International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:9, No:7, 2015

Sensory Acceptability of Novel Sorrel/Roselle (*Hibiscus sabdariffa* L.)

Tamara Anderson, Neela Badrie

Abstract**—**Consumers are demanding novel beverages that are healthier, convenient and have appealing consumer acceptance. The objectives of this study were to investigate the effects of adding grape polyphenols and the influence of presenting health claims on the sensory acceptability of wines. Fresh red sorrel calyces were fermented into wines. The total soluble solids of the pectinase-treated sorrel puree were from 4°Brix to 23.8°Brix. Polyphenol in the form of grape pomace extract was added to sorrel wines (w/v) in specified levels to give 0. 25. 50 and 75 ppm. A focus group comprising of 12 panelists was use to select the level of polyphenol to be added to sorrel wines for sensory preference The sensory attributed of the wines which were evaluated were colour, clarity, aroma, flavor, mouth-feel, sweetness, astringency and overall preference. The sorrel wine which was most preferred from focus group evaluation was presented for hedonic rating. In the first stage of hedonic testing, the sorrel wine was served chilled at 7°C for 24 h prior to sensory evaluation. Each panelist was provided with a questionnaire and was asked to rate the wines on colour, aroma, flavor, mouth-feel, sweetness, astringency and overall acceptability using a 9-point hedonic scale. In the second stage of hedonic testing, the panelist were instructed to read a health abstract on the health benefits of polyphenolic compounds and again to rate sorrel wine with added 25 ppm polyphenol. Paired t-test was used for the analysis of the influence of presenting health information on polyphenols on hedonic scoring of sorrel wines. Focus groups found that the addition of polyphenol addition had no significant effect on sensory color and aroma but affected clarity and flavor. A 25 ppm wine was liked moderately in overall acceptability. The presentation of information on the health benefit of polyphenols in sorrel wines to panelists had no significant influence on the sensory acceptance of wine. More than half of panelists would drink this wine now and then. This wine had color L 19.86±0.68, chroma 2.10±0.12, hue° 16.90 ±3.10 and alcohol content of 13.0%. The sorrel wine was liked moderately in overall acceptability with the added polyphenols.

Keywords**—**Sorrel wines, Roselle *Hibiscus sabdariffa* L, novel wine, polyphenols, health benefits, physicochemical properties.

I. Introduction

SORREL or roselle (*Hibiscus sabdariffa* L. belongs to the family *Malvaceae* [1]. The brilliant red pigments in sorrel calyces contain anthocyanins [2], [3]. Anthocyanins are the major sources of antioxidant capacity in sorrel extract and have been shown to exhibit substantially more antioxidant activity than ascorbic acid [4]. The findings of a study support the ethno-medicinal use of sorrel in the treatment of cardiovascular disease and hypertension [5]. The ethanolic extract of dried sorrel strong hypolipidemic as well as antioxidant properties in alloxan-induced diabetic rats could be useful in preventing the development of atherosclerosis and possible related cardiovascular pathologies associated with diabetes [6] which could be useful in preventing the development of atherosclerosis and possible related cardiovascular pathologies associated with diabetes.

Polyphenols have antioxidant properties [7] and are most Polyphenols have antioxidant properties [7] and are most abundant in the diet [8]. There is evidence to strongly support the contribution of polyphenol to the prevention of cardiovascular diseases [9], cancers, and osteoporosis and suggests a role in the prevention of neurodegenerative diseases and diabetes mellitus [10]. In a study of phenol compounds as natural antioxidants in red grape wine suggest that phenolic components could be an important contributor to the protective action due to antioxidant activity and do not exclude the possibility of synergistic action among different classes of polyphenols [11].

Due to the potential health benefits, sorrel is gaining more attention in the food processing industry. In the West Indies, tropical Africa, Philippines and Indonesia, sorrel calyces are utilized in refreshing drinks, non-alcoholic drinks (soborodo), tea, syrups, puddings, condiments, colorants, sauces, wines, leathers and yoghurts, reduced calorie-jam [12]-[22]. The addition of polyphenol could further add to the health benefits of sorrel wines. However, many polyphenols have a taste and may affect color [23] and consumers now want both the health benefits and sensory acceptable food products.

