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Development and Quality Evaluation of Biscuits from Sweet Potato and Minor Millets

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Abstract: ***In the present research work, attempt was made to develop biscuits from sweet potato and Minor millets viz. Amaranth and Echinochloa colona. The sweet potato tubers were sorted, washed, peeled, sliced, blanched, drained, dried and milled into flour. The Amaranth and Echinochloa grains were cleaned, sorted and milled into the flour. These flour samples were thereafter subjected to functional properties analysis. Efforts were made to develop biscuits having different proportions of sweet potato flour, Amaranth flour and Echinochloa colona flour viz. SPFB2 (10 % + 60 % + 30%), SPFB3 (20% + 45%+ 35%), SPFB4 (30% + 30%+ 40 %), SPFB5 (40% + 15%+ 45%) while SPFB1 (100% + 00 + 00) served as control. The biscuits were baked in a thermally controlled oven at temperature of 170 º C for 15 mins. The prepared biscuits were subjected to proximate, textural, sensory analysis and stored under ambient conditions for a period of 120 days in LDPE and aluminium foil bags. The physical properties of biscuits made by various blending were determined. The results of sensory analysis showed that, SPFB5 (40% sweet potato + 15% Amaranth flour + 45% Echinochloa colona flour) secured maximum score for colour, flavour, taste, texture, appearance and overall acceptability. The developed biscuits were shelf stable till 90 days of storage in aluminium foil bag. The cost of production of biscuit for the best selected treatment on sensory basis was about Rs.200/kg.***

Keywords: Sweet potato flour, *Amaranth* flour, *Echinochloa colona* flour, functional properties

1. Introduction

Bakery products are getting increasingly popular in India thanks to their convenience, unique taste and straightforward availability at reasonable cost. Among bakery products, biscuits/cookies and crackers are the foremost popular and versatile snack foods and widely consumed to satisfy the occasional 'pangs' of hunger and are an integral part of the society. (Nagi*et al*., 2012).

Starchy root and tuber crops are global sources of carbohydrates after cereals. The Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant thatbelongstomorning glory family, *Convolvulaceae. (*Purseglove and Williams, 1968). Sweet potatoes have high levels of digestible carbohydrates, contributing to calories, vitamins and minerals intake. Also, it is a source ofcarotenoids, vitamins A, C and B complex, besides minerals such as potassium, iron and calcium. Sweet potato flour provides 14%-28% of the dietary reference intake (DRI) for magnesium and 20-39% for potassium (Van Hal M., 2000).

Amaranth plants are classified as pseudo cereals that are grown for their edible starchy seeds. Amaranth seed have higher level of dry matter, protein and ash than cereals and are rich source of protein, fat, fiber and important minerals. (Bodrozaet *al.,* 2003). Because of its high nutritional qualities, it has various baking applications (Lorenz K and F. Collins., 1981). Also, Amaranth has become popular among patients with celiac disease because it does not cause allergies within in the intestinal mucosa. However, the high prevalence of diabetes mellitus among these patients is well known (Guerra-Matias and Areas, 2005).

Echinochloa colona (Vari cha Tandul or Samay ka chawal) may be a fair source of protein with high digestible value and it is an excellent source of dietary fibre with good amount of soluble and insoluble fractions (Veena *et al.,* 2005). The carbohydrate content is low and slowly digestible. Besides, it is rich in minerals and phytochemicals. It has been proved to be suitable for people suffering from metabolic disorders such as *diabetes mellitus (*Ugare, 2008). Additionally, it can blend with most of traditional and novel foods without imparting any flavours of its own.

Considering the nutritional and health benefits of sweet potato flour, *Amaranth* flour, *Echinochloa colona* flour and to increase value addition to it by providing alternative product during fastings (Wrat), the present study was undertaken to replace wheat flours by gluten free flours.

2. Materials and Methods

Processing of raw materials

Good quality of sweet potatoes without any bruises and other major ingredients viz. *Amaranth*and *Echinochloa colona* grains, sugar, vanaspati, baking powder were purchased from local market of Dapoli. Milling of amaranth and Echinochloa colona was done to obtain fine flour with help of attrition mill. The experimental studies were carried out at Bakery training centre, Department of Agricultural Process Engineering, College of Agricultural Engineering

and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Table 1: Treatment details

Treatment	Sweet potato flour	Amaranth flour	Echinochloa colona flour
SPFB1	100%	00	00
SPFB2	10%	60%	30%
SPFB3	20%	45%	35%
SPFB4	30%	30%	40%
SPFB5	40%	15%	45%

Table 2: Ingredients used in preparation of Biscuits (g.)

