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Processed Sorrel/Roselle (*Hibiscus sabdariffa* L.) Leather from Pectolase-Treated alyces. Effects of Xanthan Gum on Physicochemical Quality and Sensory Acceptance

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Abstract: This study investigated the effects of adding xanthan gum on the physicochemical and sensory quality of sorrel/roselle (*Hibiscus sabdariffa* L.) leather. Also, the influence of health benefits of sorrel on sensory acceptance of sorrel leather was determined. Calyces were hot-water processed at 90°C for 60 min and treated with 0.5% pectolase at 20°C for 24 h for puree. Sorrel purees with different levels of xanthan gum were dehydrated at 50°C for 48 h into leather. The addition of xanthan (0.15%) resulted in more chromatic ($p<0.01$), less bluish red hue ($p<0.01$) lower firmness ($p<0.05$) and lower Total Soluble Solids (TSS) ($p<0.05$) than control (0% xanthan gum) sorrel leather. The addition of xanthan gum influenced ($p<0.05$) only sensory sweetness of the product. The presentation of health benefits on sorrel calyces to panellists did not ($p>0.05$) influence hedonic rating of all sensory attributes. All sensory attributes except for aroma (liked slightly to moderately) were liked moderately to very much. On storage for 6 wks at 4°C, products were darker, ($p<0.05$) less bluish red ($p<0.05$), less firm ($p<0.05$) and had lower TSS ($p<0.01$) and citric acid ($p<0.05$). All microbial counts were < 10 CFU g^{-1} throughout storage.

Key words: Sorrel/roselle, *Hibiscus sabdariffa* L., calyces, leather, xanthan gum, pectolase, storage, physicochemical, sensory acceptance

INTRODUCTION

Sorrel (*Hibiscus sabdariffa* L.) is a member of the *Malvaceae* family (Purseglove, 1968). It is native from India to Malaysia and is widely distributed in the West Indies, Central America and some parts of Africa (Purseglove, 1968; Morton, 1987). Vernacular names in addition to sorrel are 'ugu', 'iroko', 'roselle', 'rozelle', 'red sorrel', 'Jamaican sorrel', 'Indian sorrel', 'Guinea sorrel', 'sour-sour Queensland jelly plant', 'jelly okra', 'lemon bush', 'karkade', 'oseille de guineé', 'l'oiselle', 'vinuela', 'bisap' and 'Florida cranberry' (Morton, 1987; Oguntona, 1988; ASNAPP, 2003). The calyx is bright red, slightly acid and closely resembles the cranberry (*Vaccinium* sp.) in flavour (Morton, 1987; Stephens, 1994) and has a fruit odour (Burdock, 1997).

Fraser (1989) focused on the drying of sorrel and its effects on subsequent processing. Sorrel calyces have been utilised in drinks, jellies, sauces, chutneys, wines, preserves, ketchup and as natural food colorants (anthocyanin) (Purseglove, 1968; Esselen and Sammy, 1973; Bloomfield, 1976; Clydesdale *et al*., 1979; Al-Kahtani and Hassan, 1990; D' Heureux and Badrie, 2004). Sorrel has a long history of use in tropical areas such as the West Indies, Taiwan and Malaysia as a fruity refreshing beverage, (Francis, 1989) andis a prized drink during the Christmas holidays (McCaleb, 1996) Sorrel leather is not found in the Trinidad and Tobago market.

It has been proposed that high sensory acceptability, as well as beneficial physiological effects need to be demonstrated for consumer acceptance of a novel product such as sorrel leather. A number of studies have examined the influence of health claims and purchase interest toward functional foods (Kahkonen *et al*., 1996; Tuorila *et al*., 1998; Tourila and Cardello, 2002). Sorrel has medicinal and health benefits (Morton, 1987). The brilliant red pigments contained in red calyces of sorrel are anthocyanins (Du and Francis, 1973; Mazza and Miniate, 2000). The interest in anthocyanin pigments has accelerated in recent years because of their possible role in reducing the risk of coronary heart disease, cancer and stroke (Wrolstad, 2004) certain epithelial cancers, visual impairments, arthritis and asthma (Murakoshi *et al*., 1992; Hertog *et al*., 1993, 1995; Bridle and Timberlake, 1997; Tseng *et al*., 1998; Gibson and Williams, 2000; Delgado-Vargas *et al*., 2000; Murkovic *et al*., 2000) Anthocyanin pigments have been recognised in disease prevention, possibly through their effects on oxidative

