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Effect of Addition of Roselle Seed Flour on Color and Textural Properties of Cookies

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A B S T R A C T

Colorimetric and texture profiles of cookies made from Roselle flour (RSF) and Roselle Seed Oil (RSO) were studied. Commission Internationale de I' Exchange (CIE) L*a*b* coordinates a rectangular coordinate system was adopted for colorimetric studies to establish the total color difference ΔE*. A texturometer was used to measure the crushing, cutting, and penetration force calculated at the entire area of cookie samples. Colorimetric test showed cookie products becomes darker (L*), less red (a*) and yellow (b*) with inclusion of RSF and RSO at 10%, 15%, 20%, 25% and 5%, 10%, 15%, 20%, 25%, 30% for the treatments Sprouted Decorticated Roselle Seed Flour (SDRSF), Un-sprouted Decorticated Roselle Seed Flour (UDRSF) and Roselle Seed Oil respectively. Texturometer test showed crushing, cutting and penetration force needed to break the cookies decreased with incorporation of RSF and RSO. The overall test results showed that there was significant difference ($p<0.05$) for both colorimetric and texture between cookies made from the composite RSF blend and RSO when compared to cookies made from whole wheat flour as control; while sensory evaluation test adjudged 15% inclusion as the overall best for all the treatments.

Introduction

All the estimated nutritional parameters based on amino acids composition showed that Roselle seed protein fractions and their isolates have a good nutritional quality and suggests their possible use as a supplementary protein source (Karma and Chavan, 2016). Fractions were found to have a high concentration of low molecular weight polypeptides, in contrast to wheat protein, gluten, with low biological and nutritional value (Lamacchia *et al.*, 2014). The Roselle protein isolates and its fractions could have excellent applications for future product development by virtue of their nutritional and functional properties. This could add value to the existing uses of the plant and expand it cultivation. Further evaluation of saturated to unsaturated fatty acids in Roselle seed lipids

(Karma and Chavan, 2016) corroborates Mohiuddin and Zaidi (1975) of 1:3 in contrast to widely acknowledged 1:2 ratio El-Adawy and Khalil (1994). Al-Wandawi *et al.,* (1984) Roselle seed has eighteen amino acids with leucine as the most abundant essential amino acids followed by lysine. Al-Wandawi (2015) compared organic acid composition of different parts of the plants, results showed seeds pods having lesser oxalic acid contents (19.28 %) when compared to calyces (44.60 %), green leaves (74.30%) and petioles (86.77 %) stating that healthy individuals can safely consume oxalic acid in moderation but those with kidney disorders, osteoporosis or rheumatoid arthritis are typically advised against even though there is no cause to be concerned. A dilute amount of oxalic acid can rapidly crack the casein in various dairy products; which gives Roselle seed a better superior quality for all round nutrition.

The oil profile of Roselle seed oil suggest beneficial use nutritionally and medically in lowering blood pressure and serum cholesterol (Savage, 2001; Enujiugba and Akanbi, 2008; Tounkara *et al.,* 2011; Cissouma *et al.,* 2013). El-Adawy and Khalil (1994) considered different cultivars of Roselle seeds in their study to have a high total carbohydrate content ranging from 36-38 %, however on the contrary a study by Hainida *et al.,* (2008), Karma and Chavan (2016), Karma *et al.,* (2017a,b,c); discovered a lower carbohydrate content in the Roselle seeds. Roselle seeds flour in composite formulation with wheat flour reduced the carbohydrate and gluten contents (Karma and Chavan, 2016). Gluten constitutes a hazard for people with celiac disease (Humbert *et al.,* 2006; Karma and Chavan, 2017).

The prevalent nutritional and chemical constituents of Roselle seeds four could impact on the physical attributes in composite formulations with other seeds flour in value added products; hence the objective of this study was to find the effect of addition of Roselle seed flour on color and textural properties of cookies.

