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Product development and nutritional evaluation of Nutri-rich millet cookies

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Abstract
The objective of the study was to develop process technology and nutritional evaluation of cookies (biscuits) prepared from different varieties of finger millets (ragi) like VR- 900, VR-988, and VR-1076 developed at ARS Vizianagaram. Process technology was developed for millets by making cookies from finger millet flour (FMF) and wheat flour blends (WF). The various ratio of WF and FMF used were 0:100, 20:80, 30:70 and 40:60. The cookies were analyzed for nutritional and sensory evaluation also. These prepared samples contained high portion of protein (4.10-5.80%), fat (19.74-21.74%), digestible carbohydrates (50.11-70.11), fiber (2.20-4.73%), ash (1.11-1.83%) and moisture content in range of (1.90-3.20%). The cookies were also analyzed for mineral content and they had iron (3.16-81.54 mg/kg), zinc (71-38.27mg/kg) and the calcium was (910.10-1131.96mg/kg). Sensory analysis of cookies concluded that the sample T_2 at blend ratio WF: FMF: 260:760g for variety "VR-988" was best for cookies, highly acceptable by panel members for their taste, flavor and texture than other cookies of other composition and even in other varieties. Nutritional and sensory evaluation results was also good enough for this variety.

Keywords: Product development, nutritional evaluation, cookies

Introduction
In India rice and wheat are the major staple food in the diet ranging from rich business man to a small farmer. With change in culture of urbanization, food and demand of supply of food to the increasing population with adequate nutrition and health, there is a huge need of recognition of "Millets" because of their three layer protection *viz*, low cost, nutri rich and good health supply to human welfare. The global search for the source of nutrition, sustainable agriculture and farmer security is fueling a revolution in cultivation, processing and value addition of millets. From being harvesters to make future India "strong" "sustainable" and "healthy" millets has to be converted to "future generation smart foods". Millets have been cultivated since time immemorial with around 6000 varieties grown through world. History tells that many decades back millets have come from Africa towards Asia and Europe. Millets were cultivated even during Indus valley civilization. The great telugu poet "Mahakavi Kalidaas" has also phrased about millets in his writing "Abhignanasakuntalam". Even till date so many "folk songs" are sung on millets in south India. In telugu millets are called as "Siri Danyalu" in which siri is "rich" danyalu is "grain" called as "rich grains" (Anonymous, 2018) [10].

In India the total cultivable land is 141 million hectors under it 85 million hectors is rainfed area which accounts about 60% of total area. In AP a total of 23 million ha of area is under millet production and small millets accounts for 3.5 million hectors (Boobier *et al*., 2006) [4]. Compared to paddy, banana, and sugarcane the cultivation of millets require only 25% of rain fed water. Millets are drought tolerant, grown in varying rainfall regimes, diversified soils, not a seasonal crop can be grown throughout the year, no need of fertilizers and pesticides also. The resilience exhibited by these crops is helpful in their adjustment of different kinds of ecological niches, disease and pest resistant and quite indispensable to rain fed, tribal and hilly region where crop substitution is difficult. (Alka Kumari *et al*, 2017) [1].

During the period of 1950-60 the production of millet was 2050 million tones and productivity was 399 q/ha in an area of 5120.08 ha. Whereas during the period of 70's the production was highest with 1785 million tones with highest area of 4488.3 ha. But due to impact of "Green revolution" over the past 60 years our agricultural policy shifted towards rice and wheat neglecting millets.

Finally the cultivated area and production has came down to 725 ha with production of 4193 million tones during 2011-16. Millets are "high protein rich" ancient "super grain" reservoir of "nutrition" rich in proteins, fibers, magnesium, calcium (30%) and iron etc. Millets have higher iron and fiber content (6.70 g), than that of paddy (0.2g), wheat (1.2g). It also contains proteins (9.05g), fat (2.5g), carbohydrates (66.9g), and energy (326K Cal), thiamine (B1-6mg), riboflavin (B2-0.14mg) along with these it also contains other minerals and vitamins in larger amounts. (Florence Suma *et al.*, 2014) [7] (Palaniswamy *et al*., 2011) [9].

