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RESEARCH PAPER

Determination of colour value of jaggery based biscuits stored under ambient temperature using hunter colour lab

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Abstract : To overcome the problems of excessive consumption of white sugar, attempts are being made to find out alternate sweeteners preferably from sugarcane, which are less harmful. A study was conducted to develop jaggery based biscuits using scientific technology to evaluate the quality and acceptance of fresh as well as stored samples. Hunter colour lab was used to determine of colouring properties of fresh and stored samples. Jaggery based biscuits were prepared using different levels of jaggery. Ingredients used in manufacturing of biscuits were of 40, 50 and 60% Jaggery with control (372 g sugar). The other ingredients were in same proportions *viz.,* wheat flour 1000 g, HVO 400 g, WMP 31.15 g, baking powder 10.90 g, salt 7.8 g, TBHQ 0.03125 g, GMS 17.57 g and 02 eggs. The finished biscuit samples of 300 g were packed in HDPE and combination of film (CF) of metalized polystyrene pouches for storage studies at ambient condition. Colour measurement of control and jaggery based biscuits was carried out by using Hunter Lab. Colour value was measured after 60 and 120 days for all four samples. L value was found decreased by increasing the levels of jaggery. The L values, which indicates the lightness decreased due to dark colour of jaggery (L value decreased from 53.32 to 42.43 as a result of jaggery incorporation). L value of colour of the control sample prepared by sugar incorporation was 53.32 because of incorporation of other ingredients and high temperature for baking which caused the browning and caramelization. However, the effect of ambient temperature storage significantly increases "L", "a" and "b" value. All four samples (control, 40%, 50% and 60% jaggery biscuits) were found to have positive "a" values as 9.42, 9.98, 11.09 and 11.60, respectively. During ambient temperature storage, the value of "a" was found to have increased for all four samples packed in HDPE and CF. However, the effect of ambient temperature storage significantly increases "a" value. The colour change observed during 120 days storage was due to additional development of little brown/red colour. The "b" values were found 20.26, 19.74, 19.55 and 19.15, respectively for biscuit samples (control, 40, 50 and 60% jaggery biscuits). Very little difference was noticed in the values of "b" for all samples. Different packaging materials did not significantly affect the "L", "a" and "b" value.

Key Words : Biscuits, Colour, Hunter lab, Jaggery, Storage

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INTRODUCTION

Biscuits are one of the most consumed bakery products eaten by everyone (Klunklin and Savege, 2018). Biscuits, cookies and crackers represent the largest category of snack items among the baked foods of India. The biscuits industry has been growing at an average rate of 6-7% during the past years and this expected to be maintained in the coming years. The term "Biscuit" is derived from the Latin word "Biscoctus" or the old French "Biscoit" meaning twice cooked. This refers to the practice, generally abandoned in the 18th Century of the first baking the product in a hot oven and then transferring to a cooler oven to complete the drying process (Gaur and Goyal, 2009). Biscuits are a ubiquitous snack food that many people are unable to resist eating because they are readily available, are bite-sized, are affordable, and have a long shelf-life. As a result, biscuits are highly favored bakery items (Caleja *et al.,* 2017). They cannot, however, be regarded as a healthy snack food because they usually contain high levels of easily digested carbohydrates and fats, generally low levels of fibre and only modest levels of protein as they are usually made from flour, butter and sugar (Park *et al.*, 2015). Recent trends suggest that people are aware of the food they consume and they are also aware of benefits of consuming nutritious biscuits (Yeh *et al.*, 1998; Pareyt and Delcaur, 2008).