Materials and Methods

Materials

Roselle (*Hibiscus sabdariffa L.*) and Wheat (*Triticum aestivum spp.*) seeds were sourced from the vegetable market in Ahmednagar, Maharashtra State, India and both were of local varieties. The various ingredients: Margarine, granulated sugar, salt, sodium bicarbonate and ammonium bicarbonate used for baking were all provided from the pilot bakery unit of the Department of Food Science and Technology, Mahatma Phule Agricultural University, Rahuri Ahmednagar District Maharashtra State India.

Cleaning

The seeds were cleaned by washing to separate poor quality seeds, adhering dust particles, stones, plant debris and dried carefully at ambient conditions under fan to preserve its nutritive value, packed in a HDPE bag and stored in a cool dry place until used.

Germination

The cleaned seeds were soaked for 6 hours to initiate the process of germination, after which the seeds were washed and allowed to drain. The drained seeds were then spread on a damped cloth in a perforated container with water sprinkled occasionally in a modified dark room to activate germination for a another 12 hour period at 70 - 85% relative humidity then gently washed and spread sparsely to dry under fan at ambient temperature to preserve its nutritive value, packed in a HDPE bag and stored in a cool dry place until used.

Equipments

Laboratory scale hammer mill was used in milling the seed samples is available in the Department of Food Science and Technology, Post Graduate Institute Rahuri, Maharashtra State India.

Pre-treatments

The pre-treatments: Un-sprouted Whole Roselle Seeds Flour (UWRSF) as *Control,* Un-sprouted Decorticated Roselle Seed flour (UDRSF), Sprouted Whole Roselle Seed Flour (SWRSF) and Sprouted Decorticated Roselle Seed Flour (SDRSF); were prepared accordingly and packed separately in a HDPE bag and stored in a cool dry place until used.

Cookie preparation

The *molded cookie* was adopted for this study owing to its simplicity, Wikipedia (2016). The Cookie was prepared according to proposed method by Noor Aziah *et al.,* (2012) with modification; using basic ingredients (Wani *et al.,* 2015) to simplify critical investigations (Table 1).

Sensory evaluation

Sensory evaluation of sample cookies was done using Hedonic test on a 9 scale points based on appearance, flavor, crispiness, taste and overall acceptability from 20 semi trained panelists. See appendix 2 and 3 for sensory evaluation score card.

Colour determination

Colour difference of sample cookies compared to the standard sample was measured by a colour scanning machine (Premier Colour scan, Thane). The principle described by Konica (2016) was employed for this determination. The Commission Internationale de I'Eclairage (CIE), L*a*b* coordinates was adopted for this study. It provides reading in terms of L^*, a^* and b^*. Where, luminance (L^*) forms the vertical axis, which indicates lightness (+) to darkness (-). In the same way a^* indicates redness (+) to greenness (-) and b^* indicates yellowness (+) to blueness (-). The instrument was standardized before placing the sample by placing the standard cookie sample in the instrument. Once the instrument was standardised, it was ready to measure the colour. The sample was filled in the sample cup. The deviation $(\Delta \mathbf{E}^*)$ of the colour of the sample to standard was observed and recorded in the computer interface expressed using the equation:

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta a^*)^2} \qquad \text{Eq.1}$$

Texture analysis of cookies

Texture analysis of cookies was performed for cutting force, crushing force and penetration force using Universal Testing Machine (Shimadzu, Japan, Model No. AG-X, with 2500N Capacity) Texturometer in the instrumentation laboratory of Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Department of Agricultural Process Engineering MPKV, Rahuri. Each cookie was placed on the loading cell and compressed. The conditions employed were as follows; cross head speed: 50mm/min, maximum load cell force: 1 kg and compression: 75 per cent. The maximum force required to just break the cookies is the hardness. It was expressed in terms of Newton (N).

Statistical analysis

All experiments were carried out in such a way that the degree of freedom remains more than 12 with suitable replications and treatments. Data obtained in the present study

were analyzed by Completely Randomized Design (C.R.D.) design as given by Panse and Sukhatme (1967).