Finger millets are generally brick-red in color. But some genotypes having white or peach colored grains. The storability of grains under ambient conditions is good. The proposed three finger millet varieties VR-900, VR-988 and VR-1076 of ARS Vizianagaram are dark red in color and has recorded high yield in AVT-3 during 2014-15 in Andhra Pradesh, Karnataka, Chhattisgarh and in Tamil Nadu. Finger millets constituted about 81% of the minor millets produced in India and rest by kodo millet, foxtail millet, and little millet. Finger millet is a major source of mineral, protein, and carbohydrates that is comparable to other common cereal grain. It is also rich source of minerals having significant amount of phosphorous, calcium and iron.

The direct consumption of millets as food has significantly declined over the past three decades. The major reasons of decrease in consumption are life style changes in rural and urbanization culture, inconveniences in food preparation as demand for processed and convenience food has increased drastically and non-availability of processed products similar to rice or wheat. As well as people spending less time in kitchen because of their busy life schedule (Eneche 1999) [6]. Along with these the other reasons for neglecting millets are lack of awareness of nutritional merits, lack of processing technology, poor marketing facilities and government policy of disincentives towards millets. In India 50 million of people suffer from diabetes and 15% of population is obese.

In order to over the above problems there is need to educate people about health and nutritional benefits of millets to increase the consumption of millets and millet based products to tackle health and malnutrition related issues as millets not only provide food security like paddy and wheat but also provide multiple securities like food, fodder, health, nutrition, livelihood and ecological benefits (Eneche., 1999) [6].

In order to make millet value chain sustainable the production and promotion of various high yielding varieties of millets along with production and preparation of various millet based products like chocolates, biscuits, cakes, sweets and ice-creams is very essential. As millets are nutritionally rich and benefited to all age of people. It is also said that in particular there is a huge need of development of "easy" and "low cost" technologies that transform millets into various value added products, as well as to making into ready to cook, ready to eat products like malt and floor. Hence by considering above points millets not only provide health benefit to human it also provide employment to rural youth and women entrepreneurs of village if they going for value chain in millets. Along with preparation and evaluation of cookies the motto of the study was to expand potentiality of these varieties in terms of yield, processing, preparation of various value added products and provide nutritional composition information for benefit of farmers, consumers and entrepreneurs. Under this motto, the present study was taken up to develop a technology for preparation of biscuits as well as quality analysis in terms of nutrition and sensory for the biscuits prepared from different varieties of finger millets.

Material and Methods

Material

1. Millets

The three new finger millet (ragi) varieties namely like VR-900, VR-988, and VR-1076 which were ready for state level release were taken from ARS Vizianagaram of Acharya N.G Rang Agricultural University for preparation of millet cookies.

2. Equipment and Machinery

Machines like de stoner cum grader cum aspirator and capacity (500kg/h), De huller (300kg/h) with 3 phase electric motor, polisher capacity(40kg/h) grader (500k/h) and pulverize (75kg/h) make of Perfura Technologies, Tamil Nadu was used for various processing operations like cleaning, milling, de husking, grading, polishing and pulverizing of other millet grain not finger millet were done in agro-processing lab of ARS, Vizianagaram. A Blender is also used for smooth and fine blending of various types of floors with ingredients. The other machines like biscuit cutter and micro oven is also used in cookies making process.

3. Methods

3.1 Cleaning of millets: the grains were thoroughly cleaned and made free from dust and other foreign material by performing various unit operations.

3.2 Pretreatment of millets

3.2.1 Soaking and drying: After cleaning millets are soaked in water for 8 hours and kept for germination for about 12 hours. After germination shade drying is done about 24 hours.