Sr. No.	Ingredients (g.)	SPFB1	SPFB2	SPFB3	SPFB4	SPFB5
1.	Sweet Potato Flour	100	10	20	30	40
2.	Amaranth flour	00	60	45	30	15
3.	E. colona flour	00	30	35	40	45
4.	Vanaspati	60	60	60	60	60
5.	Sugar	30	30	30	30	30
6.	Baking powder	5	5	5	5	5
7.	Salt	5	5	5	5	5

Figure 1: Flow chart for preparation of sweet potato flour

Proximate composition of flours and Biscuits

Proximate composition of flours and developed biscuits was evaluated using standard methods at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

1) **Protein Content:** Protein content of developed flours and biscuits was determined by Kjeldahl method (AOAC, 2000).

$$\text{Protein (\%)} = \frac{(S-B)\times N\times 14.01\times 100\times 6.25}{W\times 1000}$$

where,
S = Volume of standard acid (0.1 N HCl) used for titration (cm^3).
B = Volume of 0.1 N HCl used for blank (cm^3).
W = Weight of sample (g).
N = Normality of acid used for titration (0.1 N HCl).

2) **Fat Content:** Fat content was estimated by the standard method (AOAC, 2000) using a Soxhlet extraction apparatus.

$$\text{Fat (\%)} = \frac{\text{Weight of sample after drying} - \text{weight of empty cup}}{\text{Weight of sample taken}} \times 100$$

3) **Moisture Content:** Moisture content was calculated by employing the standard methods of analysis (AOAC, 2000).

$$\text{Moisture Content (\%)} = \frac{W_1 - W_2}{W1 - W} \times 100$$

where,
W = Weight of empty dish (g).
W_1 = Weight of sample before drying (g).
W_2 = Weight of sample after drying (g).

4) **Ash Content:** Ash content was estimated by employing the standard method of analysis (AOAC, 2000) using a muffle furnace.

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

where,
W = Weight of sample (g).
W_1 = Weight of crucible + Weight of sample before heating (g).
W_2 = Weight of crucible + Weight of sample after heating (g).

5) **Crude Fibre:** Crude fibre was determined by the method reported by Rangana, 1986.

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

where,
W = Weight of sample (g).
W_1 = Weight of the sample before ashing in g.
W_2 = Weight of the sample after ashing in g.

6) **Carbohydrate:** Carbohydrate content was determined by the method reported by NIN, 1983.

Total Carbohydrate = 100-(%moisture + % fat + % protein + % ash + % fibre).

7) **Energy:** The energy was calculated by method reported by Sally *et al*., 1996.

Energy = (% crude protein × 4) + (% crude fat × 9) + (% carbohydrate ×4).

8) **Free fatty acid:** Free fatty acid was determined by standard method of AOAC, 2000.

$$\text{Free fatty acid (FFA) \%} = \frac{28.2 \times V \times N}{W}$$

where,
V= Volume of standard KOH in ml
N= Normality of KOH solution
W= Weight of sample

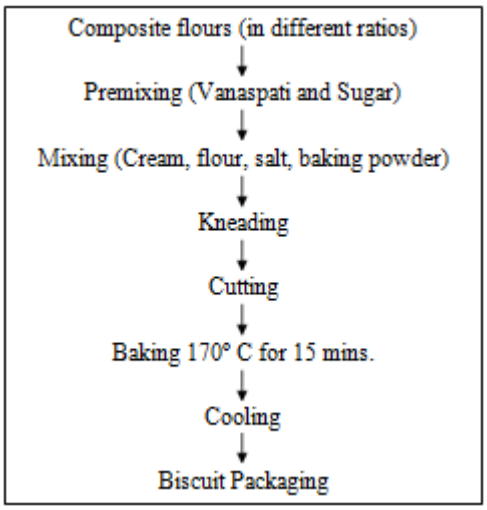

Figure 2: Flow chart for preparation of sweet potato biscuits

Physical properties of developed biscuits

Thickness: The thickness was measured in mm using Vernier caliper.

Diameter: The diameter was measured inmm using Vernier caliper.

Volume: Volume of biscuit is defined as the area of the biscuit multiplied bythickness.

$$\text{Volume (cm}^3\text{)} = \frac{\pi \times T \times d^2}{4}$$

where,

T = Average thickness of biscuit (mm).

d = Diameter of biscuit (mm)

Spread ratio: The spread ratio was determined by using the formula.

$$\text{Spread ratio} = \frac{\text{Diamater (mm)}}{\text{Thickness (mm)}}$$

Density: After calculating volume, density was obtained by ratio of weight ofvolume (AACC 1983).

$$\text{Density (g/cm}^3\text{)} = \frac{\text{Mass of sample (g)}}{\text{Volume of sample (cm}^3\text{)}}$$

Hardness of Biscuits

Biscuit hardness was determined using texture analyser machine (Make: Shimadzu, Japan, Model: AG-X, Capacity: 2500 N). The samples were subjected to compression at testerhead travel speed of 5 mm/min using a probe and the trigger force was 0.196 N. The biscuits wererandomly selected to evaluate hardness.