Many studies have suggested that presenting nutritional or health information can, but does not always influence sensory responses [24]-[27]. Therefore, the objectives of this study were to investigate the effects of adding polyphenol to sorrel wines on physicochemical and sensory properties and influence of providing health claims on polyphenols on their sensory acceptance and to characterize the physicochemical characteristics.

II. Materials and Methods

A. Processing of Wines

Fresh red sorrel calyces were fermented into wines as previously described [17]. Modifications to the method included adjustment of the total soluble solids (TSS) of pectolase-treated sorrel puree from 4°Brix to 23.8ºBrix with granulated sucrose (Caroni Ltd, Couva, Trinidad, West Indies), and application of wine yeast (Côte de Blancs active

Neela Badrie is with the Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies National (phone: 868-662-2002; fax: 868-645--0479; e-mail: neela.badrie@sta.uwi.edu).

Tamara Anderson was associated with the Department of Agricultural Economic s and Extension, Faculty of Food and Agriculture, The University of the West Indies and is now with the Caribbean Industrial Research Institute. (e-mail:Anderson_tamara83@yahoo.com).

dry wine yeast, Red Star, Lessaffre Yeast Corporation, Milwaukee, Wisconsin, USA) at (0.16% w/v).

Polyphenol in the form of grape pomace extract (MegaNatural ® GSKE, PIN# GK2000, Polyphenolics, Madera, California, Madera) was donated from the company and added to sorrel wines (w/v) in specified levels to give 0. 25. 50 and 75 ppm. Grape by-products contain large amounts of phenolic compounds, mostly flavonoids at high concentrations of 1000-1800 mg/L [28]. Addition of polyphenol to wines was done 24 hours prior to focus group evaluation and hedonic testing.

B. Focus Group Evaluation

Focus groups provide an insight into consumer's preference and defined the critical attributes of a product [29] such as sorrel wine. The focus group selected the most appropriate level of polyphenol to be added to sorrel wines for sensory preference. It also provided an early assessment of the prototypes [30], the sorrel wines with 0, 25, 50 and 100 ppm polyphenol. The focus group method utilized small groups of 8-12 consumers to obtain reactions, both positive and negative to products [31]. This group was comprised of 12 panelists (5 males and 7 females) who were willing to participate in the evaluation of the sorrel wines. The panelists self-reported that they were in good health and had previously consumed sorrel drinks and alcoholic wines. The wines were three-digit coded using random numbers. The control sorrel wine (0% polyphenol) was presented to the panelists first followed by three other wine samples (25, 50, 100 ppm) in a balanced order. The session was conducted around a round table. The moderator asked several leading questions based on the characteristics of the wines such as the color, clarity, aroma, flavor, mouth-feel, sweetness, astringency and overall preference. The reactions of panelists were observed and comments from the panelists were transcribed. By consensus, the most preferred wine chosen by the panelists, which was further evaluated by hedonic testing?

C. Hedonic Testing

The sorrel wine (i.e. 25 ppm polyphenol) which was preferred from focus group evaluation was presented for hedonic rating. The consumer acceptance test is a small panel test, usually involving only 50 -100 panelists [32]. The panel comprised of 50 volunteer panelists (26 males; 24 females) of age ranges 18-25 yrs (24%), 26-45 yrs (60%) and over 45 years (6%) who were academics, students or employees of the University of the West Indies. Initial assessor selection criteria were based on personal interest, availability and having previously consumed sorrel drink and wines. This research was approved by the Department of Agricultural Economics and Extension.

In the first stage of hedonic testing, the sorrel wine (25 ppm) was chilled at 7ºC for 24 h prior to sensory evaluation. Each panelist was served 30-35 ml of chilled wine [33]. Wines were coded with random three-digit number and served in clear 50 ml shot glasses. Wines were presented in a balance order to panelists and served with crackers, cheese and water. Each panelist was provided with a questionnaire and was asked to rate the wines on color, aroma, flavor, mouth-feel, sweetness, astringency and overall acceptability using a 9-poin hedonic scale [34] (1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely).