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damage (Prior and Cao, 2000; Porter *et al*., 2001; Bors and Michel, 2002). It is known that anthocyanosidic extracts from plants act as free scavengers (Saint-Cricq *et al*., 1999) and as antilipoperoxidants, (Saija *et al*., 1995) and are helpful in protecting collagen from degradation caused by superoxide anion radical (Wang and Jiao, 2000). Anthocyanins (i.e., cyanidin, delphinin, malvidin, peonidin and pelargonidin) have a high antioxidant capacity as measured by Oxygen Radical Absorbance Capacity ($ORAC_{ROO}$) (Wang *et al*., 1997).

The objectives of the study were to investigate the effects of xanthan gum on the physicochemical and sensory quality of sorrel leather processed from pectolase-extracted puree. Also, to determine whether the presentation of health benefits on sorrel calyces to panellists would have influenced the rating of hedonic scores and to investigate the changes in physicochemical quality during storage of sorrel leather at 4°C for 6 weeks.

MATERIALS AND METHODS

Processing: Fresh sorrel of the red variety was purchased at a local market. De-cored calyces in water (9:1) were processed at 90°C for 60 min (Du Heurex and Badrie, 2004) with 0.4% all spice (*Pimenta diecea* L. Merril), (Chatak Food Products, Caroni, Trinidad, West Indies). After cooling to 35C, 0.5% pectolase (Young's Home Brew and Allied Products Limited, Bilston West Midlands, MV) was added to the calyces and allowed to steep at 20°C for 24 h. The sorrel puree was blended and sieved through #10 (2 mm) sieve (US Standard Testing Sieve ASTM. E-11).

For sorrel leather processing, the thawed puree was pasteurized at 65°C for 30 min and xanthan gum (Kelco, Rahway, NJ) at levels of 0, 0.15, 0.30 and 0.60% w/w and 0.2% potassium sorbate (Tastemakers Ltd, Port-of-Spain) which were added varying levels. Refined crystallised sucrose was added to increase the Total Soluble Solids (TSS) from 5°Brix in sorrel puree to 50°Brix in sorrel leather mixture. Approximately, 1.6 kg of sorrel leather mixture was poured into 25.4×17.8 cm plastic-lined containers to a depth of ~ 6 mm and dehydrated in a convection oven (German Ehret D-783 Emmendingen 14, Germany) at 50°C for 48 h.

Focus group evaluation: Initially, sorrel leathers with two levels of xanthan gum (0.30 and 0.60% xanthan gum w/w) were presented to a focus group of 12 panellists. The focus group provided an insight into consumer's preference and defined the critical attributes of the product (Resurreccion, 1998) and which also guided the hedonic testing questionnaire. These sorrel leathers were found to be 'too sticky', 'too red', 'not sweet enough' but had an acceptable flavour.

Based on the first focus group evaluation, the level of xanthan gum was reduced to improve on texture. A second focus group (12 panellists) evaluated two sorrel leathers (0 and 0.15% w/w) and found that the appearance, texture, flavour and were acceptable. The sorrel leather with 0.15% xanthan gum had a surface sheen in comparison to the dull appearance of control sorrel leather (0% xanthan gum). These treatments were analysed for physicochemical, microbiological, sensory acceptance (hedonic testing) and shelf-life at 4°C for 6 weeks.

Statistical analysis: Analysis was performed using Minitab Statistical Software, version 14 for Windows (Minitab, 2004, Enterprise State College, PA 16801-3003). Two sample t-test was used to determine differences due to xanthan gum (0 and 0.15%) on physicochemical and sensory quality if sorrel leathers. Also paired t-test determined the influence of presenting information on the health benefits of sorrel on sensory acceptance of the sorrel leathers. Binomial distribution tables at 5% level of significance tested the difference in paired preference test. Analysis of Variance (ANOVA) was used to analyse storage data. Significant means were separated by Fisher's Least Significant Difference at $p<0.05$. Means are represented with±standard error.