Colour

A colour co-ordinate of biscuit was measured under Colour Scanning Machine (Make: Premier colour scan, Thane). It represents the colour in L*, a* and b* value. Degree of lightness or darkness of the samples was represented by "L*" value, redness to greenness by "a*" value and yellowness to blueness by "b*" value on Hunter scale. The apparatus was previously calibrated with standard white and black tile. Colour (L*, a*, b* values) of the biscuit samples were determined.

Sensory Analysis

Sensory analysis was carried out in NAIP laboratory of Department. of Agricultural Process Engineering and Technology, CAET, Dapoli. Product of different treatments were analysed by panel of judges from college faculty and students. The samples were evaluated on the basis of colour, flavour, taste, texture, appearance and overall acceptability using 9-point hedonic scale.

3. Results and Discussions

Functional Properties

Table 3: Functional Properties of flours

Properties	Flours		
	Sweet potato	*Amaranth*	*Echinochloa colona*
Bulk Density, (Kg/m^3)	867	750	802
Swelling Capacity, (ml/g)	3.427	2.560	2.353
WAC, (g/ml)	2.600	9.423	2.850
OAC, (%)	83.157	58.430	85.583
Wettability, (s)	44	37.333	38.667
Solubility, (%)	9.400	6.553	5.850

Table 4: Proximate composition of developed flours

Properties	Flours		
	SPF	Amaranth	E. colona
Protein, (%)	2.31	15.32	11.13
Crude Fat, (%)	0.55	5.84	8.47
Moisture, (%)	8.74	7.54	9.62
Ash, (%)	2.92	2.76	3.75
Fibre, (%)	1.72	8.42	2.94
Carbohy. (%)	88.41	68.47	64.65
Energy, (kcal/100g)	385.68	319.43	339.26

Table 5: Proximate composition of developed biscuits

Nutritional property	Treatments				
	SPFB1	SPFB2	SPFB3	SPFB4	SPFB5
Protein (%)	1.28	6.82	6.10	5.28	4.54
Crude Fat (%)	55.63	31.63	31.6	31.39	31.27
Moisture (%)	4.89	4.56	4.66	4.693	4.76
Ash (%)	1.06	1.37	1.28	1.103	1.007
Crude Fibre (%)	0.73	3.53	2.88	2.17	0.84
Carbohy. (%)	56.36	47.79	46.4	44.87	43.61
Energy, (kcal/100g)	744.97	502.5	492	482.3	472.1

Table 6: Physical properties of developed biscuits

Treatment	Dia. (cm)	Thick. (cm)	Weight (g)	Vol. (cm^3)	Spread Ratio	Density (g/cm^3)
SPFB1	3.79	0.89	7.66	10.04	4.27	0.77
SPFB2	3.74	0.86	7.30	9.46	4.34	0.77
SPFB3	3.75	0.88	7.52	9.74	4.29	0.78
SPFB4	3.76	0.88	7.54	9.78	4.28	0.77
SPFB5	3.78	0.89	7.64	9.93	4.27	0.77

Table 7: Colour and Hardness of developed biscuits

Treatments	Colour			Hardness (N)
	L*	a*	b*	
SPFB1	57.22	3.98	17.94	10.06
SPFB2	61.5	2.91	17.73	36.39
SPFB3	58.41	3.43	15.53	30.74
SPFB4	56.68	3.47	16.41	26.48
SPFB5	60.92	3.25	18.24	16.78