Results and Discussion

Sensory evaluation of cookies

Sensory study of cookies with the addition of varying percentages of Pretreated Roselle seeds flour and Oil were evaluated. Panels of 20 semi-trained human panelists were employed to test the cookie products and record effective responses based on 9 point hedonic scale to evaluate the attributes of appearance, flavour, taste, crispiness and overall acceptability. The results obtained were outlined in the tables (Table 2 to 4; Fig. 1).

For Un-sprouted Decorticated Roselle Seed Flour (UDRSF)

UD_2 ranked the highest for overall acceptability of 8.6, followed by UD_3 8.22, UD_o 8.20, UD_4 8.14; while UD_4 had the minimum score of 7.7.

The result score for appearance ranged from 7.4 to 8.14 with UD_0 being the most appealing to sight 8.14 and UD_4 had the least 7.4. Results for flavour showed UD_2 had 8.47 the highest while UD_4 had 7.4 the lowest score (Table 2).

The score range for crispiness showed UD_2 having the highest score 8.2 while UD_4 had the least score 7.66. For taste attribute UD_o had the highest 8.4 while UD_4 had the least with a score of 7.58.

The score for appearance, flavour, crispiness and taste showed that there was a significant difference ($p<0.05$) between cookies made from the composite flour mix and wheat flour. UD_2 (15-85%) formulation had the most superior quality attributes in the final baked products.

For Un-sprouted Decorticated Roselle Seed Flour (SDRSF)

SD_2 ranked the highest for overall acceptability of 8.9, followed by SD_3 8.27, SD_1 8.14, SD_0 8.0; while SD_4 had the minimum score of 7.75. The Score for appearance, flavour, crispiness and taste showed that there was a significant difference ($p<0.05$) between cookies made from the composite flour mix and wheat flour (Table 3).

The score for appearance ranged from 7.56 to 8.26. SD_0 ranked highest with 8.26 followed by SD_2 8.0, SD_3 7.9, SD_1 7.89 and SD_4 having the least score of 7.56. For flavour SD_2 had the highest 8.45 while SD_4 had the lowest 7.4. For crispiness SD_2 had the highest 8.5 while SD_4 had the lowest 7.99. For taste SD_2 had the highest 8.5 while SD_4 had the lowest 7.9.

The Score for appearance, flavour, crispiness and taste showed that there was a significant difference ($p<0.05$) between cookies made from the composite flour mix and wheat flour. Cookie SD_2 with formulation 15-85 % had the most superior quality attributes in the final baked products.

For Roselle Seed Oil (RSO)

RO_3 ranked the highest for overall acceptability of 8.3, followed by RO_2 8.13, RO_1 8.12, RO_0 and RO_4 8.0 at per; RO_6 7.46; while RO_6 had the minimum score of 6.47. The score for appearance, flavour, crispiness and taste showed that there was a significant difference ($p<0.05$) cookies made from replacing margarine with Roselle seed oil.

For appearance RO_0 had the highest 8.30, while RO_6 had the least 7.01. For flavour RO_3 had the highest 8.42 while RO_6 had the least score 6.9. For crispiness RO_3 had the highest 8.63 while RO_6 had the lowest 6.64.