3.2.2 Roasting and Pulverization: after soaking and drying roasting is done for about 5 minutes and it allowed for cooling for some time. After that is made into floor in pulverize.

3.3 Experimental Details

For making cookies the various ingredients like WF, sugar, baking powder, butter were procured from local market and FMF is procured from above mentioned process.

Different blends of wheat flour and finger millet flour were taken as shown below:

Wheat flour (WF): Finger millet flour(FMF)	Treatments
00 : 100	T_0
20 : 80	T_1
30 :70	T_2
40:60	T_3

Table 1: Formulation table for preparation of millet cookies

Ingredients	T_0	T_1	T_2	T_3
WF(g)	-	250	260	270
FMF(g)	750	750	740	730
Sugar(g)	250	250	250	250
Baking powder(Tea spoon)	1/4	1/4	1/4	1/4
Butter(g)	500	500	500	500
Water (or) milk(ml)	20	20	20	20

3.4 Cookies formulation

Finger millet cookies (ragi) cookies was made by taking sugar and butter in bowl in above said composite composition and

kneading is done to make it into smooth and fine paste. Generally kneading and mixing is done in blender equipment or done manually also. Then finger millet flour and wheat flour as told in above blend ratio (Table 1) is taken in a bowl and added to blender for blending and kneading purpose. After blending baking powder is added along with initial blended butter and sugar paste. After fine mixing of the composition it is again added with cardamom for flavor and aroma purpose. At last the all the ingredients flour blend is added with water or milk and made into round balls in the form of dough. Then dough is made into thin flattened sheets (like chapatti) by spreading. The flattened dough are now cut into required shapes like star, round and other shapes with help of mold. The mold shaped dough are arranged on tray and kept in micro oven at 120°C for 20 min for baking purpose. After baking it is cooled and packed. The sequential steps involved in preparation of cookies is given below.