Jaggery is the natural sweetener and available in solid, semi-solid and powder form. The micronutrients which are present in Jaggery have many nutritional and medicinal aspects like its anti-carcinogenic, antitoxic activity, etc. It has been proved itself better as compared to white sugar. Jaggery is known to produce heat and give instant energy to a human body (Mahalaxmi and Hemlata, 2018). Jaggery or gur is a processed solid or semi solid product produced by boiling down juice of sugarcane (or sap of palm tree) with or without purification. Sugarcane, an agro industrial crop, is cultivated on 5.11 m ha area with the production of about 400 million tones in 2018-19 (Anonymous, 2020). Prior to 1902, almost all the sugarcane produced was processed for manufacturing of jaggery and khandsari. Latter, while jaggery and khandsari industry remained practically static, the sugar industry made rapid stride. Number of sugar mills increased from one in 1902 to above 525 in 2018 (Anonymous, 2020). Even after such a phenomenal increase in number of sugar mills during the past years, above 40% of the total sugarcane produced is still being utilized for manufacturing of jaggery and khandsari. About 10 million tonnes of jaggery, from about 80 lakh crushers spread all over the rural areas under unorganized sector, is produced in the country. This meets about 40% of total sweetener's demand and gives employment to over 25 lakh people in rural area (Alam, 1999). In developing countries like India with increasing urbanization, the demand for processed food is increasing popularly (Patel *et al.*, 2003). Among them, bakery products particularly cookies command wide popularity in both urban and rural mass (Manley, 1998 and Hemlatha *et al.*, 2006). To overcome the problems of excessive consumption of white sugar, attempts are being made to find out alternate sweeteners preferably from sugar crops, which are less harmful (Pareyt *at el*., 2001 and Taylor *et al.*, 2008). Jaggery contains appreciable amount of carbohydrates, proteins, minerals and vitamins, which are basic food ingredients for human consumption (Shrivastav *et al.*, 2016). Jaggery, besides having high nutritional value has medicinal properties also. It is considered good to cure breathlessness, cough, coryza, headache, rheumatism, cardiac disease, piles, inflammation of body, leucorrhoea, impotency, and is useful in hair care (Anonymous, 1991), family planning (Jain, 1992), veterinary medicine (Sharma, 1991) and urine problems. It also acts as cardiac tonic, coolant, diuretic, lactcogenic, aphrodisiac, aperients (Ahmad *et al.,* 2001). Minor diabetic patients may consume jaggery as it contains less amount of sucrose.

The common Indian diet is deficient in nutrition, particularly protein (Pasha *et al.,* 2002). Protein deficiency in Indian diet can be supplemented by introducing some jaggery based cereal/ pulse products by taking advantage of nutritional value of both. Attempts are being made to develop confectionery products such as jaggery chocolate, toffee, candies, patti, etc. that have acceptable taste and quality. As the food habit of common Indian are changing, value added jaggery based products may find a suitable place in Indian diet. The nutritional value of sugarcane jaggery as reported by Mitra (1940) is protein 0.25, sucrose 50.71, glucose 21.18, total minerals 3.6, calcium 0.40 and phosphate 0.045. Colour characteristic is a major criterion that affects the quality of the final product (CIE, 1986 and Hutchings *et al.*, 1999). It was not considered to be a real disadvantage since event the commercial control biscuits or bread varies in colour intensity according to the fortified biscuits or bread from which it is produced by addition of raw

and germinated legumes flour and mushroom flour (Barron and Espinoza, 1993).

Keeping the above points in consideration, a study was conducted to develop jaggery-based biscuits using scientific technology to evaluate the quality and acceptance of fresh as well as stored samples. Hunter colour lab was used to determination of colouring properties of fresh and stored samples.

MATERIAL AND METHODS

Manufacturing of jaggery-based biscuits were undertaken in the Product Development Laboratory of Food Craft Institute of University Polytechnic, A.M.U. Aligarh (U.P.). Studies were also carried out to evaluate the quality of product just after preparation and after 60 and 120 days of storage in HDPE and metalized polystyrene pouches at ambient temperature conditions.

The jaggery, manufactured in PHET department of A.M.U., Aligarh was used in the study. The freshness of jaggery was determined on the basis of colour and it was ensured that the colour of jaggery remained light during the preparation of the products. Other ingredients as fresh wheat flour, Full fat (18% fat) milk powder (Dairy Milk, Nestle), ISI marked Hydrogenated vegetable oil (HVO), good quality baking powder (Weikfield Product Company, Pune, India), Glycerol monosterate (GMS), salt, antioxidant TBHQ (LR grade) were used in the manufacturing of biscuits to retard the oxidative rancidity, eggs were used in the manufacturing of biscuits as an emulsifier because it contains huge amount of lecithin were procured from the local market for the preparation of jaggery-based biscuits. The finished biscuits were packed in metalized polystyrene and HDPE pouches for storage studies at ambient temperature condition.

Preparation of biscuits :

Jaggery based biscuits were prepared using different levels of jaggery. The jaggery was ground in pestle and mortar. It was transferred in a bowl and measured amount of HVO was added to it. Antioxidant TBHQ was also added. Proper creaming of jaggery and HVO were done with the help of wooden spoon. Cream was mixed in sieved material (wheat flour + whole milk powder + baking powder) beated eggs and required amount of boiling water was added. GMS and salt was added into boiling water to completely dissolve. All these materials were transferred into a pan and mixing is done by hand until the dough was formed. The formed dough was rolled by domestic flattering wooden roller on smooth surface. After rolling, the cutting of biscuits was done with the help of die to provide shape to biscuits. These biscuits were kept into thermally controlled oven at 200°C for 15 min for baking. After baking biscuits were kept out from oven and cooled at room temperature. At last, the cooled biscuits were packed into metalized polystyrene and HDPE pouches and stored for further studies at ambient temperature condition.