Fig.1 Preparation of cookies by adding roselle seeds flour

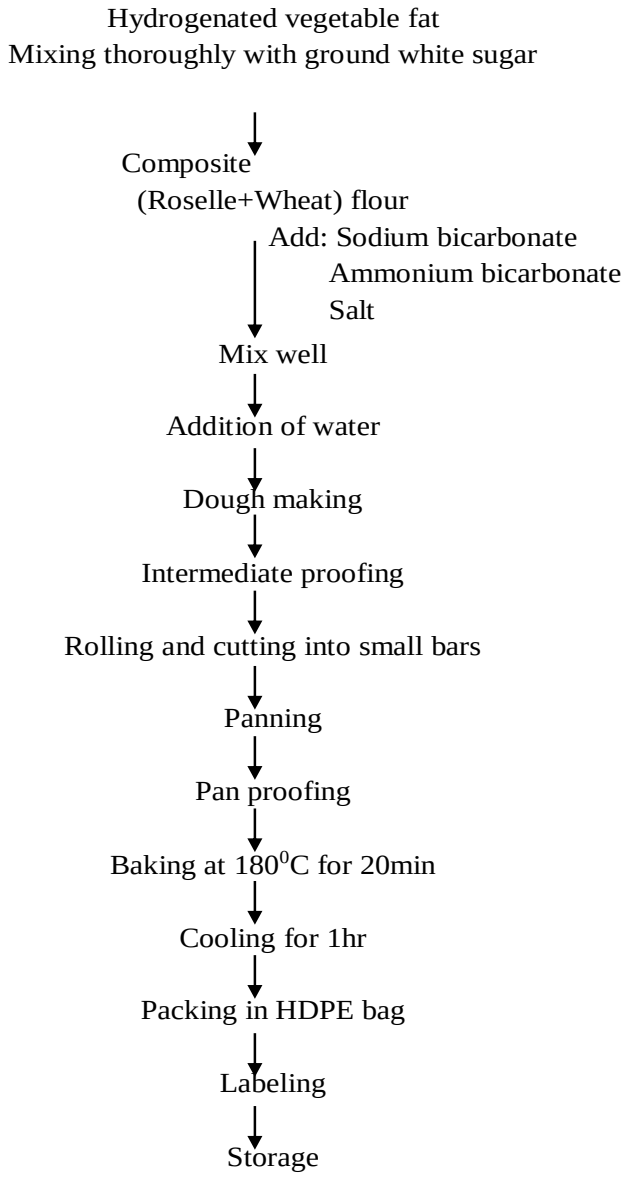

Table.1 Ingredients and composition for composite flour for cookies

Ingredients (at 100 g basis)	Control	Flour Replacement			
		10%	15%	20%	25%
Flour	100	10:90	15:85	20:80	25:75
Sugar	40	40	40	40	40
Margarine	50	50	50	50	50
Sodium bicarbonate	0.5	0.5	0.5	0.5	0.5
Ammonium bicarbonate	0.5	0.5	0.5	0.5	0.5
Water	20	20	20	20	20
Salt	1	2	2	2	1

Table.2 Organoleptic evaluation of cookies prepared from UDRSF

Sample Code	Appearance	Flavour	Crispiness	Taste	Overall acceptability	Rank
UDo	8.14	7.78	8.78	8.40	8.20	3
UD_1	7.88	8.07	8.30	8.00	8.14	4
UD_2	**7.88**	**8.47**	**8.20**	**8.38**	**8.60**	**1**
UD_3	7.82	7.95	8.19	8.12	8.22	2
UD_4	7.40	7.50	7.66	7.58	7.70	5
SE(±)	0.02	0.03	0.02	0.02	0.01	
CD@5 (%)	0.07	0.09	0.07	0.07	0.06	
CV (%)	0.62	0.79	0.53	0.54	0.46	

Where: (UDo) as Control; (UD_1) 10-90 %; (UD_2) 15-85 %; (UD_3) 20-80 %; and (UD_4) 25-75 % RSF replacement respectively.

Table.3 Organoleptic evaluation of cookies prepared from SDRSF

Sample Code	Appearance	Flavour	Crispiness	Taste	Overall acceptability	Rank
SD_0	8.26	7.70	8.14	8.00	8.00	4
SD_1	7.89	7.49	8.20	8.50	8.14	3
SD_2	**8.00**	**8.45**	**8.50**	**8.54**	**8.90**	**1**
SD_3	7.90	8.13	8.30	8.50	8.27	2
SD_4	7.56	7.40	7.99	7.90	7.75	5
SE(±)	0.004	0.02	0.02	0.02	0.004	
CD at5 %	0.01	0.06	0.06	0.05	0.01	
CV (%)	0.11	0.46	0.45	0.45	0.09	

Where: (SD_0) as Control; (SD_1) 10-90 %; (SD_2) 15-85 %; (SD_3) 20-80 %; and (SD_4) 25-75 % RSF replacement respectively.

