Development of biscuits substituted with millets (Ragi and Foxtail) and traditional rice varieties flour.

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Abstract

The present investigation has been focused to determine the physicochemical properties of the biscuits substituted with millets like foxtail and ragi flour followed by the pigmented rice flours like black and red rice. The prepared biscuit samples were executed to analyze the physical properties like diameter, thickness, spread ratio and baking loss. Among the treated samples T4 exhibited the better sensory characteristic of 8 with a highest fibre content of 2.61±0.09% followed by 22.07±0.79% protein and a carbohydrate of 42.30±1.52% with a hardness value of 132.06±4.76 N respectively. The microstructure of all the samples showed the uniform change in the colour and better mixing properties. Hence the studies concluded that development of biscuits by the incorporation of millet flour and pigmented rice flours not only improves the organoleptic properties but also enhance the nutrient availability to combat lifestyle diseases and disorders.

Keywords: Biscuits, Black rice, Foxtail millet, Red rice, Ragi**.**

1. Introduction

Biscuits are a group of bakery products relished by people of all age groups. The main ingredient used in the preparation of this aesthetic product is refined wheat flour followed by fat, sugar, colour and flavouring agents[1]. Though biscuits are found to be nutritious due to the inclusion of fat and refined wheat flour has proven to be unhealthy and considered as 'allergenic' among the elderly people suffering from lifestyle diseases and disorders like diabeties, obesity and cognitive heart failure[2]. Various researches have been undertaken to improve the nutritional status of the

biscuit by substituting other flours rich in fibre like millets especially with ragi, pearl millet, bajra, foxtail millet bajra etc. Among the minor millet ragi and foxtail millets have proven to be rich in fibre, vitamins, Sulfur containing amino acids, zinc, calcium, phytochemicals, gluten free and helps in reliveing the blood glucose level by releasing the sugar slowly into the blood stream. Thus incorporation of such flours in the preparation of bakery goods not only enriches the taste but also maintains the intestinal microflora by aids in digestion and easy bowel movement among diabetic people[3].

Researches have also proven that flours fortified with traditional rice varieties like black rice, red rice like Poongar, Mapillai samba, Karunguruvai improves the antioxidant levels in the bakery products. Traditional rice varieties, on the other hand are a group of rice which is also called as 'coloured rice' or 'pigmented rice', the colour may vary from red, purple or black due to the deposition of anthocyanin pigment present on the outer covering of the rice[4]. These class of rice varieties helps in controlling the blood glucose level, helps to fight against obesity, aids in digestion, circulation of blood, relives stomach problems, muscle cramps.The red rice varieties have wide array of nutritional and medicinal properties. They can be consumed as a whole or can be converted in the form of rice wine, incorporated with other ingredients in new product development like cookies, cakes, fermented bread etc. Apart from red rice, black rice is loaded with ample amount of anthocyanin like peonidin 3 gulcoside and cyanidin 3 glycoside which help to combat cancer through regular consumption also it contains vitamin E and antioxidants. It provides around 35% of the required nutrients and antioxidants in our daily diet. Hence it is advisable to incorporate multi-grains in the diet to fulfill the nutrition gap[5].

By considering the above problems in to the consideration, the present study has been undertaken with the following objectives like a) to develop biscuits substituted with foxtail millet and traditional rice varieties (red and black rice) b) to investigate the physico-chemical properties of the developed product.

2. Materials and methods

Raw material procurement

The local market in Guntur, Andhra Pradesh, provided the basic materials needed for the current inquiry and the lab analysis was done in Vignan University, Guntur, Andhra Pradesh, India.

The composition of the biscuits substituted with foxtail millet and traditional rice flour has been depicted in Table 1. The detailed procedure comprises of creaming of butter along with sugar, weighing and mixing of the dry ingredients, kneaded into a dough and sheeting it followed by cutting into the desired shape, baking in a oven with a prior heat of 180 °C for 20 minutes, cooling and packaging.