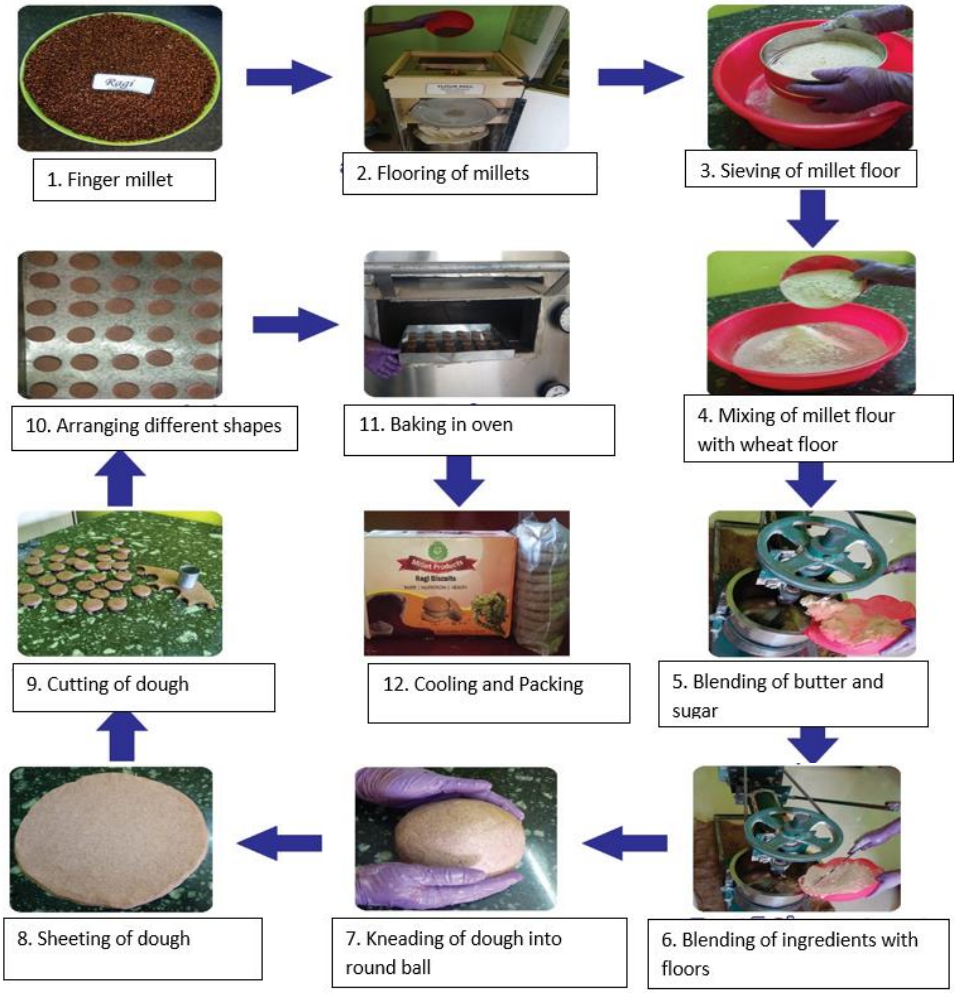

Fig 1: Flow chart for preparation of Finger millet cookies with different varieties

Measurement of Physio-chemical Properties of Cookies

1. Moisture content

Five grams of sample was taken in pre –weighted moisture box and kept in an oven at 105°C for 5 h and transferred to desiccators for cooling. The sample was weighed after half an hour and the weight was recorded. Reheated the sample for 1h cooled and weighed until a constant weight was obtained.

$$\text{Moisture (\%)} = \frac{Intial\ weight - Final\ weight}{Intial\ weight} \times 100$$

2. Crude protein

Nitrogen (N_2, %) of brown rice samples was estimated by using auto Kjeldahl equipment (Kel Plus, Pelican System, India). The percentage of N_2 of flaked rice samples was calculated using following equation.

$$N_2(\%) = \frac{14.01 \times (SR - BR) \times 0.1 \times 100}{1000 \times \text{Weight of sample}}$$

Where,

14.01 is atomic weight of nitrogen,

SR = titrate reading of the sample (ml)

BR = titrate reading of the blank sample (ml)

W_s = weight of the sample (g)

Then, protein content was estimated by using the following expression (Juliano 1985):

Protein content = $N_2 \times 6.25$

3. Fat Content

Crude fat was determined by using the Soxhlet apparatus, (AACC, 1976). Oven dry beaker and sample at 100°C for half hrs. Keep them in desiccator to avoid moisture content gain from the atmosphere. Weight the beaker and note the reading as initial weight. Carefully weight 2 g of flaked rice flour and keep in cellulose thimble. The thimble was then placed in a soxhlet apparatus and extracted with petroleum ether (80 ml) for 2 h. Initially apparatus takes 20 min time to reach 100°C, afterwards 40 min to boil at 100°C. The next 20 min it takes to reach 180°C, afterwards 40 min to boil at 180°C, during

this stage the evaporated ether condenses and mixed with rice flour in thimble for three times. The ether was then removed by evaporation and the flask with the residue dried in an oven at 105°C for 15 min., cooled in a desiccator and weighed. The percentage of oil was calculated using the formula:

$$\text{Fat Content (\%)} = \frac{W_2 - W_1}{W} \times 100$$

Where,
W_1 = Weight of empty beaker (g)
W_2 = Weight of beaker containing oil (g)
W = initial weight of sample (g)

4. Fiber Content

Crude fiber was determined by using the fiber plus apparatus. The fiber content of sample is calculated by using following equation

$$\text{Fiber content (\%)} = \frac{W1 - W2}{W} \times 100$$

Where,
W1 = Weight after oven drying (g)
W2 = Weight after ashing (g)
W = initial weight of sample (g)

