw and germinated WGL 44 0.23 ± 0.030, 0.25 ± 0.02, 0.26 ± 0.01, 0.46 ± 0.06, 0.66 ± 0.06, 0.46 ± 0.06, 0.36 ± 0.03, 0.28 ± 0.01 and 0.26 ± 0.01 degrees Brix respectively with a mean value of 0.36±0.02 °Brix.

The milling yield percentage was best for 24 hours of germination although raw grains had the highest yield. The husk percentage was lowest for 24 hours of germination with raw grains showing lowest values. As the grains germinated, due to enzymatic activity and release of lactic acid breakage in the grains too increased causing decreased grain yield.

The pH and titratable acidity are inversely proportionate. The conversion of starch to lactic acid during germination led to an increase in titratable acidity and decreased pH. Numerous studies revealed that the germination of grains resulted in a drop in pH and an increase in titratable acidity due to the

Table 4: Physical parameters of germinated rice (WGL 44)

Germination time (hr)	Milled percentage	Husk percentage	Titratable acidity	pH	TSS °Brix
0.0	80.59 ± 0.02	19.41 ± 0.02	4.03 ± 0.01	6.70 ± 0.00	0.23 ± 0.03
6.0	71.68 ± 0.06	28.32 ± 0.05	4.05 ± 0.02	6.66 ± 0.00,	0.25 ± 0.02
12.0	72.63 ± 0.06	27.37 ± 0.06	4.11 ± 0.01	6.66 ± 0.01,	0.26 ± 0.01
18.0	74.37 ± 0.02	25.63 ± 0.02	4.23 ± 0.01	6.44 ± 0.22,	0.46 ± 0.06
24.0	76.24 ± 0.01	23.76 ± 0.01	4.49 ± 0.00	6.62 ± 0.01	0.66 ± 0.06
36.0	68.47 ± 0.07	31.53 ± 0.07	4.65 ± 0.02	6.61 ± 0.01	0.46 ± 0.06
42.0	64.47 ± 0.18	35.60 ± 0.12	4.70 ± 0.05	6.60 ± 0.00	0.36 ± 0.03
48.0	58.17 ± 0.09	41.83 ± 0.09	4.76 ± 0.03	6.60 ± 0.00	0.28 ± 0.01
54.0	56.66 ± 0.01	43.34 ± 0.01	4.81 ± 0.00	6.60 ± 0.00	0.26 ± 0.01
Grand Mean	69.25	30.75	4.42	6.61	0.36
SE of Mean	1.49	1.50	0.05	0.02	0.02
CD	0.22	0.18	0.07	0.21	0.12
% CV	0.18	0.34	1.02	1.93	20.87

Note: Values are expressed as mean ± standard deviation of three determinations.

breakdown of some complex organic molecules like lipids, proteins, phytins and carbohydrates into organic acids like fatty acids, amino acids, and phytic acid, which provided energy for seed growth (Gernah et al., 2011).

Sensory evaluation of cooked germinated rice: A semi-trained panel of 15 members evaluated the cooked germinated WGL 44 rice using the 9-point hedonic scale for colour, texture, flavour, taste and overall acceptability at time durations of 6, 12, 18, 24, 36, 42 and 48 hours of germination with a constant soaking time of 24 hours and room temperature. The scores were based on a hedonic scale of 1 to 9 where: 1 = I dislike extremely (very bad) and 9 = I like extremely (excellent) (*Meilgaard* et al., 1999). The sensory response was analysed and the mean values of each of the sensory attributes was presented in Figure 3.

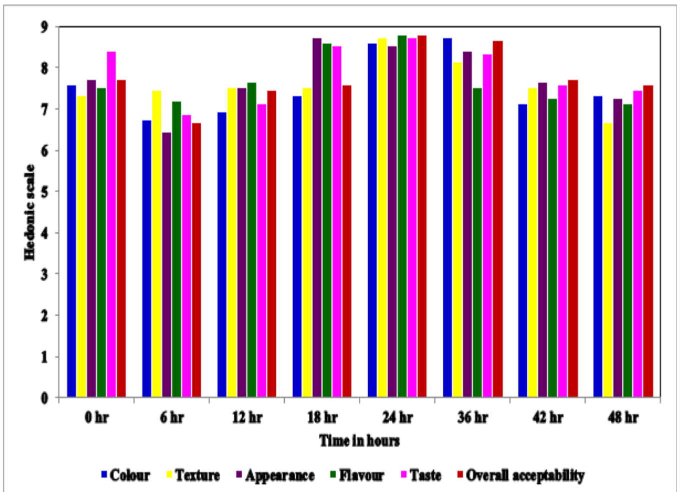

Figure 3: Sensory evaluation of cooked germinated rice

Cooking is a means of processing food without which many foods would be unfit for human consumption. The perception of flavour is often more about texture than flavour molecules that include protein coagulation, melting of fats, collagen turning to gelatin, moisture is removed from the surface with starches turning stiff and crunchy. These affect the "mouth feel" as well as the flavour of the foods.

The best score for the colour of cooked rice was at 36 hours with 8.73 ±0.11 followed by 24 hours 8.60±0.13. The best appearance was for 18 hours with 8.73 ± 0.11 followed by 24 hours with 8.53± 0.13. The flavour was scored highest for 24 hours with 8.80 ± 0.10 followed by 18 hours with 8.60±0.13. Taste also scored highest for 24 hours with 8.73±0.11 followed by 18 hours with 8.53±0.13. The best scores for texture were also 24 hours followed by 36 hours with 8.73±0.11 and 8.13± 0.19 respectively. Overall acceptability was highest for 24 hours with score 8.80±0.10 followed by 36 hours with 8.66±0.12. All the sensory parameters for cooked rice were high at 24 hours.

Conclusion

Germination parameters were carried out for selecting the best germination time of rice variety WGL 44 at 24 hours soaking time and room temperature. The germination percentage and radical length were directly proportional to time duration and the non-germinated percentage inversely proportional. The germinated percentage was highest at 48 hours with 98.00 ± 0.06% and the non-germination percentage was highest for 6 hours with 91.32 ± 0.06. there was a significant difference at $p<0.05$ for a radical length of germinated rice at different time intervals. The vitamin C content for 24 hours of germination was highest with 78.25 ± 0.15 mg/100g with a mean value of 35.6 ± 4.03 mg/100g from 6 to 54 hours of germination. The milling yield of raw and 24 hours germinated rice were highest with 80.59 ± 0.02 and 76.24 ± 0.01% respectively.

Similarly, the husk percent of raw and 24 hours germinated were 19.41 ± 0.02 and 23.63 ± 0.01% respectively which was lowest among the various time intervals. There were significant differences at $p<0.05$ for milling yield and husk percentage at different intervals. The sensory parameters for cooked rice were best at 24hr germination and hence the best-accepted germination time was 24 hours.

Conflict of interest

All the authors have read the manuscript and approved the submitted final manuscript. Authors have declared that no competing interests exist.

Author's contribution

Author AA carried out the research work and written the manuscript. Author JSW has designed monitored the research work and corrected the manuscript. Author BAK has monitored the research work. Authors JHK and MS have overviewed the writing of manuscript with timely suggestions and provided the Siddi rice required for the research work.

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Future scope of study: Certain rice varieties are disease tolerant but may not be suitable for primary processing and polishing. The value addition to these rice varieties through germination will help farmers in additional income generation.

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