Table.4 Organoleptic evaluation of cookies prepared from RSO

Sample Code	Appearance	Flavour	Crispiness	Taste	Overall acceptability	Rank
RO_0	8.30	8.10	8.20	8.00	8.00	4
RO_1	8.22	8.11	8.00	8.09	8.12	3
RO_2	8.17	8.02	8.00	8.23	8.13	2
RO_3	**7.94**	**8.42**	**8.63**	**8.90**	**8.30**	**1**
RO_4	8.20	8.00	8.45	8.40	8.00	4
RO_5	7.43	7.54	6.93	7.82	7.46	6
RO_6	7.01	6.90	6.64	6.00	6.47	7
SE(±)	0.004	0.02	0.04	0.03	0.02	
CD at 5 %	0.01	0.06	0.13	0.10	0.06	
CV (%)	0.13	0.57	1.35	1.05	0.65	

Where: (ROo) as Control; (RO_1) 5-45 %; (RO_2) 10-40 %; (RO_3) 15-35 %; (RO_4) 20-30%; (RO_5) 25-25 % and (RO_6) 30-20 % RSO replacement respectively at 50% standard recipe formulation

Table.5 Effects of addition of *SDRSF on total colour difference of cookie

Colour Space	TREATMENTS FOR SDRSF COOKIES					Delta of Colour Space	TOTAL COLOUR DIFFERENCE			
	Control	10	15	20	25		10	15	20	25
L*	68.61	67.20	66.73	66.63	66.31	ΔL*	-1.41	**-1.88**	-1.98	-2.30
a*	5.85	5.19	4.79	4.75	4.44	Δa*	-0.66	**-1.06**	-1.10	-1.41
b*	24.22	20.65	19.58	19.42	18.53	Δb*	-3.57	**-4.64**	-4.80	-5.69
SE(±)	0.66	0.30	0.12	0.09	0.10	**ΔE***	3.89	**5.12**	5.31	6.29
CDat5 (%)	1.96	0.86	0.35	0.28	0.30	Comments				
CV (%)	2.84	1.36	0.56	0.44	0.48	ΔL*	Darker	Darker	Darker	Darker
						Δa*	<Red	<Red	<Red	<Red
						Δb*	<Yellow	<Yellow	<Yellow	<Yellow

*Spouted Decorticated Roselle Seed Flour (SDRSF); each value is an average of seven determinations.

Table.6 Effects of addition of *UDRSF on total colour difference of cookie

Colour Space	TREATMENTS FOR UDRSF COOKIES					Delta of Colour Space	TOTAL COLOUR DIFFERENCE			
	Control	10	15	20	25		10	15	20	25
L*	68.61	67.58	67.06	66.52	66.42	ΔL*	-1.03	**-1.55**	-2.09	-2.20
a*	5.85	5.73	5.57	5.09	4.61	Δa*	-0.12	**-0.28**	-0.76	-1.24
b*	24.22	21.81	20.69	19.01	18.96	Δb*	-2.41	**-3.53**	-5.21	-5.26
SE(±)	0.66	0.40	0.59	1.01	0.68	**ΔE***	2.62	**3.87**	5.66	5.84
CDat5 (%)	1.96	1.20	1.76	3.01	2.01	Comments				
CV (%)	2.84	1.80	2.70	4.75	3.19	ΔL*	Darker	Darker	Darker	Darker
						Δa*	<Red	<Red	<Red	<Red
						Δb*	<Yellow	<Yellow	<Yellow	<Yellow

*Un-sprouted Decorticated Roselle Seed Flour (UDRSF); each value is an average of seven determinations.