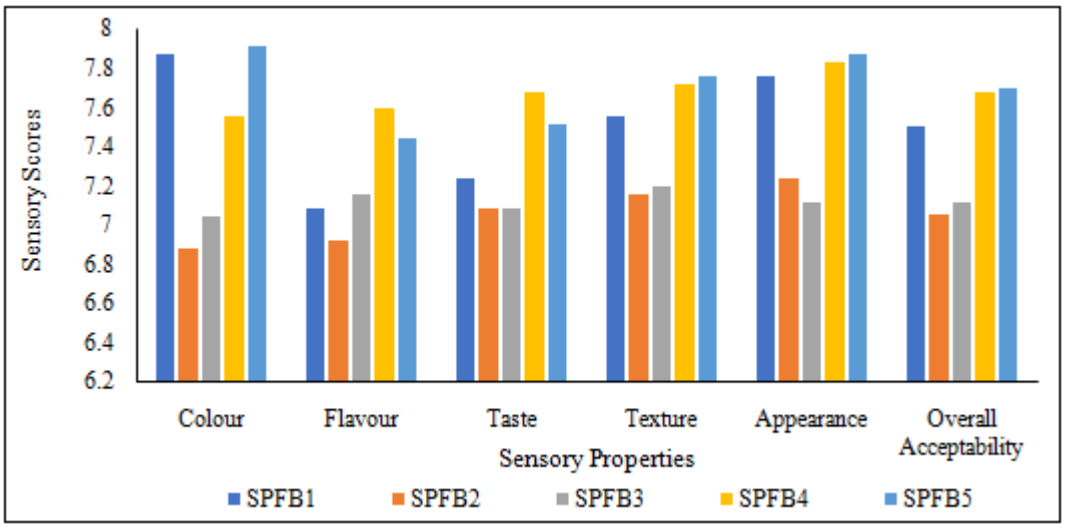

Figure 3: Effect of different proportions of flours on the sensory properties of developed biscuits

Functional Properties of developed flours

The functional properties of developed flours are presented in Table 3. The average bulk density of sweet potato flour was found to be 867 Kg/m^3 while that of *amaranth* flour and *Echinochloa colona* was found to be 750 Kg/m^3 and 802 Kg/m^3 respectively. Water absorption capacity of sweet potato flour was found to be 2.6 g/ml while that of *amaranth* and *Echinochloa colona* flours was found to be 9.423 and 2.85 g/ml.

The oil absorption capacity of sweet potato flour which was found to be 83.157 % and that of *Amaranth* and *Echinochloa colona* flour was 58.43 and 85.583 % respectively. Wettability of sweet potato flour was found to be 44 s while that of *Amaranth* and *Echinochloa colona* flour was found to be 37.33 and 38.667 s. Solubility of sweet potato flour was found to be 9.4% and that of *Amaranth* and *Echinochloa colona* was found to be 6.553% and 5.850% respectively. Nearly similar findings were observed by Etudaiye*et al.*, 2014 who reported similar results that sweet potato flour was significantly higher in moisture content, water absorption capacity and bulk density. Singh *et al.*, 2020 reported that WAC of 9.40 g/ml whereas Nazani et al., 2016 reported that WAC of *Echinochloa colona* flour as 2.93 g/ml.

Proximate composition of developed biscuits

The proximate composition of developed flours is presented in Table 5. Protein content of biscuits ranged between 1.283 to 6.827 %. There was significant decrease in the protein content of the biscuit with increase in proportion of sweet potato flour from 10% to 40%. The least protein content was observed in the control treatment with 100% sweet potato flour which might be due to higher moisture content in the control treatment. Crude fat content of biscuit ranged between 31.27 to 55.63 % with maximum in biscuit SPFB1 (Control) incorporated with 100 % sweet potato flour and minimum in biscuit SPFB5 with 40% sweet potato flour, 15% *Amaranth* and 45% *Echinochloa colona* flour. It was observed that Fat content decreased with increase in percentage of sweet potato flour. The moisture content of biscuit samples ranged between 4.567 to 4.897%. It is found that moisture content of biscuit increased with increase in sweet potato flour percentage and this is attributed to high water binding capacity of sweet potato which retained higher moisture content in ultimate product (Srivastava *et al.*, 2012). Previous studies have shown that incorporating sweet potato with other flours in biscuit production increases the moisture content of composite biscuits (Srivastava et al., 2012; and Kalpana M., 2005).

Ash content of the prepared biscuit samples ranged between 1.007 to 1.370 %. It was found that ash content decreased with increase in sweet potato flour percentage. Crude fibre ranged between 0.733 to 3.530%. It is observed that fibre content decreased with addition of sweet potato flour due to low fibre content in sweet potato flour and Echinochloa colona flour. The carbohydrate content in biscuit ranged between 43.607 to 56.360 %. It is seen that carbohydrate content increased with increase in sweet potato flour and baking temperature which may be due to high carbohydrate content of sweet potato flour itself. Energy in the prepared biscuit samples ranged between 472.133 to 744.970 kcal/100g. Energy content is observed higher in control with 744.97 kcal/100g.