In the second stage of hedonic testing, the same sorrel wine (i.e. 25 ppm polyphenol) as in the first stage of hedonic testing was again presented to panelists but coded with a different random three-digit code. Before sensory evaluation of the wine, panelist were instructed to read a health abstract on the health benefits of polyphenolic compounds. This health abstract read as follows:

'*Polyphenols are the most abundant antioxidants in the diet. Antioxidants prevent substances from being converted into harmful oxidized chemical states, including low density lipoprotein known as LDL or bad cholesterol. Antioxidants help to reduce the level of LDL thus reducing the risk of cardiovascular diseases. Evidence from studies indicated that polyphenols contribute to the prevention of cardiovascular diseases, cancers and osteoporosis'.*

TABLE I
AWARENESS OF POLYPHENOLS

Questions	Responses,% n= 50
Have you heard of polyphenols?	
yes	42
no	58
Do you know of any health benefits of polyphenols?	
yes	24
no	34
do not know	18
no response	24
State the health benefits	
no response	76
prevented heart disease	12
as antioxidants	12

TABLE II
CONSUMPTION INTENT TOWARDS DRINKING OF NOVEL POLYPHENOL ENRICHED SORREL WINES

Options	*% Responses*
I will drink this novel polyphenol-enriched sorrel wine, every opportunity I had	16
I will drink this novel polyphenol- enriched sorrel wine, very often	4
I will frequently drink this novel polyphenol-enriched sorrel wine	0
I like this and will drink this novel polyphenol-enriched sorrel wine, now and then	54
I will drink this novel polyphenol-enriched sorrel wine, but will not go out of my way	20
I do not like it but will drink this novel polyphenol-enriched sorrel wine, on an occasion	4
I will 'hardly ever' drink this novel polyphenol-enriched sorrel wine	2
I will drink this novel polyphenol-enriched sorrel wine, only if there were no other drink choice	0
I will drink this novel polyphenol-enriched sorrel wine, only if I were forced to	0

After reading of the health abstract on the benefits of polyphenols, panelists were instructed to rate the wine samples using hedonic scoring as previously performed in the first stage of hedonic testing. Also, the panelists were asked questions in respect to their knowledge of polyphenols (Table I). In addition, they were asked questions relating to their intent of drinking the sorrel wine with 25 ppm polyphenol (Table II).

D.Physicochemical Analysis

Color of fresh sorrel calyces and polyphenol-enriched sorrel wines was measured using a Minolta chroma meter (Chroma Meter CR 200b, Minolta Corporation Head Office Meter Division, Ramsey New Jersey, USA). The instrument was standardized with a white tile (L=92.6, a=0.3137, b=0.3209). At least three reading per sample was take and for each reading, the 'L', 'a' and 'b' values were recorded. The 'L' value represented the lightness of color, the higher the value, the lighter the color, negatives 'a' represented greenness and positive 'a' represented redness. A positive 'b'value represented blueness and negative 'b' represented yellowness. The combinations of the values were described mathematically. Hue angle (Hº) and chroma (C) were derived from the respective formulae [14] Chroma represented color saturation from dull (low value) to vivid color (high value). Hue denotes the shade or tint of wines [33]. For most colors, the brightness increases, the chroma increases as well, except with the very light colors. Hue angle was measured as described [44].

The hue angle (Hº) of 0, 45, 90, 180 and 270 represented bluish red-purple, red, and orange, yellow, green and blue respectively [35].

The pH of the sorrel puree and sorrel wines was measured electronically with an Orion pH meter (Orion SP 301, Thermo Orion, USA).The total soluble solids (TSS) expressed as ºBrix was determined using a refractometer (Eclipse hand-held refractometer, Bellingham and Stanley, UK). A drop of the samples was placed on the refractory surface and ºBrix value was taken. At least three readings per sample were taken. Total titratable acidity (TTA*)* was expressed as % citric acid, after titration of 10 ml of sample with 0.1N NaOH with phenolphthalein as indicator according to # 962.12 [36].The alcohol content (%, v/v) of the sorrel wines was measured from the specific gravity according to # 11.005 on 100 ml of sorrel wine [36](AOAC, 1990). Clarity of the sorrel wines was expressed in nephelometric turbidity units (NTU) by using a turbidimeter (LaMotte 2020, Chestertown, USA).