Table.7 Effects of addition of RSO on total colour difference of cookie

Colour Space	TREATMENTS FOR RSO COOKIES							Delta of Colour Space	TOTAL COLOUR DIFFERNCE					
	Control	**5**	**10**	**15**	**20**	**25**	**30**		**5**	**10**	**15**	**20**	**25**	**30**
L*	68.61	68.27	68.21	68.20	67.80	67.77	67.55	ΔL*	-0.34	-0.41	**-0.42**	-0.81	-0.84	-1.06
a*	5.85	5.67	5.47	4.99	4.90	4.68	4.25	Δa*	-0.17	-0.38	**-0.86**	-0.95	-1.17	-1.60
b*	24.22	23.51	23.44	23.39	22.30	22.26	21.17	Δb*	-0.71	-0.78	**-0.83**	-1.92	-1.96	-3.05
SE(±)	0.66	0.06	0.16	0.06	0.08	0.10	0.25	**ΔE***	0.80	0.96	**1.26**	2.29	2.43	3.60
CD@5 (%)	1.96	0.17	0.46	0.17	0.25	0.29	0.74	Comments						
CV (%)	2.84	0.25	0.68	0.24	0.37	0.44	1.13	ΔL*	Darker	Darker	Darker	Darker	Darker	Darker
								Δa*	<Red	<Red	<Red	<Red	<Red	<Red
								Δb*	<Yellow	<Yellow	<Yellow	<Yellow	<Yellow	<Yellow

*Roselle Seed Oil (RSO); each value is an average of seven determinations.

Table.8 Effect of incorporating SDRSF on the texture of cookies

Treatment	Crushing Force (N)	Cutting Force (N)	Penetration Force (N)
Control	69.13	78.18	39.60
SDRSF 10-90	64.15	60.66	26.06
SDRSF 15-85	55.50	49.83	22.84
SDRSF 20-80	51.03	41.70	20.76
SDRSF 10-90	45.03	35.58	20.52
SE(±)	0.56	0.52	0.41
CD at5 (%)	1.70	1.58	1.24
CV (%)	1.97	1.97	3.18

Each value is an average of four determinations

Table.9 Effect of incorporating UDRSF on the texture of cookies

Treatment	Crushing Force (N)	Cutting Force (N)	Penetration Force (N)
Control	69.13	78.18	39.60
UDRSF 10-90	58.90	77.20	27.01
UDRSF 15-85	38.29	63.86	26.06
UDRSF 20-80	26.47	52.66	22.68
UDRSF 25-75	22.10	52.35	21.68
SE(±)	0.37	0.41	0.52
CD at5 (%)	1.10	1.23	1.55
CV (%)	1.71	1.25	3.74

Each value is an average of four determinations

Table.10 Effect of incorporating RSO on the texture of cookies

Treatment	Crushing Force (N)	Cutting Force (N)	Penetration Force (N)
Control	69.13	78.18	39.60
RSO 5-45	60.18	56.53	26.06
RSO 10-40	58.18	52.24	25.51
RSO 15-35	46.23	44.85	24.67
RSO 20-30	42.89	42.73	21.09
RSO 25-25	38.46	38.37	18.75
RSO 30-20	27.04	35.47	16.65
SE(±)	0.31	0.48	0.19
CD at5 (%)	0.95	1.47	0.57
CV (%)	1.57	2.39	1.88

Each value is an average of four determinations

NB: Treatments details as: SDRSF (Sprouted Decorticated Roselle Seed Flour); UDRSF (Un-sprouted Decorticated Roselle Seed Flour); RSO (Roselle Seed Oil).

For taste RO_6 had the highest 8.9 while RO_6 had the lowest 6.0 score reason could be that the panelists are not use to the aroma and taste of Roselle seed oil since the oil is novel, as it is not widely known.

The score for appearance, flavour, crispiness and taste showed that there was a significant difference ($p<0.05$) between cookies made from substituting margarine with Roselle seed oil and control with just margarine. Cookie RO_3 with formulation 15-35 % had the most superior quality attributes and acceptability in the overall final baked products.

Colour determination of cookie

Colorimetry is the technique used to identify colour difference between samples and how they differ from standard. No matter how close two samples look the same, slight difference may be found when evaluated with a colour measurement instrument.