Table 1. Ingredient formulation in the development of biscuit substituted with millets and traditional rice varieties flour.

Ingredients	**Control**	**T1**	**T2**	**T3**	**T4**
Refined wheat flour, g (RWF)	100	60	50	40	30
Red rice flour (RRF), g	-	20	20	30	30
Black rice flour ((BRF), g	-	10	10	10	15
Ragi Flour (RF), g	-	5	10	10	10
Foxtail millet flour (FMF), g	-	5	10	10	15
Icing Sugar, g	30	30	30	30	30
Butter, g	50	50	50	50	50
Milk powder, g	20	20	20	20	20
Sodium bicarbonate, g	1	1	1	1	1

Fig 1: Biscuits substituted with millets and traditional rice varieties flour.

Physical properties of the biscuits

Diameter

A ruler was used to measure the six biscuits' overall diameter and thickness in mm. The biscuits were turned 90 degrees in order to read twice. To determine the average diameter, the experiment was repeated three times, and the results were reported in millimetres (mm)[6].

Thickness

Biscuits were stacked on top of one another to gauge thickness. With the use of a ruler, the entire height was measured in mm. This technique was carried out three times to obtain an average value[7].

Spread ratio and baking loss

Spread ratio of the prepared formulation was determined by dividing the diameter over the height of cookies. The baking loss has been calculated by taking into an account of weight of 5 cookies before and after baking. The obtained results were experimented in triplicates as per the procedure followed by Chauhan, Saxena, & Singh (2016)[7].

Proximate composition

The developed biscuits have been analyzed for the proximate composition in triplicates like moisture, protein, carbohydrate, fat, ash and fibre as per the procedure followed by AOAC, (2007)[8]. By placing 5g of the sample in a hot air oven for 1 h at 130 °C, followed by cooling in a desiccator to determine weight loss, the moisture content of the produced formulation was calculated. The determination of the crude fibre and ash content using gravimetric and dry ashing methods followed by the fat content using the Soxhlet apparatus and solvent extraction method. The differential approach was used to compute the amount of carbohydrates, which is 100 minus (Moisture% + Fat% + Protein% + Crude Fibre% + Ash%)[9].

Antioxidant activity

The produced samples' antioxidant activity was examined using DPPH in triplicates. 3.9 ml of 0.1 M DPPH solution in the methanol is added to 90 ml of distilled water,

10 µl of acidified methanolic extract, and 3.9 ml of the methanol during the operation. In order to determine the percentage of DPPH inhibition, the solution was mixed in a vortex machine for 30 minutes in the dark[10].

Texture analysis

The cookies' textures were examined using a texture analyzer (TA-XT2i, Stable Micro Systems, UK). Using a Texture Analyzer and Texture Expert software, the samples' instrumental texture measurements were performed. A flatended cylindrical probe (P/75) measuring 75 mm in diameter was used for a single compression test. The compression platen moved down onto the spread when a trigger force of 1000 g was reached, and a sharp increase in force was noticed. Although the sample distorted during this step due to the applied strain, the product didn't seem to be breaking down. Small peaks could be noticed on the graph profile as the compression distance grew, signifying a sample failure due to compression. When the test was over, this phase rapidly came to an end, as shown by a significant drop in force. The ability to sustain compression without sample breaking increases as the distance increases. Hardness was one of the parameters derived from the curves. For each formulation, values were the mean of at least three replicates and represented in N[11].

Sensory analysis

Using a 9-point Hedonic scale, a semi-trained 32-member panel rated the sensory qualities comprising appearance, texture, flavour (taste and scent), aftertaste, and overall acceptability. The lowest score was 1 (severe dislike), and the highest was 9 (like extremely). Here, we performed an analysis of variance (ANOVA) test using R software to see if there were any significant differences between the variances for different sensory aspects[9].