E. Microbiological Analysis

Total aerobic plate counts, yeasts and moulds and lactic acid bacteria were enumerated on plate count agar (PCA, Oxoid, and Basingstoke, England), potato dextrose agar (PDA, Oxoid) and tomato juice agar (TJA, Oxoid). The pour plate technique was used for enumeration of microorganisms on PCA and PDA plates, while the spread plate technique was applied to TJA plates. Plates were incubated at 35ºC for 48 h. Plates between 30 and 300 colonies were counted [37] as CFU ml^{-1} and converted log 10 cfu ml^{-1}.

F. Experimental Design

The experiment design comprised of four treatments sorrel wines with 0, 25, 50 and 100 ppm polyphenol. Qualitative sensory evaluation of sorrel wines with 0, 25, 50 and 75 ppm polyphenols was performed by focus groups. The preferred sorrel wine (25 ppm polyphenols) was analyzed for physicochemical, microbiological and sensory evaluation by hedonic testing one week after bottling and for physicochemical and microbiological 6 weeks at 24°C after bottling.

G.Statistical Analysis

Statistical analysis was performed using Minitab Statistical software, version 14 for windows. Means were represented with ± standard errors (SE). Paired t-test determined whether the panelists were influenced by presentation of health information on polyphenols on hedonic scoring of sorrel wines and independent T-test conducted to investigate the effects of storage on physicochemical properties of polyphenol-enriched wines.

III. Results and Discussion

A. Qualitative Characteristics of Wines

The control sorrel wine (0 ppm polyphenol) was attractive red, had pleasant aroma, well liked sorrel flavor, smooth mouth-feel with no jarring effect or sharp change, no noticeable astringent and bitter taste. However, there were differing opinions by panelists as to the sweetness of this wine, as it was perceived as dry and felt that the TSS content should be higher being acquainted to the seasonal popular sorrel drinks around Christmas time. With all the sensory characteristics evaluated, the focus group rated this wine as being most preferred of all wine treatments.

In reference to the control wine (0 ppm polyphenol), the addition of 25 ppm polyphenol to sorrel wine did not alter color, aroma and flavor. However, it was less clear, had slightly rough mouth-feel and slightly astringent. Astringency is described as a puckering, rough, or drying mouth-feel sensation [23]. The sweetness of this sorrel wine was perceived to be equivalent to the control sorrel wine. The focus group reported that wine with 25 ppm polyphenols was lower in preference in comparison to control sorrel wine, taking into the evaluation all the sensory characteristics.

The overall preference of sorrel wines declined with increasing polyphenol additions (i.e. 50 ppm and 100 ppm). The phenolic compounds consist primarily of flavonoid and non-flavonoid monomers [33], which exert a marked influence on taste and mouth-feel. Alone, or in combination, they generate a very large group of polymers called tannins [12]. Flavonoid tannins constitute the major phenolic compounds in red grape wines. The color and aroma of the polyphenol-enriched sorrel wines remained unaltered in comparison to control wines (0ppm). With increasing addition of polyphenols to sorrel wines, clarity decreased (more cloudy), sorrel flavor became masked, mouth-feel was more rough,

bitterness and astringency were highly detectable and wines tasted less sweet. It was reported that when consumers liked red grape wines, they did not use bitter as a descriptor since it expressed dislike and tend to associate it with acid and astringent sensory characteristics [23]. These authors reported that learning to like astringent red wines may require repeated exposure and consumption under positive conditions. Based on consensus by focus group, the maximum addition of polyphenols to wines was at 25 ppm (w/v).

B. Hedonic Scores

The reading of the abstract on the health benefits on polyphenols by panelists did not (P>0.05) influence the hedonic scores given to sorrel wine (25 ppm polyphenol). This may have been due to the initial (before reading the health abstract) high hedonic scores (6.22-8.02) given to the sorrel wine. In another related study, it was found that the presentation of health benefits on sorrel calyces to panelists had no influence the hedonic scores on all sensory attributes of sorrel leather [19]. It was found that after a brief education program on the benefits of cranberry did not influence the acceptance of 100% cranberry juice [38]. This could have been due to the dislike for the extremely sour and bitter taste of the juice. Unlike our study, a study on consumer attitudes and acceptability of soy-fortified yogurt found that after being informed of the health benefits of fortifying yogurts with soy, acceptability scores were enhanced indicating that nutritional concerns took precedence over sensory attributes [39]. Consumer responded to an off-flavor in juice in the presence of specific health claims by higher overall liking scores [40]. Fig. 1 shows that clarity and color were rated with the highest average hedonic score.