5. Ash Content

Ash content was determined according to AACC (1976) procedure. 1 g of sample was taken in a silica and weighed. It was made to ash in a muffle furnace at 600°C for 4 hours. The crucible was cooled in the desiccators and weighed, and the value for ash content was calculated by using the following expression:

$$\text{Ash Content} = \frac{W_2 - W_1}{W} \times 100$$

Where,
W1 = Weight of empty crucible (g)
W2 = Weight of crucible and ash (g)
W = initial weight of sample (g)

6. Estimation of iron, zinc and calcium

The ash obtained under 3.5 was digested in 15 ml of concentrated hydrochloric and volume made to 100 ml. the ash solution was used for estimation of minerals like iron, zinc, and calcium by atomic absorption spectroscopy methods. Calcium was determined by precipitating it as calcium oxalate and titrating the solution of oxalate in dilute H_2SO_4 against standard $KMnO_4$.

7. Total carbohydrates

Total carbohydrates content of cookies was calculated by deducting the sum of values for moisture, protein, fat, fiber and total minerals in 100.

8. Sensory evaluation

The biscuits were evaluated for sensory attributes by a panel of 10 semi-trained judges, using a 9 point hedonic scale for different parameters like color, appearance, shape, flavor, texture, crispness and overall acceptability. The mean values of 10 semi – trained judges were considered for evaluating the quality.

Results and Discussions

Experiment results for values of response variables for cookies prepared at different blend ratios of different varieties viz., VR-900, VR-988 and VR-1076 are presented in table 2, 3 and 4 respectively. The chemical analysis of four blended biscuits indicate all biscuits contained favorable proportions of protein, fat, digestible carbohydrates and minerals.

Moisture content of millet cookies for variety VR-900 varies from 2.01 to 3.10 wb (Table 2) is highly significant in parallel to baking temperature and blend proportions. The maximum moisture content is 3.10 % and minimum is 2.01% at blend proportion of T_1 and T_0. The control treated biscuits had lower protein content of 4.10% whereas highest protein content was recorded for treatment T_2. (5.70%) which was higher than 5.1% reported by Pearson. The lowest value control sample may be due to exclusion of wheat flour in the control sample biscuit. Similarly the increase in protein and ash contents could be due to increase in proportions of WF and MF blends. It is also stated that wheat flour consists of protein in the range of 10% to 13% which also resulted to highest in blend treatment of T_2.

In variety VR-900 the fat content of decreased from 22.82 of control sample to 21.41% of T_3 sample. The decrease in fat content may be formation of decrease in proportions of millets used in blend biscuits used in experiment. In sample T_3 and T_2 the carbohydrate content is 68.99% and 68.37% which is lowest than control sample (69.71 %.). The decreasing trend of carbohydrate is as wheat occupies major part of blend ratio in biscuit preparation and wheat flour contains 78.10% of carbohydrates more than millets and millets are gluten free grains.

The calcium content of finger millet biscuits for the sample T_2 was highest *ie*., 1131.96 mg/kg compared to other samples of T_0 T_1 and T_3. The presence of calcium in finger millet cookies shows abundant nature of mineral present. The results were in accordance with the findings of (Bhatt, Singh and Baskheti 2003) who stated among cereals like wheat has the calcium content. Iron content of different samples ranged between 60.20 to 64.5mg/kg. When compared control sample 30.16mg/kg. The blended biscuits have higher iron content due to natural existence which occupies major portion among minerals. The maximum zinc content (mg/kg) = 35.29 was achieved for sample $T_1$and minimum is 35.10 for sample T_3. Pushpa devi studied the value addition of different foods using different processed millet powder and reported that zinc content shows a significant increment in freeze dried samples than tray and sun dried samples which is highly dependent on the heat maintained during processing of powder.