Physical properties of developed biscuits

The diameter of biscuits ranged from 3.738 cm to 3.789 cm. The diameter of biscuits increased with increase in the levels of sweet potato flour and Echinochloa colona flour. The thickness of biscuits increased with increase in sweet potato flour proportion from 10 to 40 % in biscuits. The weight of biscuits increased with increase in sweet potato flour proportion from 10 to 40 %. The volume of biscuits ranged from 9.456 cm^3 to 10.044 cm^3. The volume of biscuits increased with increase in sweet potato flour proportion in biscuits. Spread ratio is the most important parameter to assess the quality of biscuits (Bose and Shams-Ud-Din, 2010). Spread ratio in developed biscuits ranged from 4.268 to 4.342. The highest spread ratio was observed in SPFB2 and lowest spread ratio was observed in SPFB5 treatment. Spread ratio of biscuits decreased with increase in proportion of sweet potato flour. Biscuits with high values of spread ratio are best (Eissa*et al.*, 2007). Density of developed biscuits decreased with increase in proportion of sweet potato flour from 10 to 40%.

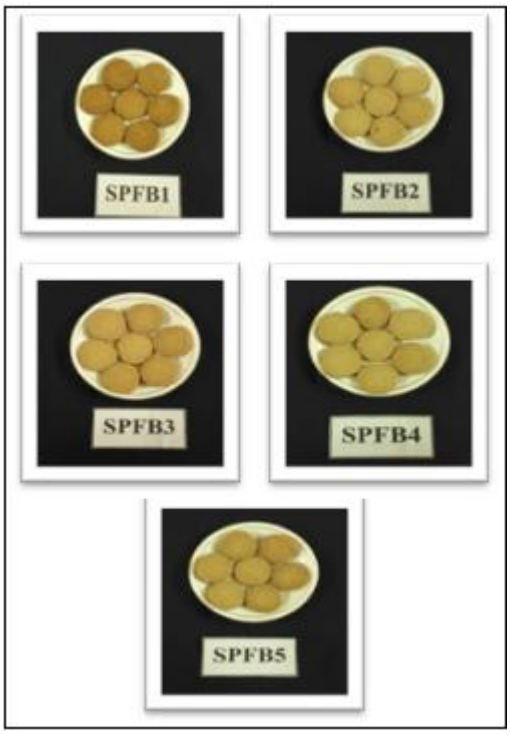

Figure 5: Developed Biscuits

Hardness and Colour of developed biscuits

Hardness and Colour of developed biscuits is presented in Table 7. The hardness strength of biscuits ranged between 10.065 N to 36.393 N. The hardness strength of biscuits decreased with an increase in the level of incorporation of sweet potato flour from 10 to 40%. The minimum hardness strength was observed in control treatment with 100 % sweet potato flour. (Hoseney and Rogers, 1994) reported that hardness of cookies is caused due to interaction of proteins and starch by hydrogen bonding.

The maximum L* value was observed in SPFB2 treatment which shows the treatment was light in colour among all the treatments. The minimum L* value was observed in SPFB4 which shows this treatment is dark in colour among all the treatments.

It is observed from Table 7 that the maximum a* value was observed in SPFB1 (Control) treatment which means that it has more redness among all treatments. The minimum a* value was observed in treatment SPFB2which means that the treatments had less redness among all treatments.

The maximum b* value was found in SPFB5 treatment which means that it is more inclination towards yellowness. The minimum b* value was found in SPFB3 treatment which indicates that its less inclination towards yellowness.

Sensory Evaluation of developed biscuits

The scores obtained from sensory evaluation of developed biscuits is presented in fig.3. The treatment SPFB5 with 40% sweet potato flour, 15% *Amaranth* flour and 45 % *Echinochloa colona* flour secured maximum score for colour, flavour, taste, texture, appearance and overall acceptability i. e.7.92, 7.44, 7.52, 7.76, 7.88 and 7.70 respectively. Gupta and Singh (2005) reported overall acceptability of biscuits containing colour and appearance, flavour, texture and taste which gives overall acceptance by considering above all attributes.

4. Conclusions

1) Amaranth flour had lower bulk density and wettability as compared to sweet potato and Echinochloa colona flour. The water absorption capacity was maximum in Amaranth flour and was minimum in Echinochloa colona flour.
2) The physical analysis shows that diameter, thickness, weight, volume of biscuits increased with increase in proportion of sweet potato flour while spread ratio and density decreased with increase in sweet potato flour.
3) The breaking strength of biscuits decreased with increase in proportion of sweet potato from 10 per cent to 40 per cent.
4) From sensory evaluation, it is concluded that the biscuits from 40% sweet potato flour, 15% amaranth flour and 45 % Echinochloa colona flour had the highest overall acceptability among all treatments.

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