Physico-chemical and Sensory Evaluation of Biscuits Developed from Blends of Jowar (*Sorghum*), Organic Jaggery and Whole Wheat Flours

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ABSTRACT

Background: Jowar (*Sorghum*) is one of the most popular millet grown in tropical and semi-arid regions. The present study was aimed to design and develop the process technology for the preparation of biscuits from blends of jowar and jaggery by replacing wheat flour.

Methods: The biscuits were analysed for physico-chemical and sensory properties. The proportions taken were 30:70:60, 40:60:60, 50:50:60, 60:40:60, 70:30:60 and 100:0:60 of jowar flour, whole wheat flour and jaggery respectively. Sensory evaluation was performed by using composite scoring test and means were evaluated by Krushkal Walli H-Test.

Result: Sensory evaluation revealed that the ratio of 100:0:60 (SWJ 6) jowar, whole wheat flour and jaggery has highest acceptability and was considered for further studies. The physical parameters of biscuits such as mass (20 g), thickness (7 mm), spread factor (64.28), diameter (45 mm) and color values were determined. The texture analysis revealed that the biscuits held hardness (32.5 g), fracturability (8.60 mm) and cutting strength (3.390 kg). Proximate analysis was estimated as energy (583 kcal), carbohydrate (92.6 g), protein (10.8 g), fat (4.8 g), crude fibre (8.6 g), calcium (46 mg), zinc (58.3 mg), iron (16.1 mg) and potassium (420 mg) per 100 g for SWJ 6 proportion.

Key words: Biscuits, Granular jaggery, Jowar (*Sorghum*), Physico-chemical properties, Sensory evaluation, Whole wheat flour.

INTRODUCTION

Biscuits are ready-to-eat, convenient snacks that are extensively consumed all over the world by all age groups. The consumption of cereal-based foods like biscuits require enhancement of a sufficient replacement for wheat. The use of millet flour is becoming common in baked products such as bread, biscuits, cookies and crackers which are targeted at consumers who are gluten sensitive or diabetic (Tanwar and Dhillon, 2017)

Sorghum also termed as Jowar, is one of the major millets known by varied names such as; great millet and guinea corn in South Africa, West Africa; mamta in eastern Africa; dura in Sudan; kaoliang in China and jowar in India (Purseglove *et al*., 1972). *Sorghum* species (*Sorghum vulgare* and *Sorghum bicolor*) is a member of the poaceae grass family and one of the oldest cereal grains, which is found abundantly in tropical and subtropical regions.

Sorghum is a traditional staple grain for domiciliary consumption (Dayakar Rao *et al*., 2007) which is rich in protein (10 g/100 g), dietary fibre (10.2 g/100 g) and low in carbohydrates (67.7 g/100 g).

It is also an excellent source of total carotenoids- 212 µg/100 g, iron- 3.95 mg/100 g and calcium- 27.6 mg/100 g (Lakshmi *et al*., 2018). Jowar is an excellent source of starch- 69.5% having amylose- 20 to 30% and remaining amylopectin-70 to 80% (Lakshmi *et al*., 2018). *Sorghum* grain is found to be responsible for reducing plasma glucose level in test subjects (Taylor and Emmambux, 2010).

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The *Sorghum* extract contained high amount of antioxidants, predominantly phenolic compounds revealing high levels of free radical sifting activity, anti-oxidant capacity and anti-lipid peroxidative activity (Kim *et al*., 2010).

Owing to the facts of nutritional aspects, jowar and organic jaggery were considered to utilize as ingredients in the preparation of biscuits. The objectives of the present study are: (i) To prepare and standardize the process of biscuits preparation with the incorporation of jowar flour, whole wheat flour and organic jaggery in different proportions (ii) To study the physico-chemical and sensory properties of developed biscuits.

MATERIALS AND METHODS

The experiment was conducted at Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Anakapalle (17°N, 83°E), Visakhapatnam district, Andhra Pradesh in the year of 2020-21.