Physicochemical analysis: Texture as a measure of firmness of sorrel leather was measured using a penetrometer (Koehler Model K 19550, Bohemia and N.Y. USA). The needle of 47.5 g was allowed to fall freely into the samples and the penetration depth read automatically. The penetrometer readings were recorded as mm/2 sec. The pH of sorrel puree and sorrel leather was measured on an Orion pH meter (Model 520 A, Orion Company Ltd, Iowa, USA). Total Soluble Solids (TSS) as °Brix of sorrel puree and sorrel leather was determined on a hand-held Eclipse refractometer (Bellingham and Stanley, UK). Colour of fresh sorrel, sorrel puree and sorrel leather was measured with a tristimulus Minolta Chromameter (Model CR-200, Minolta Corp, Ramsey, New Jersey) and calibrated with a white standard Minolta calibration plate Cr-A43. L (lightness or darkness; 100-white; 0-black), 'a' (+ a = redness; -a = greenness) and 'b' (+b = yellowness; -b = blueness). Colour parameters of Lightness (L), saturation or intensity (Chroma or 'C') and hue angle (h°) best correlate with human perception (Setser, 1984; Thai and Shewfelt, 1991; Lawless and Heymann, 1998)

Also 'a' and 'b' readings which are dependent on 'L' were used in the calculation of Hue (h°) (Francis, 1998). The h° represented colour 0 = bluish-red and 45 = red (Francis, 1987). Total Titratable Acidity (TTA) was expressed as % citric acid was determined by standard AOAC (1998). Using 0.1 N NaOH and phenolphthalein as an indicator. Moisture of the sorrel leather was determined according to AOAC (1985).

Microbiological analysis: Microbiological analysis of sorrel leather was conducted during storage at 4°C for 6 weeks. The sorrel leathers (0 and 0.15% xanthan gum) were analysed for aerobic mesophilic counts, lactobacilli, yeasts and moulds by serial dilution using Plate Count Agar (PCA, Difco, Detroit, MI,USA) Tomato Juice Agar (TJA, Oxoid Ltd., Basingstoke, Hampshire, UK) and Potato Dextrose Agar (PDA, Oxoid Ltd.), respectively by pour plate method as described by Swanson *et al.* (1992). Samples were placed in sterile stomacher bags and blended in a Seward Stomacher (Seward Stomacher 80 Laboratory System, UK). PDA plates were incubated at 32°C for 48 h; PCA plates and TJA plates were incubated at 35-37°C for 48 h. Petri plates with 30 to 300 microbial colonies and counts were expressed as CFU g^{-1}.

Hedonic test: In the first session of sensory evaluation, two sorrel leathers (0 and 0.15% xanthan gum) were presented to 50 untrained panellists who were students and staff of the University of the West Indies, Trinidad and West Indies. Panellists comprised of 18% males and 82% females, who were 56% 17-24 year, 24% 25-34 year, 18% 35-44 year and 2% 44 year and over. Samples (2 cm width×2 cm length×6 mm thick) were placed in 28.4 g (1 oz) three-digit randomly coded containers. Panellists were asked to score the products on colour, aroma, flavour, texture, sweetness, tartness/acidity and overall acceptability by hedonic scoring as : 9-like extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither like nor dislike; 4-dislke slightly; 3-dislike moderately; 2-dislike very much and 1-dislike extremely (AOAC, 1985). Panellists were allowed a 10 min break, during which they were provided with water and crackers for clearing of the palate before the start of the second session of sensory evaluation.

In the 2nd stage of sensory evaluation panellists were presented with sorrel leathers (0 and 0.15% xanthan gum) as in the first session, but differently coded with random three-digit codes and were given a script to be read (without references) on the health benefits of sorrel calyces. This script read as follows (without references):

Recent advances in medicine and a greater understanding of human nutrition have led researchers to recognise the existence of a number of substances occurring in plants known as nutraceuticals, which can enhance human health (SRC, 2004). Nutritionists have found that sorrel calyces are high in calcium, niacin, riboflavin, iron, phosphorus and amino acids (Morton, 1987; Sharaf, 1962). The brilliant red pigments contained in red calyces of sorrel are anthocyanins (Du and Francis, 1973; Mazza and Miniati, 2000). Anthocyanin pigments are effective scavengers of free radicals and thus there is much research activity on their possible health effects (Wrolstad, 2004). The efficacy of sorrel as a functional food has been revealed lately, where sorrel was suggested to play a role in the prevention of artherosclerosis and obesity (Tee *et al*., 2002). Some medicinal uses of sorrel calyces have been reported as being diuretic, cholerectic, febrifugal, hypertensive, anti-helminthic, anti-microbial, decreasing viscosity of the blood, reducing blood pressure and stimulating intestinal peristalsis' (Morton, 1987; Delgado *et al*., 2000; Kerharo, 1971; Ali *et al*., 1991; Faraji and Haji Tarkhani, 1999; Onyenekwe *et al*., 1999).