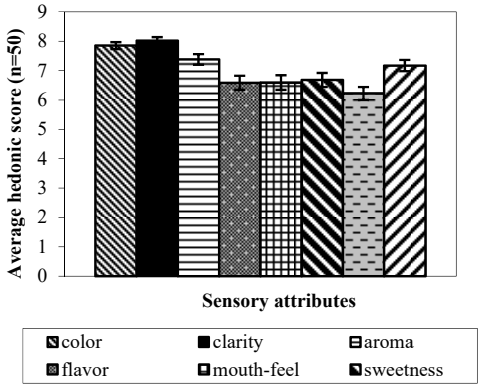

Fig. 1 Hedonic Scores of Sorrel Wines (25 ppm polyphenol)

The hue ° indicates shows that the wine was red (Table III) which was liked very much (7.85/9/0) by panelists. Astringency was rated with the lowest score (6.22/9.0), being liked slightly too moderately. Also, the focus group evaluation had indicated that sorrel wines became increasingly astringent on increasing addition of polyphenols to wines. The wine was liked moderately in overall acceptability. The most important sensation perceived during wine consumption is astringency [41]. This sensation is mainly elucidated by flavonoid polyphenols [42].

C. Storage Changes in Physicochemical Characteristics

Table III shows significant changes in color, clarity and microbial growth on storage of sorrel wines at 24°C for 6 weeks. From the initial color of sorrel wines, hue became more (P<0.01) red (lower hue^{o}), and 'L' became darker (P<0.01; higher 'L'). In another study, color of sorrel wine also became redder (P<0.01) on storage at 23^{o}C for 2 months [17]. The pH has a marked influence on color of anthocyanins in aqueous media [43], [44]. The pH of sorrel wines was acidic (3.59 ±0.03). Acidic pH favors the appearance of the colored forms: the flavyium cation, AH which is red [45], [46].

Research on sorrel sauces [15] has found that color became less dark and less red on storage at 20^{o}C for 6 weeks. It was observed that the sorrel pigment is stable during normal preparation and storage of foods at 23ºC and 25ºC [13].

TABLE III
EFFECT OF STORAGE ON PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF * SORREL WINE

Physicochemical	*Week 0 after bottling*	*Week 6 after bottling*	*P*
Color			
'L'	19.86±0.68	17.05±0.25	0.01
Chroma	2.10±0.12	2.21±0.14	0.56
Hue	16.90 ±3.10	5.88±0.87	0.01
TSS, °Brix	6.30±0.48	6.40±0.48	0.78
TTA, % citric acid	0.57±0.09	0.52±0.00	0.57
Clarity, ntu	69.00±18.4	2.78±0.30	0.04
Alcohol, %	12.96±0.13	12.86±0.13	0.54
Microbiological, log $_{10}$ cfu ml^{-1}			
PCA	4.33±1.11	nil growth	0.01
PDA	2.80±1.08	nil growth	0.04
TJA	2.18±0.56	nil growth	0.04

* 25 ppm polyphenol

The total titratable acidity content did not vary on storage (Table III). The organic acids found in raw sorrel calyces were citric acid, d-malic acid, hibiscic acid, indolyl-acetic acid, tartaric acid and oxalic acid [47]-[49]. Alcohol did not vary (P>0.05) on storage (Table III).

D. Awareness of Polyphenols and Purchase Intent

Only 42% of panelists had heard of polyphenols (Table I). Of the 24% of panelists who knew of the health benefits, 12% related polyphenols for prevention of cardiovascular diseases and 12% as antioxidants. More than half of panelists liked the enriched sorrel wine and will drink now and then (Table II). Studies have shown that consumer preferences for novel foods increase with exposure due to reduction in neophobia can increase in familiarity [50].