Procurement and selection of raw materials

Jowar was collected from Agricultural Research Station, Vizianagaram (18°N, 83°E) and milled in Agro- Processing Centre, RARS, Anakapalle. Granular jaggery used in this study was prepared as per the procedure described elsewhere (Rao *et al*., 2007). Whole wheat flour, unsalted butter, sodium bicarbonate, baking powder, milk and vanilla flavours were procured from local markets of Anakapalle.

Standardization of jowar jaggery biscuits

The preparation of value-added biscuits was standardized with different proportions of jowar flour (S), whole wheat flour (W) and jaggery (J). The ratios were 30:70:60 (SWJ 1), 40:60:60 (SWJ 2), 50:50:60 (SWJ 3), 60:40:60 (SWJ 4), 70:30:60 (SWJ 5) and 100:0:60 (SWJ 6) of jowar flour, whole wheat flour and jaggery respectively. The ratios of jowar flour and wheat flour were varied keeping proportions of ingredients *i.e.* granular jaggery, unsalted butter, milk, sodium carbonate and vanilla essence were kept constant and details are presented in Table 1. The process flow chart for the preparation of jowar jaggery biscuits is given in Fig 1.

Organoleptic evaluation of jowar and jaggery biscuits

The organoleptic evaluation was done by using a composite scoring test which is a type of rating scale. In the present study organoleptic evaluation was carried out for jowar and jaggery biscuits by 30 semi-trained respondents aged between 22 and 50 years. Non-smokers and non-betel leaf chewers were selected as semi- trained respondents based on their good health at RARS, Anakapalle and means were evaluated by Krushkal Walli H-Test.

Physical properties of SWJ biscuits

Mass of jowar and Jaggery biscuits

Mass of biscuits were determined by using an electronic weighing balance (Model no- ATX224). 10 biscuits were randomly chosen from the most accepted biscuit formula (Navaneetha, 2019).

Diameter of jowar and jaggery biscuits

The diameter was measured, as per the procedure in AACC (2000). To determine the diameter (D), six biscuits were placed edge to edge. The total diameter of the six biscuits was measured in mm by using a ruler. The biscuits were rotated at an angle of 90° for duplicate reading. This was repeated thrice and the average diameter was reported in mm (Hussain *et al*., 2006).

Thickness of jowar and jaggery biscuits

The thickness of the biscuits was measured, as defined in AACC (2000). To determine the thickness (T), six biscuits were placed on top of one another. The overall height was measured in mm with a ruler. This process was repeated thrice and results were reported in mm (Hussain *et al*., 2006).

Spread factor of jowar and jaggery biscuits

The spread factor (SF) was measured by the method described in AACC, (2000). It was determined from the diameter (D) and thickness (T), with the help of the formula:

$$SF=\frac{D}{T}\times CF\times 10 \qquad \text{eq...(1)}$$

Sieving jowar flour and whole wheat flour twice with addition of sodium bicarbonate and baking powder

↓

Creaming butter and granular jaggery at the stage of creamy liquid

↓

Addition of flour gradually to the creaming mixture

↓

Pouring milk into the flour with the addition of essence

↓

Rolling out and cutting with biscuits moulds

↓

Baking at 175°C (305°F) from the range of 15 to 20 minutes

Fig 1: Process flow chart for preparation of jowar and jaggery biscuits.

Table 1: Standardization of different proportions of biscuits.

List of ingredients	Proportions					
	SWJ 1	SWJ 2	SWJ 3	SWJ 4	SWJ 5	SWJ 6
Jowar flour (g)	30	40	50	60	70	100
Whole wheat flour (g)	70	60	50	40	30	0
Granular jaggery (g)	60	60	60	60	60	60
Unsalted butter (g)	50	50	50	50	50	50
Milk (ml)	20	20	20	20	20	20
Sodium bicarbonate (g)	2	2	2	2	2	2
Baking powder	2	2	2	2	2	2
Vanilla essence	Few drops	Few drops	Few drops	Few drops	Few drops	Few drops

*SWJ: *Sorghum*-whole wheat- jaggery.

CF is a correction factor, (1.0) at constant atmospheric pressure (Hussain *et al*., 2006).

Color of jowar and jaggery biscuits

Color values of biscuits were measured by colorimeter (SS5100 Spectrophotometer color lab) using L* (lightness), a* (red to green) and b* (yellow to green) uniform color space producers. Each measurement was in triplicate and the average value was considered (Sareepuang *et al*., 2008).