Table 2: Chemical analysis of finger millet cookies for variety VR-900

S. No	Chemical analysis	T_0	T_1	T_2	T_3
	Proximate Composition				
1.	Moisture	2.01	3.10	2.36	2.10
2.	Protein	4.2	4.12	5.70	4.83
3.	Fat	19.74	20.10	21.74	21.41
4.	Fiber	2.24	3.14	3.81	3.90
5.	Carbohydrates	50.11	65.25	68.37	68.99
6.	Ash	1.20	1.80	1.83	1.90
Mineral Content					
7.	Iron	30.16	60.20	67.40	64.5
8.	Zinc	25.11	32.89	35.29	35.10
9.	Calcium	931.96	1171.77	1131.96	1113.40

Table 3: Chemical analysis of finger millet cookies for variety VR-988

S. No	Chemical analysis	T_0	T_1	T_2	T_3
	Proximate Composition				
1.	Moisture	2.2	2.16	2.20	2.7
2.	Protein	4.1	5.77	5.80	4.8
3.	Fat	20.11	21.77	21.64	21.77
4.	Fiber	2.3	3.3	4.73	4.21
5.	Carbohydrates	52.22	66.41	68.65	68.10
6.	Ash	1.18	1.77	1.71	1.77
Mineral Content					
7.	Iron	32.20	91.30	94.30	94.10
8.	Zinc	23.71	29.76	29.34	28.14
9.	Calcium	980.0	1014.21	1061.88	1068.12

From the table 3 for variety VR-988 the moisture content ranges between 2.16% to 2.7% and form table 4 for variety VR-1076 moisture content ranged between 1.90% 2.45%. Same trend of moisture content was also reported and validated by several others (Suma *et al*., 2014) [7]. Low moisture of finger millet cookies is due to roasting of millets prior to making of cookies. For both the varieties the fat content ranged from 20.11% -21.74%. While the lowest occupied by control sample 20.11% and 20.71%. The results are similar to results of (Suma *et al.*, 2014) [7]. The higher fat content in pearl millet blended samples is due to addition of butter during cookie recipe (Table 3 and Table 4). For varieties VR-988 and VR-1076 the protein and ash content increased from 4.40%, 5.5.79% and 5.80% and 1.19%, 1.77% and 1.87% while the control samples are at lower percentage of 4.10% and 1.18%. The increase protein and fat in all the blended samples is due to increase of addition of millet flour in all the three samples. The highest increase in protein is seen in samples of T_3 (5.80%) for VR-988 and for ash it forT_3 sample (1.87%) while the lowest ash content is reported in control sample for variety VR-1076. The crude fiber of four samples ranged from 2.30% - 4.73% for variety VR-988 and 2.20% - 3.91% for VR-1076 which recorded lower than VR-988. However significant ($p<0.05$) difference was observed in fiber and carbohydrate content of four samples control. The highest digest carbohydrate was recorded for variety VR-1076 (69.12%) for T_2 composite mixed sample. The lowest is was recorded by variety (68.37%) for VR-900 compared favorably with 42.80% reported by (Eniche, 1999) [6] and 64.4% reported by (Oyenuga 1968). The higher values of carbohydrates can be attributed raw material flour which were, much not affected by processing operations.

The mineral composition like iron, zinc and calcium of the varieties VR-988 and VR-1076 are presented in table 3 and table 4. Lower calcium content (910.10 mg/kg) was recorded in variety VR-1076 than of VR-988 (1068.12mg/kg). A major significant difference was observed between the three verities for iron content 67.40mg/kg (VR-900), 81.34mg/kg (VR-988) and 81.34 mg/kg (VR-1076). Zinc content was found highest 38.27mg/kg in composite mix T_2 sample of VR-1076 variety and lowest in 23.71mg/kg for VR-988. However, statistically significant difference was observed among blend of T_2 for variety VR-900 and T_3 for variety VR-1076.