SEM analysis

A scanning electron microscope (TE-SCAN VEGA 3 SEM) has been used to study the microstructure of a sample of pigmented rice, foxtail, and ragi flour in the biscuit recipe in order to look for any surface modifications[4].

Statistical analysis

Completely Randomized Design (CRD) has been adopted in the present study to analyze the significant difference (P≤0.05) between the treatments.

3. Results and discussion

The physical properties of the prepared biscuits has been analysed for diameter, thickness, spread ratio and baking loss and presented in Table 2. It has been noticed that the maximum diameter of 55.90±2.01 and 55.90±0.64 mm in T4 and T3 respectively with less significant difference between the treatments (P≤0.05). The slight variation in the diameter of different treatments might me the variation in the proportion of added flour and also the bulk density of the ingredients utilized in the formulation. Similarly, a decrease in thickness of 8.5±0.30 mm(T4) with an increase in diameter of upto 55.91±2.01 mm has been noticed in T4. This variation in diameter in thickness might be due to the difference in retention of water among the ingredients used in the formulation which indeed affects the final weight of the developed formulation. The same observation in terms of decrease in thickness in foxtail millet fortified with papaya pulp has been noticed by Kulla & Kuraganti (2021)[2].

On the other hand, the maximum spread ratio of 6.2±0.07 and 6.2±0.22 has been noticed in T3 and T4 respectively with no significant difference compared to other samples. This might be due to the interference of the ingredients like pigmented rice, foxtail millet and ragi along with the butter and baking soda which affects the rising quality of the final product. The spread ratio of biscuits mainly determines the quality of the flour used in the formulations[12].

The baking loss indicated the percent of moisture lost during the baking process which indeed affect the baked goods texture and organoleptic properties. In the present investigation, the significant reduction in the moisture loss has been assessed with respect to the ingredient modification. Among the treatments T4 and T3 showed the maximum baking loss of 15.12±0.51 g/100g and 15.12±0.16 g/100g respectively with a minimum baking loss of 17.65±0.81 g/100g in Control sample might be due to the difference in water evaporation and retention capacity of the flour. With respect to the variation in the flour composition and its water holding properties indirectly affects the moisture loss and weight in the prepared formulations[13].

Table 2: Physical properties of the biscuit fortified with traditional rice flour, ragi and foxtail millet.

Treatments	Diameter (mm)	Thickness (mm)	Spread ratio	Bake loss (g/100g)
Control	55.64±2.55	8.70±0.39	5.60±0.25	17.65±0.81
T1	55.70±2.00	8.60±0.310	6.12±0.22	16.42±0.59
T2	55.85±1.47	8.56±0.226	6.15±0.16	15.18±0.40
T3	55.90±0.64	8.54±0.09	6.20±0.07	15.12±0.16
T4	55.90±2.01	8.50±0.30	6.20±0.22	15.12±0.51
S.Em	**1.071**	**0.165**	**0.114**	**0.311**
CD (5%)	**3.374**	**0.521**	**0.36**	**0.981**
CV	**3.33**	**3.349**	**3.28**	**3.48**

Proximate composition

The proximate composition of the formulated biscuits evaluvated for moisture, protein fat, ash, carbohydrates and fiber have been presented in Table 3. It has been observed that among the treatments T4 should the least moisture content of 5.5±0.19% compared to other treatments, this is because as the percentage of ragi (10%) and foxtail millet (15%) flour increases more moisture will be retained in the dough and during the baking more moisture will be evaporated. The maximum moisture content of 7.0±0.32% has been depicted in control sample which is devoid of other flours. It has been observed that T4 exhibited a highest protein content of 22.07±0.79% followed by 20.32±0.23%. Similarly T4 and T3 also proven to have a highest fibre content of 2.61±0.09 and 2.59±0.03% respectively. This is because the ingredients like ragi, traditional rice like red and black rice, foxtail millets comprises more of protein and fibre with less amount of carbohydrates and fats respectively. These properties impact the final nutrient composition of the prepared biscuties. Among the preparations control sample. Due to the inclusion of red rice and black rice a slight increase in the carbohydrate composition has been noticed in T1 followed by T2, T3 and T4 respectively. The variation in the nutritional composition of the

prepared biscuites is directly influenced by the flours of the grain used in the formulation[7,11].