IV. CONCLUSION

The results indicated that addition of 25 ppm polyphenol to sorrel wine resulted in no significant detectable sensory changes in color and aroma in reference to control sorrel wine,

but was slightly more astringent. Color and clarity were liked very much and overall acceptability was liked moderately. Also, presenting information on the health benefits of polyphenols did not change the sensory acceptance of the wine attributes. The findings of this study could encourage the enrichment of sorrel wines with polyphenols for added health benefits. There is a need for education on the health benefits of polyphenols since more than three-quarter of panelists were unaware. Also, it has been suggested that providing consumers with specific health and formulation information, in addition to using exposure as a means to familiarize consumers with sensory attributes may have significant effects on consumer acceptance of functional food (e.g. probiotic orange juice) and thereby have important research and commercial applications [51].

ACKNOWLEDGMENT

The authors acknowledge the technical assistance from Mr. Esau Mohammed, Dr. Vidya De Gannes, Mr. Keshwar John and Mrs. Radickha Seerattan-Persad of the laboratories of the Department of Food Production and all the panelists who participated on sensory evaluation.

REFERENCES

[1] Y. Qi, K.L, Chin, F. Malekian, M. Berhane, J. Garger, "Biological characteristics, nutritional and medicinal value of roselle, *Hibiscus sabdariffa circular". UFNR* No. 604 March, 2005. Available online from: <http://www.suagacenter.com.

[2] C.T, Du and F.J. Francis, Anthocyanins of roselle (*Hibiscus sabdariffa*, L*)," J. Food Science*, vol. 38 (5), pp 810-812, 1973.

[3] G.E. Mazza and E. Miniati, *Anthocyanin in Fruits, Vegetables and Grains.* Boca Raton, Florida USA: CRC Press, 2000, pp. 309-311.

[4] P.J. Tsai, J. McIntosh, P. Pearce, B. Camden, B.R. Jordan, "Anthocyanin and antioxidant capacity in roselle (*Hibiscus sabdariffa* L.) extract, *Food Research International,* vol. 35, pp. 351-356

[5] K.R. Christian and J.C. Jackson, **"**Changes in total phenolic and monomeric anthocyanin composition and antioxidant activity of three varieties of sorrel (*Hibiscus sabdariffa*) during maturity," J. *Food Compos Anal.,* vol.22 (7-8), pp. 663-667, 2009.

[6] E.O. Farombi and O.O. Ige, "Hypolipidemic and antioxidant effects of ethanolic extract from dried calyx of *Hibiscus sabdariffa* in alloxan-induced diabetic rats," *Fundamental and Clinical Pharmacology*, vol. 21, pp. 601–609, 2009.

[7] V. Chenier, "Polyphenols in foods are more complex than often thought," *American Journal of Clinical Nutrition,* vol. 81(suppl), pp. 223S–229S, 2005.

[8] A. Scalbert, I.T. Johnson and M. Saltmarsh, "Polyphenols: antioxidants and beyond", *American J. Clinical Nutrition*, vol.81 (1 Suppl.), pp. 215S–217S, 2005.

[9] J.-C. Stoclet, T. Chataigneau, M. Ndiaye, M-H. Oak, J. El Bedoui, M. Chataigneau and V. Svini-Kerth, "*Vascular protection by dietary polyphenols*", *European J. Pharmacology*, vol. 500 (1-3), pp. 299-313, 2004.

[10] A. Scalbert, C. Manach, C. Morand, C. Rémésy and L. Jiménez, "Dietary polyphenols and the prevention of chronic diseases," *Critical Review in Food Science*, vol. 45 (5), pp.287-306, 2005.

[11] M. López-Vélez, F. Martínez-Martínez and C. Valle-Ribes, "The study of phenolic compounds as natural antioxidants in wine, "Critical *Review in Food Science*, vol. 43 (3), pp. 233-244, 2003.

[12] W.B. Esselen and G.M Sammy, "Roselle: a natural colorant for foods," Food *Prod Dev*, vol. 7, pp.80-82, 1973

[13] W.B. Esselen and G.M.Sammy, "Applications for roselle as a red colorant, *Food Prod Development*, 9, 34-40, 1975.