Texture analysis of jowar and jaggery biscuits

Textural properties of biscuits were analyzed for highly accepted biscuit SWJ 6, using Texture Analyzer TA-XT2i (Stable Micro Systems, Surrey, England). The test was conducted by using cylindrical and cutting probes at pre-test speed of 5.0 mm/sec, test speed of 2.0 mm/sec, post-test speed of 10 mm/sec, distance of 10 mm, trigger force of 25 g, and load cell of 5 kg. Crispness was measured in terms of major positive peaks (Nath and Chattopadhyaya, 2007).

Nutrient analysis of jowar and jaggery biscuits

SWJ 6 biscuits were analyzed for moisture content (dry basis), energy (kcal), fat (g), protein (g), carbohydrate (g) and crude fibre (g) (AOAC, 2006). Minerals were estimated by Atomic Absorption Spectrophotometer.

Statistical analysis of biscuits

The analytical data of different proportions were tested by using Krushkal Walli H-Test (One-Way ANOVA and Non-Parametric) (Gopal and Kanji, 2006).

RESULTS AND DISCUSSION

Organoleptic evaluation by composite scoring test

Jowar and jaggery biscuits were prepared by varying the proportions of jowar flour and whole wheat flour, whereas proportions of granular jaggery, unsalted butter, milk, sodium carbonate and vanilla essence were kept constant. These biscuits were subjected to sensory evaluation and the mean sensory scores of composite scoring test values are presented in Table 2. There was a significant difference in the mean score of overall acceptability of the biscuits with 11.07° of freedom. H value was 15.74 and there was a significant difference between the six varieties of the sample.

Sinha and Sharma (2017) reported that biscuits prepared by incorporating ragi millet flour up to 50% level were found acceptable. The results showed that there were non-significant differences in the scores of flavour, texture, taste and overall acceptability of biscuits prepared from composite flours of ragi and refined flour.

Colour

The sensory evaluation of colour revealed a significant difference among the six proportions of biscuits. SWJ 6 has gained the highest acceptability and SWJ 1 has gained the lowest acceptability.

Flavour

The sensory analysis for flavour attribute indicated a significant difference between 6 proportions of biscuits. SWJ 6 gained the highest acceptability and SWJ 1 gained the lowest acceptability. The results suggested change in flavour of the biscuits due to the addition of whole wheat flour. (Chavan *et al*., 2016) reported that the *Sorghum* supplementation (10, 20 and 30%) significantly enhanced the flavour of biscuits as compared with the control (0% *Sorghum* flour).

Texture

The texture of the six biscuits proportions were quite different when compared with each proportion, as revealed by the composite scoring test. SWJ 6 has gained the highest acceptability and SWJ 1 has gained the lowest acceptability. (Chavan *et al*., 2016) reported that biscuits prepared with 10, 20 and 30% *Sorghum* flour were not significantly different in texture as compared with control (0% *Sorghum* flour), whereas biscuits prepared from 40 and 50% *Sorghum* flour was showed low score for texture.

Taste

The sensory score test for taste revealed that there is a significant difference between 6 proportions of biscuits. SWJ 6 has gained highest acceptability whereas SWJ 1 has gained lowest acceptability. Chavan *et al*. (2016) reported that the biscuits prepared with 10, 20 and 30% *Sorghum* flour were not significantly different in taste as compared with control (0% *Sorghum* flour).

Table 2: Composite scoring tests for six biscuits samples.

Quality attributes	Proportions					
	SWJ 1	SWJ 2	SWJ 3	SWJ 4	SWJ 5	SWJ 6
Colour	9.1	17	19	18	20	24.5
Flavour	8.1	17	16	20	17	26.2
Texture	7.8	14	16	15	17	26.2
Taste	3.5	14	14	15	19	25.4
Absence of defects	3.9	15	12	14	20	27.5

Note: Krushkal Walli H-Test.

Absence of defects

The sensory evaluation of absence of defects revealed a significant difference among the 6 proportions of biscuits. SWJ 6 has gained highest acceptability and SWJ 1 has gained the lowest acceptability.