Table 3. Proximate composition of the biscuit fortified with traditional rice , ragi and foxtail millet flour.

Treatments	Moisture	Protein	Fat	Ash	Carbohydrates	Fibre
C	7.0±0.32	14.89±0.68	29.38±1.34	8.4±0.38	39.91±1.82	0.42±0.02
T1	6.0±0.21	17.34±0.62	21.62±0.78	7.8±0.28	43.65±1.61	2.43±0.09
T2	6.5±0.17	17.17±0.45	21.30±0.56	8.0±0.21	43.60±1.16	2.53±0.07
T3	6.0±0.06	20.32±0.23	21.22±0.24	7.6±0.08	42.32±0.48	2.59±0.03
T4	5.5±0.19	22.07±0.79	21.18±0.76	6.4±0.23	42.30±1.52	2.61±0.09
S.Em	**0.122**	**0.342**	**0.475**	**0.149**	**0.81**	**0.039**
CD (5%)	**0.385**	**1.077**	**1.496**	**0.47**	**2.553**	**0.122**
CV	**3.42**	**3.236**	**3.596**	**3.389**	**3.305**	**3.178**

Antioxidant Properties

Antioxidants are those compounds that neutralizes the formation of free radicals to combat oxidation process. It has certain functional properties like anti-inflamatory, anti-carcinogenic and anti-ageing. From the studies, it has proven that red, black rice and certain millets like foxtail and ragi are a great source of antioxidants. Inclusion of these cereals and millets in bakery formulation not only enhances the antioxidant level but also helps to fight against certain lifestyle disorders. Fig 2 depicts the antioxidant levels of the developed biscuits. It has been observed that T4 exhibited a highest level of antioxidant of around 20.10±0.72% DPPH followed by 20.08±0.23% DPPH (T3), 19.58±0.52% (T2) and 19.46±0.70% (T1) respectively with a least level of 17.60±0.81% in control sample. The same has been noticed by Kulla and Kuraganti (2021)[2] in a biscuit fortified with 35% of papaya pulp. From the studies it has also been concluded that biscuits enriched with traditional rice varieties can improve the antioxidant level.