A forced paired test measured the preference of one sample over the other (Stone and Sidel, 1985). Panellists (100) were presented with the two sorrel leathers (0 and 0.15%) and were asked for their preference ('no option choice' was not included) of samples. Also, panellists were asked to give the ways, in which they have utilized sorrel, to provide recommended uses and to indicate their purchase intent ('definitely purchase'; 'probably purchase' and 'would not purchase').

RESULTS AND DISCUSSION

Processing changes: The yield of sorrel puree by enzymatic treatment was high (98%). The initial pH and TTA of fresh sorrel calyces were 2.30±0.01 and 0.23 g±0.01 100 g^{-1} citric acid, respectively. Sorrel calyces have been found to be high in citric acid, d-malic acid, tartaric acid and hibiscic acid (Morton, 1987). The dried calyces minus the ovary contained 13% of a mixture of citric and malic acid (Duke, 2003). Citric acid predominates (12-17%) in the sorrel sepals, but malic and tartaric acids are also present in the sepals (Kerharo, 1971). Colour of fresh sorrel calyces ('L' 26.20±0.21, 'C' 9.55±0.38 and 'h°' 18.93±1.0) sorrel was less ($p<0.01$) dark and less red than enzymatic-extracted sorrel puree ('L' 22.56±0.30, 'C 3.24±0.61 and hue 8.90±1.0). Colour intensity and hue of anthocyanin pigments are affected by pH, with the most effective range for most anthocyanin colorants being below pH 4 (Wrolstad, 2004). The initial TSS of fresh sorrel was 5°Brix was increased to 50°Brix by addition of sucrose to sorrel puree and on dehydration to 72-78°Brix in sorrel leather.

Table 1: Effect of xanthan gum on physicochemical quality of sorrel leather

	% xanthan gum		
Physical attributes	0	0.15	p-value
L	39.48±0.80	38.23±1.44	0.42
Chroma	4.93±0.19	6.84±0.15	0.00**
Hue°	0.00±0.00	1.99±0.15	0.00**
Texture, mm/2 sec	2.86±0.26	3.39±0.41	0.05*
TSS,°Brix	78.00±0.01	74.00±0.01	0.05*
TTA,% citric acid	0.27±0.01	0.28±0.01	0.64
pH	2.30±0.07	2.38±0.11	0.50

*Significant at p<0.05; **Significant at p<0.01

Table 2: Effect of storage on physicochemical quality of sorrel leather

	Storage (week)			
Parameter	0	4	6	p-value
L	$42.05\pm0.34_a$	$37.88\pm2.20_b$	$38.30\pm1.15_b$	0.02*
Chroma	$5.89\pm0.62_b$	$6.75\pm1.15_a$	$6.17\pm0.75_a$	0.61
Hue (h°)	$0.80\pm0.76_c$	$5.73\pm2.08_a$	$4.71\pm2.72_a$	0.03*
Texture, mm/2 sec	$2.85\pm0.33_b$	$3.12\pm0.50_a$	$3.40\pm0.50_a$	0.03*
TTA, % citric acid	$0.30\pm0.00_a$	$0.29\pm0.00_b$	$0.24\pm0.08_c$	0.02*
TSS, °Brix	$76.0\pm0.01_a$	$73.0\pm0.01_b$	$72.0\pm0.01_c$	0.00**
pH	$2.25\pm0.04_a$	$2.47\pm0.22_a$	$2.18\pm0.07_a$	0.14

*Significant at p<0.05; **Significant at p<0.01, Means±SE with different subscripts in rows are significantly different at p<0.05

Effect of xanthan gum: Table 1 shows that the addition of xanthan gum was significant on chroma (p<0.00), hue (p<0.01), TSS (p<0.05) and texture (p<0.05) of sorrel leathers. Sorrel leather product with 0.15% xanthan gum was more chromatic, less bluish-red, less firm and had lower TSS than control sorrel leather (0% xanthan gum).