[14] M. Clydesdale, J.H. Main and F.J. Francis, "Roselle *(Hibiscus sabdariffa* L.) anthocyanins as colorant beverage and gelatine deserts," *J. Food Protection*, vol. 42, pp.204-267, 1979.

[15] D'Heureux-Calix and N. Badrie, "Consumer acceptance and physicochemical quality of processed red sorrel/roselle (*Hibiscus sabdariffa* L.) sauces from enzymatic extracted calyces," *Food Service Technology*, vol. 4(4), pp. 141-148, 2004

[16] G. Oboh and C.A. Elusiyan, CA (2004) "Nutrient composition and antimicrobial activity of sorrel drinks (soborodo)," *J. Med Food*, vol7 (3), pp. 340-342, 2004.

[17] P. Mounigan and N. Badrie, "Physicochemical and sensory quality of wines from red sorrel/roselle (*Hibiscus sabdariffa* L) calyces," *International. J. Food Science and Tech*nology, vol. 41, pp.1-7, 2006a.

[18] P. Mounigan P and N. Badrie, "Roselle/sorrel (*Hibiscus sabdariffa* L.) Wines with varying calyx puree and total soluble solids: Sensory acceptance, quantitative descriptive and physicochemical analysis," J. *Foodservice*, vol 17, pp. 102-110, 2006b.

[19] M. Jueanville and N. Badrie N, "Processed sorrel/Roselle (*Hibiscus sabdariffa* L.) Leather from pectolase-treated calyces. Effects of xanthan gum on physicochemical quality and sensory acceptance," *J. Food Technology*., vol. 5 (2), pp. 164-168, 2007.

[20] N. Henry and N. Badrie, "Utilization of sorrel/roselle (*Hibiscus sabdariffa* L.) Nectar in stirred yoghurts: Physicochemical and sensory quality," *J. Food Technology*, 5 (1), pp. 55-61, 2007.

[21] M. Bolade, I.B. Oluwalana, and O. Ojo, "Commercial practice of roselle (*Hibiscus sabdariffa* L.) Beverage production: Optimization of hot water extraction and sweetness level," *World Journal of Agricultural Sciences*, vol.5 (1), pp. 126-131, 2009.

[22] J. Broomes and N.Badrie, "Effects of low-methoxyl pectin on physicochemical and sensory properties of reduced-calorie sorrel/roselle (*Hibiscus sabdariffa* L.) Jams," *The Open Food Science J.,* vol. 4, pp.43-50, 2010.

[23] I. Lesschaeve and A.C. Noble, "Polyphenols: factors influencing their sensory properties and their effects on food and beverage preferences," *Am J. Clinical Nutrition*., vol. 81 (supplement): pp. 330S-335S, 2005.

[24] T. Solheim, "Consumer liking for sausages affected by sensory quality and information on fat content", *Appetite* 19, pp. 285-292, 1992.

[25] P. Kähkönen, H.Tuorila and H. Rita, "How information enhances acceptability of a low-fat spread?," *Food Quality Preference,* Vol. 7, pp.365-372, 1996.

[26] P. Kahkonen, H. Tuorila and H. Lawless, "Lack of effect of taste and nutrition claims on sensory and hedonic responses to a fat-free yogurt", *Food Quality Preference*, vol. 8, pp. 125-130, 1997.

[27] C.D. Goerlitz and J.F. Delwiche, "Impact of label information on consumer assessment of soy-enhanced tomato juice," *J Food Science,* vol. 69 (9), pp. S376-S379, 2004.

[28] J. Kanner, E. Frankel, R.Granit, B. German and E. Kinsella, "Natural antioxidants in grapes and wines," *J. Agriculture and Food Chemistry*, vol. 42, pp. 64-69, 1994.

[29] F.C.F. Galvez and A.V.A.Resurreccion, "Reliability of the focus group technique in determining the quality characteristics of mungbean (*Vigna radiata* (L.) Wilczec) noodles," *J. Sensory Studies*, vol. 7, pp. 315-326, 1992.

[30] ASTM Committee E-18, ASTM Manual on Consumer Sensory Evaluation. In E.E. Schaefer (Ed), *ASTM Special Technical Publication* 682, (pp. 5, 28-30). Am Soc Testing and Materials, Philadelphia, PA, pp. 5, 28-30, 1979.