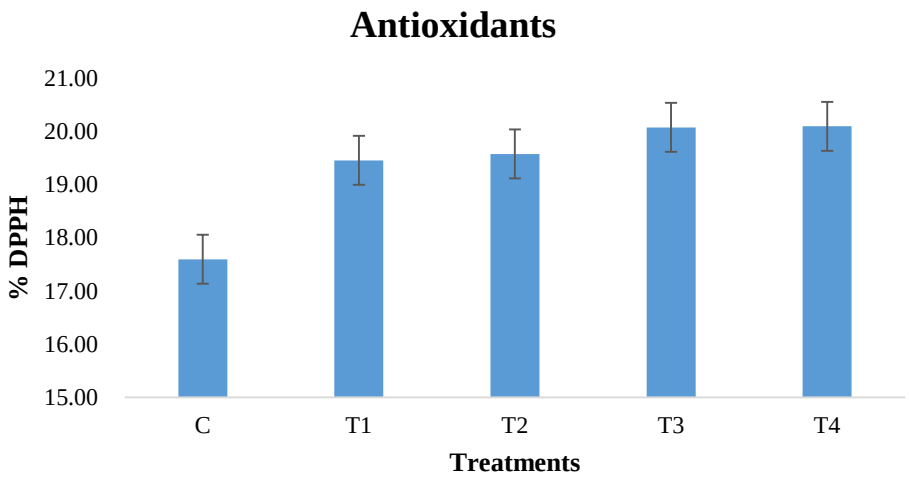

Fig 2. Antioxidant properties of the biscuit samples

Texture

The textural features of the biscuit samples were analysed using a texture profile analyzer(TPA) and presented in Fig 3. It has been predicted that hardness of the biscuits varies with respect to the percentage of flours used in the fortification. It has been noticed that the control sample executes a hardness value of 145.06±6.65 N. Among the treated samples, T3 showed a minimum hardness of 130.01±1.50 N and 132.06±4.76 N (T4) with a maximum of 136.32±4.92N (T1) and 134.07±3.55 N(T3) respectively. However, the studies rectified that the hardness value increases when the wheat flour is fortified with other flours.

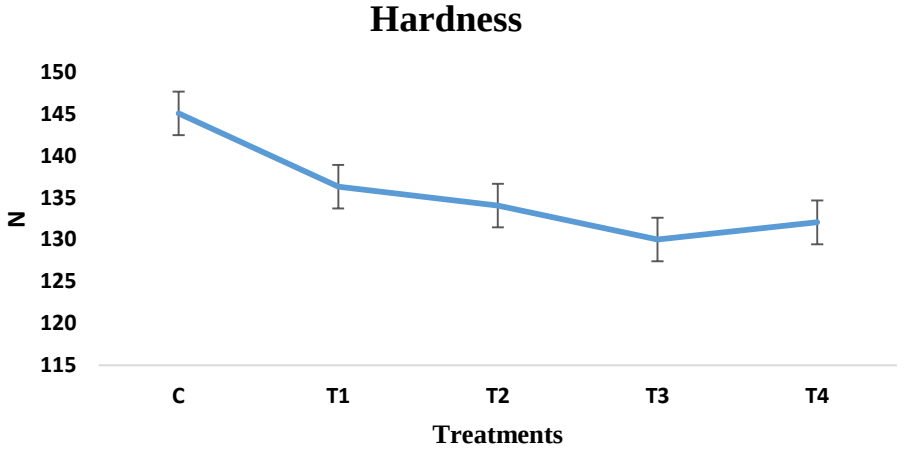

Fig 3. Texture profile (Hardness) of the biscuit samples.

as a part of treatment and the same has been reported by Sharma & Chopra (2015)[14] in a developer biscuits fortified with malted barley[15].

Sensory Characteristics

Sensory properties are an important attribute to judge the organoleptic properties of the product and has been presented in Fig 4. From the present investigation it has been observed that as the percentage of black rice and red rice flour along with ragi, the

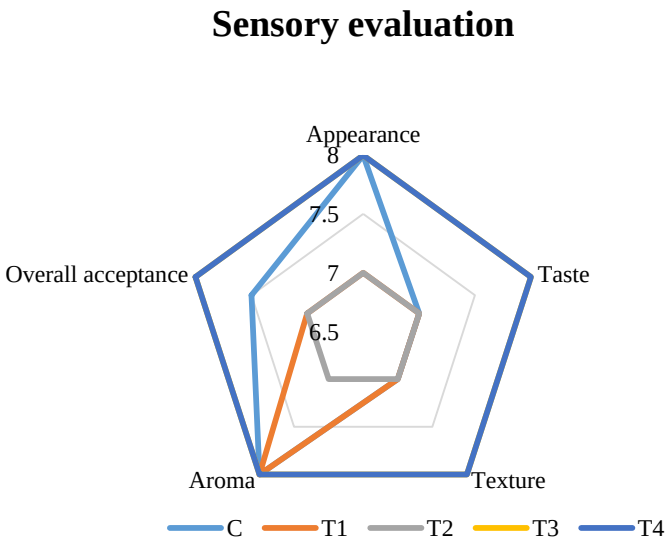

Fig 4. Sensory evaluation of the biscuit samples.

colour seems to be dark after baking. The highest appearance score of 8 has been observed in control, T3 and T4 samples with a minimum score of 7 in T1 and T2 respectively. On the other hand the taste and texture of the developed biscuits was seemed to be acceptable by the sensory panelist and the product I.e., T3 and T4 ranked 8 with an acceptable aroma and flavor. Conversely the overall acceptability of

8 has been given to T3 and T4 followed by the other treatments. The outcomes were in agreement with those of Asefa, Assefa, Girma, Tsehanew, & Shemsadin (2017)[16] who reported that the colour of the cookies changes with an increase in the proportion of added mango pulp. Similarly, Yusufu & Akhigbe (2014) also reported that the inclusion of papaya flour (25%) along with wheat flour tastes better with overall acceptability[17].