The colour differences between cookie samples were studied using the CIE L* a* b* coordinates a rectangular coordinate system defined by Commission Internationale de I' Eclairage (CIE), the L* a* b* colour space was modeled after a colour-opponent theory stating that two colours cannot be red and green at the same time. Where L* indicates lightness, a* is the red/green coordinates, and b* is the yellow/blue coordinate. Deltas for L* (ΔL*), a* (Δa*) and b* (Δb*) may be positive (+) or negative (-). The total difference, Delta E (ΔE*) is however always positive. Where:

ΔL* (L* sample minus L* standard) = difference in lightness and darkness (+ = lighter, - = darker).

Δa* (a* sample minus a* standard) = difference in red and green (+ = redder, - = greener).
Δb* (b* sample minus b* standard) = difference in yellow and blue (+ = yellower, - = bluer). And,

ΔE* = Total Colour Difference.

The colour difference between all three coordinates was calculated using the formula (Eq. 19 section 3.2.10.2.4.).

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta a^*)^2}$$

The results obtained are as shown in Table 4 to 7. The results showed that cookie products becomes darker (L*), less red (a*) and less yellow (b*) with inclusion of Roselle seed flours and oil in at 10 %, 15 %, 20 %, 25% and 5 %, 10%, 15 %, 20 %, 25 %, 30 % for the pair of SDRSF, UDRSF and RSO respectively. The results showed that there was a significant difference ($p<0.05$) between cookies made from Roselle seed flour blends, Roselle seed oil and wheat flour as control respectively.

The summary of the total colour difference (ΔE*) for selected cookies in sensory evaluation Table 5 to Table 7 showed: SDRSF 15-85 having the highest colour difference with ΔE* value 5.12 followed by UDRSF 3.87 and RSO15-35, 1.26. The high value for SDRSF 15-85 could be due to the combined effects of enzymatic browning due to sprouting, non-enzymatic browning (maillard reaction between reducing sugars and amino acids), starch dextrination and sugar caramelization during baking (Gomez *et al.*, 2008; Zucco *et al.*, 2011).

Texture analysis of cookies

Texture testing is a well-established technique for evaluating the mechanical and physical properties of raw ingredients and food structure and is a property that relates to the sense of touch and can be measured easily by mechanical methods in units such as force (N). In these studies a texturometer was used to measure the crushing, cutting and penetration force calculated at entire area of the cookie samples the results obtained are outlined Tables 8 to 10

The results showed that crushing, cutting and penetration force needed to break the cookies decreased with the incorporation of Roselle

seed flour. The control sample had the highest value followed by 10, 15, 20 and 25 % respectively.

The results showed that there was significant difference ($p<0.05$) in texture between cookies made from the composite flour blend and wheat flour as control. The difference could be as a result of decrease in gluten content in the composite flour as Roselle seed flour is added; flour with low gluten produce a low extensive gluten structure which will result in softer cookies (Ajila *et al.,* 2008). The same decrease was recorded in cookie samples in which margarine was replaced with Roselle seed oil at 5, 10, 15, 20, 25 and 30%.

A study of viscosity of Roselle Seed oil showed the oil to have a shear thickening (*dilitancy*) property (Karma, *et al.,* 2017) as such its inclusion in the product recipe could weaken the viscoelastic property of gluten in wheat flour, as gluten impacts strength to the dough (Misra *et al.,* 1998). The results showed that there was significant difference ($p<0.05$) in texture between cookies made from substituting margarine with Roselle seed oil at varying percentages compared to the control cookie with just margarine.

The overall summary Table 8 to 10, showed crushing force (N) for SDRSF 15-85% ranked highest when compared to control, followed by UDRSF 15-85% and RSO 15-35%. For cutting force (N), UDRSF 15-85 ranked highest followed by SDRSF 15-85 and RSO 15-35. For penetration force (N), SDRSF 15-85 ranked the highest followed by RSO 15-35 and UDRSF 15-85. The summary results showed that there was a significant difference ($p<0.05$) between cookies made from Roselle seed flour and oil blends compared to the control.

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