Ingredients :

After initial trials, three levels of jaggery were taken for manufacturing of biscuits namely 40%, 50% and 60% (wheat flour basis) and control biscuit was prepared by using 37.2% white sugar as shown in Table A. Each combination was replicated thrice.

Experimental plan :

Experimental layout for the preparation of jaggery-

Table A : Ingredients used in manufacturing of biscuits

Ingredients	Types of biscuits			
	40% Jaggery	50% Jaggery	60% Jaggery	Control
Wheat flour (g)	1000.00	1000.00	1000.00	1000.00
H.V.O. (g)	400.00	400.00	400.00	400.00
W.M.P. (g)	31.15	31.15	31.15	31.15
Baking powder (g)	10.90	10.90	10.90	10.90
Salt (g)	7.80	7.80	7.80	7.80
Jaggery (g)	400.00	500.00	600.00	372.00 sugar
T.B.H.Q. (g)	0.03125	0.03125	0.03125	0.03125
G.M.S. (g)	17.57	17.57	17.57	17.57
Eggs (Nos)	2	2	2	2

Table B : Experimental layout for the preparation of jaggery based biscuits

Experimental parameters	Levels	Description
Product	1	Jaggery based biscuits
Composition jaggery: wheat flour	3	4:10, 5:10, 6:10
Packaging materials	2	HDPE and metalized polystyrene (combination film)
Mode of packaging	1	Air packaging (heat sealing)
Storage condition	1	Ambient
Sample size	1	300g
Replications	3	

based biscuits is given in Table B.

Hunter lab :

Hunter Lab, Mini Scan XE Plus, (45/ O-L model) manufactured by Hunter Associates Laboratory Inc. U.S.A. was used to measure the colour value (L, a, b term) of the biscuits. This spectrocolourimeter is a versatile colour measurement instrument that can be used on product of virtually any size and in industries as diverse as paint and textiles (Hutchings, 1999). Colour value measured using Mini Scan XE Plus are relative to the absolute value of perfect reflecting diffuser as measured under the same geometric condition, according to the January 1, 1969 recommendation of the International Commission on Illumination (CII).

Statistical analysis :

Statistical analysis of data obtained from the hunter colour lab of different biscuit samples were carried out in triplicate and mean values with standard deviation (SD) were computed by using Microsoft Excel, 2007 (Galla *et al.,* 2017). Two way factorial analysis of variance ANOVA was applied to test the data at 1% and 5% level of significance.

RESULTS AND DISCUSSION

Colour measurement of control and jaggery treated biscuits was carried out by Hunter Lab. The instrument described the colour in three dimensions namely "L", "a" and "b". "L" indicates lightness/darkness (100-0) it distinguish light colour from dark or white from black. "a" indicate the redness with positive value and greenness with negative value and "b" described the shade of yellow varying to blue colour (from positive value to negative value).

Effects on "L" value :

Table 1a presents the result of colour evaluation of sugar and jaggery based biscuits packed in HDPE and combination film. L value was found to have decreased by increasing the levels of jaggery. "L" value indicates lightness (maximum value is 100) decreased because of dark colour jiggery. L value decreased from 53.32 to 42.43 as a result of jaggery incorporation. L value of colour of the control sample prepared by sugar incorporation was 53.32 because of incorporation of other ingredients and high temperature baking which caused the browning and caramelization. The sugar is white in colour and therefore the value of L for the white sugar

Table 1a : Effect of jaggery levels, storage period and packaging materials on colour value "L" of jaggery based biscuits

Biscuit samples and packaging materials	Storage period		
	Fresh	60 Days	120 Days
Control in HDPE	53.32±5.86	55.78±3.95	58.81±1.40
40% jaggery biscuits in HDPE	47.95±4.87	49.10±2.95	54.78±5.73
50% jaggery biscuits in HDPE	47.59±2.18	50.19±2.49	53.39±2.12
60% jaggery biscuits in HDPE	42.43±2.13	50.84±3.03	50.89±1.06
Control in CF	53.32±5.86	55.97±5.62	64.74±5.03
40% jaggery biscuits in CF	47.95±4.87	49.09±4.19	52.85±5.84
50% jaggery biscuits in CF	47.59±2.18	51.01±1.29	55.68±0.93
60% jaggery biscuits in CF	42.43±2.13	46.63±1.29	51.15±0.31