Microstructure of the biscuits

The microstructure of the developed biscuits has been analyzed using a SEM analyzer with different magnifications to visualize the structural changes after the baking and presented in Fig 5(a), 5(b), 5(c), 5(d) and 5(e) respectively. The minor cracks on the surface of all the samples have been evidenced. This might be due to the exposure of biscuit samples to a baking temperature of 180 ℃ for 20 min which helps in the uniform absorption and distribution of heat. Conversely, the darken surface of the biscuit was found to be more in treated samples compared to the control sample. This is because of the inclusion of pigmented rice flour along with the ragi flour which varies with respect to the treatment. The colour change is also due to the caramelization of sugar along with the amino acid. Apart from all these changes a surface cavities can be seen on the surface of T1, T2, T3 and T4 respectively as a result of inclusion of fibre present in the flour samples like millet and ragi. The another reason for the variation in size of the surface cavity is due to escape of gases and expansion of bubbles as a result of baking and In soy flour enhanced biscuits, Yang et al.(2022)[17] recorded a similar observation.

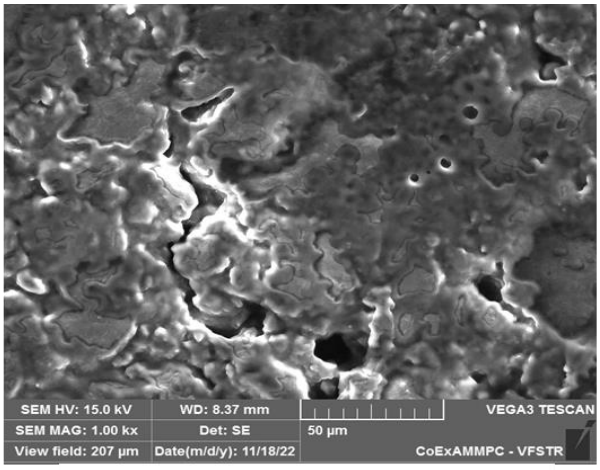

Fig 5(a): Control: 100% (RWF)

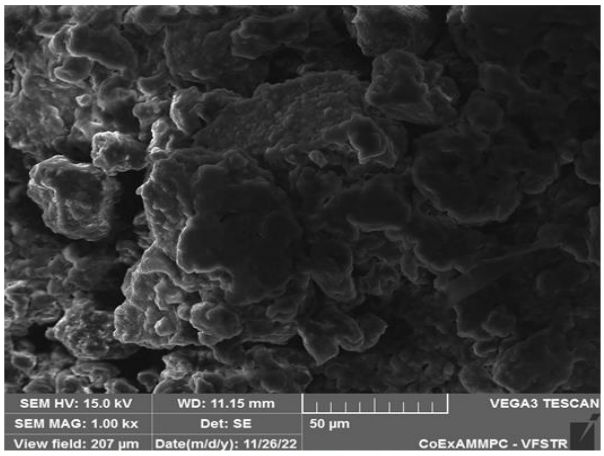

Fig 5(b): T1-60(RWF):20(RRF):10(BRF):5(RF):5(FMF)