Table 4: Chemical analysis of finger millet cookies for variety VR-1076

S. No	Chemical analysis	T_0	T_1	T_2	T_3
	Proximate Composition				
1.	Moisture	2.2	2.2	1.9	2.45
2.	Protein	4.4	4.9	5.71	5.78
3.	Fat	20.71	21.1	20.82	20.97
4.	Fiber	2.2	3.4	3.90	3.91
5.	Carbohydrates	50.11	70.11	68.71	69.12
6.	Ash	1.19	1.77	2.10	1.68
Mineral Content81.54					
7.	Iron	38.20	81.10	80.01	81.54
8.	Zinc	24.44	37.17	38.71	38.27
9.	Calcium	910.10	911.97	998.30	985.60

Sensory evaluation

The results in table 6 showed that all the blended biscuits had high sensory ratings for all selected sensory attributes. The organoleptic study of millet cookies was done for parameters like appearance, color, taste, flavor, texture and overall acceptability which was analyze by a panel of judges using hedonic point scale as per IS: 6273(Part-ii), 1971.

For control sample T_0 of variety VR-900 the color, taste, flavor, texture and overall acceptability the recorded average score is 6.1 which is lower than T_1 T_2 andT_3 (Table 5). In the present study control samples are darker in color and crisper in texture. Desirable attributes such as aroma and sweetness were low in sample that consequently reduced its overall quality. Among three varieties viz, VR-900, VR-988 and VR-1076 the average best sensory evaluation scores were given to millet cookies made of variety VR-988(8.0) by panelist. In this variety of biscuits, the overall acceptability score was given to blend sample of T_2 (8.3) followed by T_1 (8.1) and T_3 (7.8). This variety of biscuits also achieved highest score in terms of color (8.25), appearance (7.75), flavor (7.50) and taste (8.75) compared to other blend composition and variety made cookies. The least average sensory scores were recoded to the variety VR-1076 (7.0) followed by variety VR-900(6.65) but nutritional composition was good for variety VR-900 followed by VR-1076 which is vice versa.

Sensory panelists opined that millet cookies of variety VR-988 had a combination of desirable and lasting aroma and flavor coupled with typical baked millet taste. However the dark color of cookies than control biscuits did not adversely affect the acceptability by panelist. Thus on the basis of results obtained it was conclude that the sample "T_2 "at blend ratio WF: FMF: 260:760g for variety"VR-988" was best cookies highly acceptable by panel members other than cookies of other composition cookies and even in other varieties.

Table 5: Effect of sensory evaluation on millet biscuits for variety VR-900

Treatment	Color	Appearance	Flavor	Texture	Taste	Overall Acceptability
T_0	7	6	6	4	7	7
T_1	7	6	8	8	7	7
T_2	8	7	5	6	7	8
T_3	7	8	7	6	5	7

Table 6: Effect of sensory evaluation on millet biscuits for variety VR-988

Treatment	Color	Appearance	Flavor	Texture	Taste	Overall Acceptability
T_0	8	7	9	7	9	8
T_1	9	8	9	8	9	9
T_2	8	7	7	8	8	8
T_3	8	7	7	8	8	9

Table 7: Effect of sensory evaluation on millet biscuits for variety VR-1076

Treatment	Color	Appearance	Flavor	Texture	Taste	Overall Acceptability
T_0	6	5	6	7	8	8
T_1	7	9	7	9	8	8
T_2	4	8	5	7	6	8
T_3	4	6	7	7	8	7

Conclusion

As millets are reservoir of "nutrition". In the present study use of finger millet flour as a replacement for refined wheat flour in the preparation of cookies was effective in enhancing its nutritional and sensory attributes. It is concluded that the sample "T_2 "at blend ratio WF: FMF: 260:760g for variety"VR-988" was best cookies highly acceptable by panel members for their taste, flavor and texture than cookies of other composition cookies and even in other varieties. Nutritional and sensory evaluation results was also good enough for this variety. So it is conclude that incorporation of millet flour in this combination not only made cookies formation easy but also gives best nutritional elements to human health. Preparing this product is economical and can consumed by all age of people. As millets are considered "future generation smart foods" by preparing millet based cookies it not only provides nutrition to people but also provides employment to farmer, rural youth and women if they are further moving towards processing of millets as well as value addition of other millets and finally turns them into food business entrepreneurs.

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