Values are expressed as mean ± SD of triplicate

Table 1b : ANOVA for "L" value of jaggery based biscuits

Source	DF	SS	MSS	F RATIO	F Tabulated	
					5%	1%
Replications	2	141.0419	70.52096			
Packaging modes (P)	1	1.433689	1.433689	0.127953	4.08	7.31
Composition (C)	3	877.7787	292.5929	26.11324	2.84	4.31
Storage periods (S)	2	671.7403	335.8702	29.97564	3.23	5.18
PxC	3	32.0085	10.6695	0.952228	2.84	4.31
PxS	2	18.77338	9.386689	0.83774	3.23	5.18
CxS	6	52.78964	8.798274	0.785226	2.34	3.29
PxCxS	6	42.22093	7.036822	0.62802	2.34	3.29
Error	46	515.4194	11.20477			
Total	71	2353.206				

should be very near to 100. Different composition of biscuit samples were significantly decrease the numerical values of "L" at ($p<0.05$) and ($p<0.01$) level of significance.

Storage study for biscuits sample was conducted in two different packaging materials (HDPE and combination film) under ambient conditions. Different packaging materials did not significantly affect the "L" value. However, the effect of ambient temperature storage significantly increases "L" value. For all four samples, the "L" values were found to increase during ambient storage when the samples were packed in HDPE or combination film. L value was measured after 60 and 120 days for all four samples. In general, the

Table 2a: Effect of jaggery levels, storage period and packaging materials on colour value "a" of jaggery based biscuits

Biscuit samples and packaging materials	Storage period		
	Fresh	60 Days	120 Days
Control in HDPE	9.42±1.81	11.93±0.97	12.41±0.82
40% jaggery biscuits in HDPE	9.98±0.75	12.21±1.56	12.74±1.51
50% jaggery biscuits in HDPE	11.09±1.83	12.38±2.94	13.48±1.38
60% jaggery biscuits in HDPE	11.60±1.46	13.55±1.20	14.42±0.88
Control in CF	9.42±1.81	10.98±0.15	11.82±1.41
40% jaggery biscuits in CF	9.98±0.75	11.58±1.99	12.46±0.78
50% jaggery biscuits in CF	11.09±1.83	12.21±2.56	12.62±2.80
60% jaggery biscuits in CF	11.60±1.46	12.95±1.53	13.93±0.41

Values are expressed as mean ± SD of triplicate

Table 2b: ANOVA for "a" value of jaggery based biscuits

Source	df	SS	MSS	F ratio	F Tabulated	
					5%	1%
Replications	2	25.59814	12.79907			
Packaging modes (P)	1	1.145089	1.145089	0.568675	4.08	7.31
Composition (C)	3	39.49703	13.16568	6.53835	2.84	4.31
Storage periods (S)	2	73.94881	36.97441	18.36226	3.23	5.18
PxC	3	1.467522	0.489174	0.242934	2.84	4.31
PxS	2	0.655878	0.327939	0.162861	3.23	5.18
CxS	6	3.519056	0.586509	0.291273	2.34	3.29
PxCxS	6	1.649878	0.27498	0.136561	2.34	3.29
Error	46	92.62599	2.013608			
Total	71	240.1074				

increment was more for HDPE packed sample as compared to combination film during 120 days. Combined effect of packaging and composition, packaging and storage, and composition and storage period did not significantly affect the "L" value. Likewise combined effect of packaging materials, storage periods and sample compositions also did not significantly affect the values of "L" (Table 1b).

Findings of Stamatovska *et al*. (2017) is advocate present results as they reported by increasing the content of barley flour in biscuits, the "L" value and overall colour change is also increased. Results of the present study are inline with the results of Kim *et al*. (2002).

Effects on "a" value :

"a" indicates the redness and it is numerically described by the positive number. The negative value of "a" described the greenness. All four samples (control, 40%, 50% and 60% jaggery biscuits) were found to have positive "a" values as 9.42, 9.98, 11.09 and 11.60, respectively (Table 2a). While, a little change in "a" value was observed during the study. Different composition of samples significantly increased the numerical values of "a".

During ambient temperature storage, the value of "a" was found to have increased for all four samples packed in HDPE and combination film (control, 40, 50 and 60% jaggery biscuits). Different packaging materials did not significantly affect the "a" value (Table 2b). However, the effect of ambient temperature during storage significantly increases "a" value. The colour change observed during 120 days storage was due to additional development of little brown/ red colour in the biscuits. Combined effect of packaging and composition, packaging materials and storage periods and sample composition and storage period did not significantly affect the "a" value. Similarly combined effect of packaging materials, storage periods and samples compositions also did not significantly affect the values of "a". These results are consistent with the data obtained by Ahmed (1999); Kenny *et al.* (2000) and Gandhi *et al.* (2001).