[31] A.V.A. Resurreccion, *Consumer Sensory Testing for Product Development*, Aspen Publishers Inc, Gaithersburg, Maryland, pp. 9-42, 1998.

[32] IFT/SED, "Sensory evaluation guideline for testing food and beverage products," *Food Technology, Chicago*, vol. 35 (11), pp.50-59, 1981.

[33] R.S. Jackson RS, *Wine Tasting: A Professional Handbook*, Brock University Food Science Technology. Int. Series, Academic Press, Ontario, Canada, 2002.

[34] D.R.Peryam and F. J. Pilgrim, "Hedonic scale method of measuring food preference," *Food Technology*, Chicago, vol. 11(9), pp. 9-14, 1957.

[35] R.G. McGuire, "Reporting of objective colour measurement," *Hort Science*, vol. 27, pp.254 -/1255, 1992.

[36] AOAC, *Official Methods of Analysis*, Association of Analytical Chemists. Blackie Academic and Professional, London vol.2, 1990.

[37] K.M.J. Swanson, F.F. Busta, E.H. Peterson and M.G. Johnson, Colony count methods. In C. Vanderzant, D.F. Splittstoessser, *Compendium of Methods for the Microbiological Examination of Foods*, American Public Health Association, Washington DC, pp. 75-95, 1992.

[38] S.Ghanzanfar and M.E. Camire, "Influence of health attitudes on the acceptability of cranberry juice," J. Food Science, vol. 67(9), pp.3497-3501, 2002.

[39] M.A. Drake and P.D. Gerard, "Consumer attitudes and acceptability of soy-fortified yoghurt," *J. Food Science*, vol. 68 (3),pp. 1118-1122, 2003.
[40] H. Tuorila and A.V. Cardello, "Consumer responses to an off-flavor in juice in the presence of specific health claims," *Food Quality Preference*, vol. 13, pp.561-569, 2002.
[41] A.C. Nobel. (2002) Astringency and bitterness of flavonoid phenols. Acs Sym Ser 825,192-201, 2002.
[42] R. Lopez, L.Mateo-Vivaracho, J. Cacho and V. Ferreira, "Optimization and validation of a taste dilution analysis to characterize wine taste," J Food Science, vol. 72 (6), pp. S345-351, 2007.
[43] R. Brouillard, Chemical structure of anthocyanins. In P. Markakis, *Anthocyanins as Food Colors*, Academic Press, New York, pp.1, 1982.
[44] G. Mazza and R. Brouillard, Color stability and structural transformations of cyaniding 3, 5 – diglucoside and four 3-deoxyanthocyanins in aqueous solutions, *J. Agriculture and Food Chemistry*, vol 35, pp. 422-426, 1985.
[45] F.T. Francis, "Food colorants –Anthocyanins," *Critical Review in Food Science*, vol. 28(4),pp. 273-314, 1989.
[46] F. Delgado –Vargas and O. Paredes – López, *Natural Colorants for Food and Nutraceutical Uses,* CRC Press, LLC, Boca Raton, Florida, 2003.
[47] M.E.Ibrahim, K.A. Karamalla and A.G. Khattab, "Biochemical studies on roselle (*Hibiscus abdariffa*)," *Sudan J. Food Science and Technology*, vol 3, pp. 37, 1971.
[48] J. Kerharo, "Senegal bisap (*Hibiscus sabdariffa*) or guinea sorrel or red sorrel," *Plant Medicine Phytotherapy,* 5,pp. 272-281, 1972.
[49] J.F. Morton, Roselle. In C.F. Dowling. *Fruits of Warm Climate* (pp. 281-286), Media Incorporated, Greensborough, NC, pp. 281-286, 1987.
[50] P. Pliner, "The effects of mere exposure in liking for edible substances," Appetite, vol 3, pp. 283-290, 1982.
[51] T. Luckow, V. Sheehan, C. Delahunty and G. Fitzgerald, "Determining the odor and flavor characteristics of probiotic, health-promoting ingredients and the effects of repeated exposure on consumer acceptance*," J. Food Science*, vol.70 (1),pp. S53-S59, 2005.