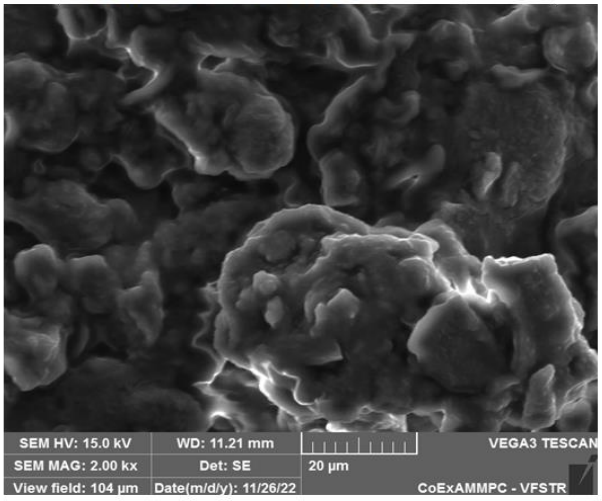

Fig 5(c):T2-50(RWF):20(RRF):10(BRF):10(RF):10(FMF)

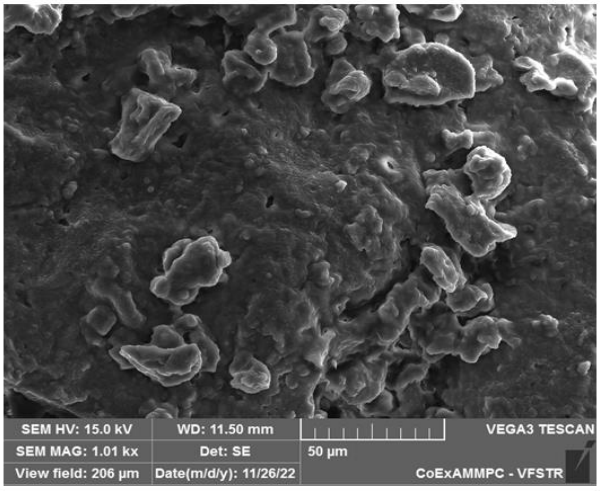

Fig 5(d):T3-40(RWF):30(RRF):10(BRF):10(RF):10(FMF)

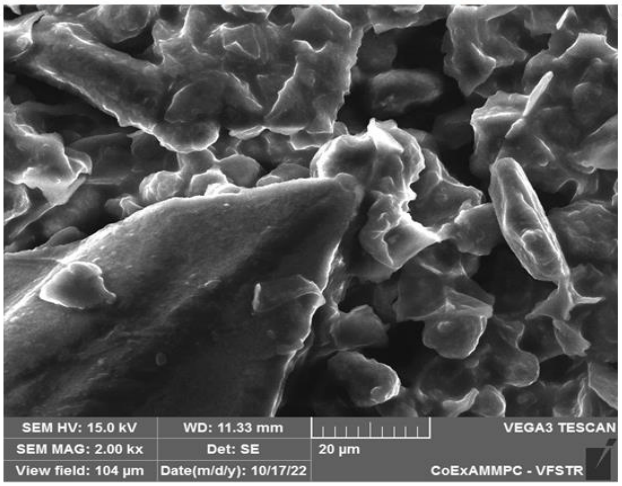

Fig 5(e):T4-30(RWF):30(RRF):15(BRF):10(RF):15(FMF)

Fig 5(a), 5(b), 5(c), 5(d) and 5(e): Microstructure of the biscuit samples captured in a SEM analyzer.

4. Conclusion

In the view of the experimental results obtained during the present investigation that biscuits prepared by incorporation of pigmented rice flours like red and black rice in combination with foxtail and ragi flour millets in the biscuit preparation has proven to increase in the substantial levels of carbohydrates, protein, fat, ash, and antioxidant levels with better textural properties . T4 was discovered to be the sample with the best organoleptic qualities, such as colour, appearance, texture, scent, taste, and general acceptance. Because these formulations offer anti-carcinogenic qualities, their development and use will not only assist the population's nutritional status but also aid in the fight against disorders like diabetes, cancer, and other illnesses.

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6. Conflict of Author(s)

There is no conflict of authors.

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