Storage: The interaction of storage by treatment was significant colour (p<0.05; 'L'), texture (p<0.05), TSS (p<0.01) and TTA (p<0.05). Sorrel leather became less bright (lower 'L'), less bluish-red (h°), less firm and had lower TTA and TSS by week 4 of storage (Table 2). Anthocyanin pigments are unstable in light and heat (Wrolstad, 2004). The effectiveness and stability of sorrel calyces as a source of red colour for fruit jellies and jams were studied (Esseleh and Sammy, 1973). Storage of the products at 6 months at 29°C showed good red colour retention although some darkening was evident. Two main anthocyanins by HPLC were identified by thin layer chromatography as cyanidin-3-sambuboside and delphinidin-3-sambuboside (Pouget *et al*., 1990).

The moisture content of sorrel leather was 19.96 g 100 g^{-1}. The moisture of fresh edible calyces was reported as 9.2 g 100 g^{-1} (Morton, 1987). Throughout storage at 4°C for 6 weeks, the total plate counts, yeast and moulds and lactobacilli were <10 CFU g^{-1}. The majority of confectionery products are not susceptible to microbial spoilage, primarily because of their high percentage of solids, which result in a water Activity (A_w) of less than 0.85 (Lenovich and Konkel, 1992). The low pH (2.18-2.47), high total soluble solids (72-78°Brix), high acidity processing and addition of potassium sorbate would have provided and high total titratable acidity (0.24-0.30 g 100 g^{-1} citric acid) would have provided antimicrobial barriers for microbial stability.

Sensory acceptance: The effect of adding xanthan gum had no (p>0.05) effect on all sensory attributes except sweetness (p<0.05). Sorrel leather without xanthan gum had higher hedonic score (7.9±0.14) for sweetness than the product with 0.15% xanthan gum (7.4±0.23), which could be related to the higher TSS (Table 1) The presentation of health benefits on sorrel calyces to panellists had no influence on all sensory attributes (colour, aroma, flavour, texture, sweetness tartness/acidity and overall acceptability), which could be related to the initial (before presentation of health benefits of sorrel) of high sensory scores given to all attributes (7-8; liked very much to moderately) and aroma (6-7; liked slightly to moderately). It was found that after a brief education program on the benefits of cranberry did not influence the acceptance of 100% cranberry juice (Ghanzanfar and Camire, 2002). 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 (Drake and Gerard, 2003).

Sorrel was consumed as drinks (98%), jams (64%), liqueur (47%), preserves (30.6%), sauces (10%) and leather (10%). In contrast to hedonic testing, which revealed no difference (p<0.05) in acceptability between

Table 3: Effect of xanthan gum on sensory acceptance of sorrel leather

Sensory attributes	0%	0.15%
Colour	7.63±0.17	7.71±0.14
Aroma	7.00±0.21	6.73±0.21
Flavour	8.00±0.12	7.76±0.14
Texture/mouthfeel	7.73±0.15	7.51±0.16
Acidity/tartness	7.49±0.18	7.27±0.23
Sweetness *	7.90±0.14	7.40±0.23
Overall acceptability	7.82±0.14	7.69±0.19

*Significant $p<0.05$; 9-like extremely; 8-like very much; 7-like moderately; 6-like slightly

sorrel leather with and without xanthum gum, the paired test indicated a significant ($p<0.05$) preference for 0.15% xanthan gum sorrel leather. Most (72%) panellists 'would purchase' the sorrel leathers if available on the market, while only 2% indicated that they 'would not purchase' (Table 3).

CONCLUSION

Sorrel leathers processed from pectolase-treated calyces were liked very much to extremely in overall acceptability and most panellists would purchase the products. Addition of xanthan gum resulted in a more chromatic, less bluish-red colour, less firm, lower total soluble solids product and with lower acceptability for sweetness. Sorrel leathers had colour of 'L' 38.23-42.05, C' 4.93-6.84, hue°.0.00-5.73, TSS of 72-78°Brix, TTA of 0.24-0.30% citric acid, pH 2.18-2.47 and texture 2.85-3.40 mm^{-1} 2 sec, Providing information on the health benefits of sorrel did not influence the initial high hedonic scores of sorrel leather. By week 4 of storage at 4°C, the sorrel leather became less bright, less bluish-red, less firm and had lower TSS and TTA. Sorrel leathers were microbiologically stable throughout the 6 weeks of storage.

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