SWJ 6 has highest acceptability with all quality parameters when compared to other formulas. Formula 1 has gained lowest acceptability in all quality attributes. Based on Krushkal Walli H-Test, H value is greater than the chi-square value indicating the significant differences in quality attributes of six varieties of biscuits.

Karki *et al.* (2016) have reported that except texture, there was no significant difference in color, taste, smell and overall acceptance of composite flour of *Sorghum* biscuits. Pushpendra *et al.* (2015) reported that the sensory scores of biscuits prepared by using millets (80-20%) with Jowar flour and whole wheat flour has higher overall acceptability with respect to taste, texture and flavour. The results revealed that the acceptability of biscuits was increased with increase in the millet flour and decreased with decrease in the whole wheat flour.

Physical parameters

Physical parameters were determined for the biscuits of mostly accepted *i.e*. SWJ 6. The mass of biscuits was 20 g and has 45 mm of diameter, 7 mm of thickness and 64.28 of spread factor. Hussain *et al.* (2006) reported that biscuits prepared with flax seed composite flour showed highest spread factor ratio and that depends on the thickness and diameter of the biscuits. Adebowale *et al.*, (2012) revealed that biscuits made from wheat flour with 20% *Sorghum* flour were different from biscuit made from 100% wheat flour in terms of physical properties.

Similarly, the result of the present study was depicted that if the ratio of millet to wheat flour increased, the dough hardness increased and spread ratio was also decreased.

Color of jowar and jaggery biscuits

The color values of SWJ 6 biscuits were (L*) lightness (64.17), (a*) red-green (12.67) and (b*) yellow-green (23.42), higher L* value of the biscuits in the present study represents brighter color of biscuits (Table 3). Similar color values were reported by Mahalakshmi and Hemalatha, (2018) for biscuits made with little millet and jaggery. The biscuits prepared with jowar and jaggery has darker in color especially more red and blue green.

Hardness and fracturability of biscuits

Textural qualities such as hardness and fracturability are very important and required quality attributes for biscuits. Hardness, represents the peak force required to break the biscuit and fracturability measures the capability of a biscuit to fight to regain its original status or form. The biscuits showed 32.5 g of hardness, 8.60 mm of fracturability with 2 mm cylindrical probe and cutting strength of 3.390 kg (Fig 2). Jowar and jaggery biscuits showed better hardness and fracturability compared to other biscuits as reported by Krishna *et al*. (2011).

Apart from the baking conditions, the type, quantity of ingredients and protein content of the flour used have been reported to influence its hardness and other textural

Table 3: Color value of SWJ 6 biscuits.

Sample	L*	a*	b*
SWJ 6 Biscuit	64.17±3.39	12.67±1.27	23.42±2.78

*Values are expressed as mean±SD of triplicate.