Table 3a : Effect of jaggery levels, storage period and packaging materials on colour value "b" of jaggery based biscuits

Biscuit samples and packaging materials	Storage period		
	Fresh	60 Days	120 Days
Control in HDPE	20.26±1.25	33.75±1.47	34.07±4.38
40% jaggery biscuits in HDPE	19.74±1.05	31.73±0.70	32.18±1.48
50% jaggery biscuits in HDPE	19.55±0.59	32.08±0.06	32.97±0.06
60% jaggery biscuits in HDPE	18.15±0.92	34.61±1.70	35.05±0.15
Control in CF	20.26±1.25	31.16±0.57	32.68±1.63
40% jaggery biscuits in CF	19.74±1.05	31.58±1.65	32.17±1.36
50% jaggery biscuits in CF	19.55±0.59	31.73±0.96	32.71±0.52
60% jaggery biscuits in CF	18.15±0.92	33.62±1.43	34.87±0.56

Values are expressed as mean ± SD of triplicate

Table 3b : ANOVA for 'b' value of jaggery based biscuits

Source	df	SS	MSS	F ratio	F Tabulated	
					5%	1%
Replications	2	8.900719	4.45036			
Packaging Modes (P)	1	4.370939	4.370939	2.431794	4.08	7.31
Composition (C)	3	16.65019	5.550065	3.087807	2.84	4.31
Storage Periods (S)	2	2923.481	1461.741	813.2467	3.23	5.18
PxC	3	4.418772	1.472924	0.819469	2.84	4.31
PxS	2	2.723103	1.361551	0.757506	3.23	5.18
CxS	6	46.89563	7.815938	4.348437	2.34	3.29
PxCxS	6	5.487586	0.914598	0.508841	2.34	3.29
Error	46	82.68101	1.797413			
Total	71	3095.609				

Effects on "b" value :

Table 3a shows the "b" value measured by Hunter Lab of four biscuit samples control and different level of jaggery incorporation. The "b" values were found respectively 20.26, 19.74, 19.55 and 19.15 for biscuit samples. Very little difference was found in the values of "b" for all samples. Numerically the value of "b" decreases when the colour shifted from light to dark. Jaggery incorporation led to decrease the value of "b" because jaggery brought a little dark colour from biscuits surface. Higher level of jaggery incorporation in samples significantly decrease the numerical value of "b" at 5% level of confidence whereas it was found non-significant at 1% level of confidence.

During storage under ambient temperature, the "b" value increased for all four samples each packed in HDPE and combination film. Different packaging materials did not significantly affect the "b" value. However, the effect of ambient temperature storage was significant on the "b" values (Table 3b). The increment in "b" value was due to appearance of fat on the surface of biscuits, which brought a light colour instead of dark. The highest value of "b" was for yellow while lowest value for blue colour. Combined effect of packaging materials and samples compositions and packaging materials and storage periods did not significantly affect the value of "b" but that of sample composition and storage period significantly affect the numerical value of "b". Combined effect of all three effects did not significantly affect the values of "b". These results are in coincidence and confirmed with these obtained by Kenny *et al.* (2000) and Mirjana (2013).

In general, the changes in Hunter colour values of "L", "a" and "b" and darkening of the biscuit samples may be due to browning and caramelization of jiggery and other ingredients during baking.

Similar finding were reported by Galla *et al*. (2017) the changes in Hunter L*, a* and b* and darkening of products may be due to browning of spinach carbohydrates during baking. The results are inline with the findings of Mahalaxmi and Hemlata (2018). They observed that the colour scores in all the three cookies, significantly different in all parameters. (L*) lightness (64.94), (a*) red to green (13.70) and (b*) yellow to green (34.07) was significantly different (p< 5%) higher in sugar cookies, while lightness was similarly in both jaggery cookies. Compared to both jaggery, red to green and yellow to green values were higher in organic jaggery cookies (10.63 and 31.68) followed by non-organic jaggery cookies (8.82 and 27.67).

Conclusion :

Colour values of "L" and "b" were found to have significantly decreased and "a" of colour increased with the increasing level of jaggery. "L", "a" and "b" value of fresh control, 40%, 50% and 60% jaggery samples were 53.32, 47.95, 47.59 and 42.43, 20.26,19.74, 19.55, 18.15 and 9.42, 9.98, 11.09 and 11.60, respectively. During storage, all the values (L, a and b) were found to have significantly increased in all the samples in both types of packaging materials.

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