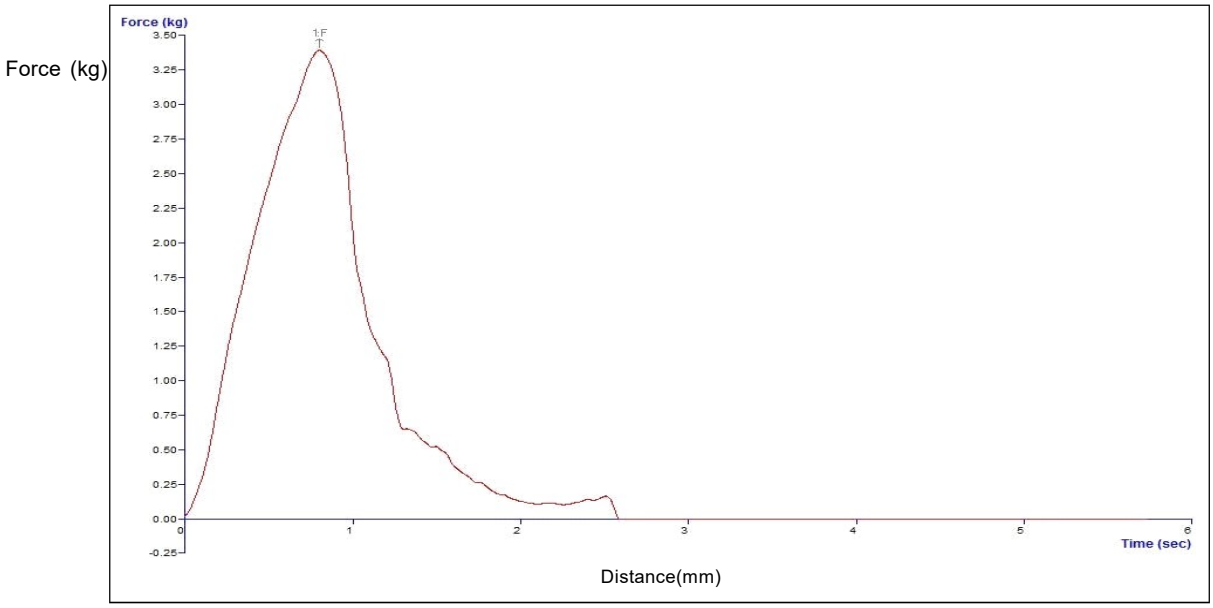


Fig 2: Cutting strength of most accepted biscuits SWJ 6.

Table 4: Proximate content of (SWJ 6) jowar and granular jaggery biscuits.

Proximate	SWJ 6 (100:0:60 ratios of jowar flour: whole wheat flour: Granular jaggery respectively) Composition - g/ 100 g	% RDA attained per 100 g of SWJ 6 biscuits
Energy (kcal)	583±10	28.89
Carbohydrate (g)	92.6±1.03	31.38
Total protein (g)	10.8±0.43	17.28
Total fat (g)	4.8±0.31	24.0
Crude fibre (g)	8.6±0.49	21.2
Moisture (%)	10±1.03	-

Table 5: Mineral composition of SWJ 6 (jowar and granular jaggery biscuits).

Minerals	(SWJ 6 100:0:60 ratios of jowar flour: whole wheat flour:Granular jaggery respectively) Composition -g/100 g	% RDA attained per 100 g of SWJ 6 biscuits
Calcium (mg)	46±3.71	7.62
Zinc (mg)	58.3±0.31	85.3
Iron (mg)	16.1±0.94	17.28
Magnesium (mg)	240±5.0.8	70.47
Potassium (mg)	420±5.10	11.9

attributes (Gaines, 1993; Pyler, 1982). The blends having higher composite flour levels were suitable to maintain biscuits shape during transportation and also fracture easily when chewed (Manley, 2001).

Nutritional analysis

The proximate and mineral compositions of the biscuits are presented in Table 4 and 5. The 100 grams of SWJ 6 biscuits (100:0:60 ratios of Jowar flour: whole wheat flour: jaggery respectively) found to meet 28.89%, 31.38%, 17.28%, 24.0% and 21.2% of RDA for energy, carbohydrate, protein, total fat and crude fibre respectively. Moreover SWJ 6 biscuits showed less fat content, high protein and fibre than biscuits prepared from jowar: wheat flour (55:45) which showed protein (13.1%) and fibre (0.07%) (Sambavi *et al.* 2015). This may be due to the usage of 100% jowar flour in the preparation of biscuits. Similarly, Sangwan and Dahiya (2013) reported significant increase in crude fibre content of biscuit after substitution of refined flour with *Sorghum* and soybean. The mineral composition of SWJ 6 meets RDA for 7.64% of calcium, 85.3% of zinc, 17.28% of iron, 70.47% of magnesium and 11.9% of potassium.

CONCLUSION

The value-added biscuits prepared from jowar millet and organic granular jaggery were highly accepted by respondents, compared to whole wheat flour incorporated biscuits. The nutritional composition of biscuits meets the daily recommended allowance of various nutrients and are rich in protein, fibre, iron and calcium. These biscuits prepared with 100% Jowar and 60% jaggery were bright in color (high L* value) and were capable to maintain shape and texture during transportation because of its hardness (32.5 g), fracturability (8.60 mm) and cutting strength (3.390 kg). Preparation of biscuits with jowar and granular jaggery is cost effective and meets nutritional requirements of all age groups.

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Conflict of interest

All authors declare that they have no conflict of interest.

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