PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 10 (1): 71-75, 2011
ISSN 1680-5194

Quality of Light Celery Mayonnaises with Erythritol-sucralose Replacement

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Abstract: This study explored physical and sensory properties of light celery mayonnaises which replaced for sugar with erythritol-sucralose at different levels (0, 25, 50, 75 and 100%). There was a significant increase ($p<0.05$) in pH, but decrease ($p<0.05$) in viscosity and firmness as the level of erythritol-sucralose replacement was increased. All reduced-sugar mayonnaises would become more light but less green and yellow than that of the control. Erythritol-sucralose replacement had a significant effect ($p<0.05$) on all sensory attributes, except for colour, of light mayonnaises with respect to the control. The sweetness score was significantly lowered ($p<0.05$) in light celery mayonnaises with higher 50% erythritol-sucralose replacement. The optimum level of 50% erythritol-sucralose can be used in the light celery mayonnaise to obtain acceptable sensory quality with respect to the control.

Key words: Mayonnaise, erythritol, sucralose, low-calorie sweetener, sugar replacement

INTRODUCTION

Low or no sugar foods have a large impact on the role of diet and health, because of high risk of health problems from over sugar consumption such as obesity, diabetes, high glucose blood and tooth decay (Dziezak, 1986). The discovery of a large number of new sweeteners over the past few decades has led to the development of various sugar-free products (Chetana *et al.*, 2010). Many low-calorie sweeteners used in food products are selected depending on their functional properties. Intense sweeteners that have no bulk property such as aspartase, acesulfame-K and sucralose are used in a small amount because of their high sweetness as compared in weight-by-weight with sucrose. On the other hand, sugar alcohols such as sorbitol, xylitol and erythritol provide less sweet than sucrose, but they give bulk volume (Goossens and Roper, 1994; Akesowan, 2010). With advantages of each low-calorie sweetener, the tendency for their combinations betwpeen sugar alcohol and intense sweetener has been increased for food application. This provides both an intense sweetness incorporated with bulk property, which promote a better quality and economy of the low-calorie product with a reasonable price.

Erythritol, a natural sugar alcohol, with about 60-80% of the sweetness of sucrose providing less than 0.5 kcal/g, is proven as safe by U.S. Food and Drug Administration (FDA) for food use with no tooth decay (Noda *et al.*, 1994). Furthermore, blood glucose and insulin levels do not increase when erythritol is administered orally to normal male subjects (Goossens and Roper, 1994). Like other sugar alcohols, erythritol is a bulking sugar replacer with less sweet than sugar, which sometimes limits their expanded applications. On the other hand, sucralose, a popular intense sweetener which provides 600 times of sucrose sweetness, is a non-cariogenic and no calorie substance. It has been extensively used in many food products; however, it costs high price and could not compensate for the bulk property of sucrose (Hoch, 1999; Mendoca *et al.*, 2001). For purpose as mentioned above, an erythritol-sucralose (98.6:1.4) or D-et® is a mixed low-calorie sweetener which has been recently introduced in Thai food market. It has superior taste to any kinds of sweeteners and provides virtually 8 times of sucrose sweetness with less than 0.18 Kcal/g, which can be used in low-calorie, low sugar food products (Akesowan, 2009; U-sing Co., 2010). So far, few studies have been related to the application of erythritol-sucralose in food products. In our previous work, it was successful for replacing 60% vegetable oil with added water incorporated with 0.4% konjac flour in celery mayonnaises (Choonhahirun, 2008). Although this product is not a sugar rich product, it is interested to develop low-calorie mayonnaises by the way of sugar replacement with erythritol-sucralose in the light celery mayonnaise. Therefore, this work was carried out to study physical and sensory properties of light celery mayonnaises with varying levels of erythritol-sucralose as sugar replacement.

MATERIALS AND METHODS

Konjac flour (Chengdu Qiteng Trading Co., Ltd) and xanthan gum (KELTROL®, CP Kelco, San Diego, CA, USA) were used. Mayonnaise ingredients including soybean oil, fresh eggs, fermented vinegar, distilled vinegar, lemon juice, mustard, sugar, pepper and celery were purchased from a local supermarket. The food grade low-calorie sweetener, erythritol-sucralose (98.6:1.4) or D-et® was obtained from U-Sing Co., Ltd., Thailand.

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Table 1: Formulas for celery mayonnaises with varying sugar replacement levels

	Replacement level of erythritol-sucralose for sugar				
Ingredients (%)	0%	25%	50%	75%	100%
Vegetable oil	28.8	28.8	28.8	28.8	28.8
Yolk egg	5.0	5.0	5.0	5.0	5.0
Fermented vinegar	1.0	1.0	1.0	1.0	1.0
Distilled vinegar	5.0	5.0	5.0	5.0	5.0
Lemon juice	3.0	3.0	3.0	3.0	3.0
Mustard	0.5	0.5	0.5	0.5	0.5
Salt	1.0	1.0	1.0	1.0	1.0
Pepper	0.1	0.1	0.1	0.1	0.1
Celery (chopped)	6.0	6.0	6.0	6.0	6.0
Xanthan gum	0.3	0.3	0.3	0.3	0.3
Konjac flour	0.4	0.4	0.4	0.4	0.4
Sugar	10.0	7.5	5.0	2.5	0.0
Erythritol-sucralose*	0.0	0.3	0.6	0.9	1.2
Water	38.9	41.1	43.3	45.5	47.7

*The equivalent sweetness of erythritol-sucralose is calculated at 125 g/kg of sucrose

Mayonnaise preparation: Formulations for light celery mayonnaises prepared with 0, 25, 50, 75 and 100% sugar replacement with erythritol-sucralose are shown in Table 1. The equivalent sweetness of erythritol-sucralose (8 times of sucrose sweetness) was calculated at 125 g/kg of sucrose. According to the light celery mayonnaise processing (Choonhahirun, 2008), yolk egg and mustard were thoroughly mixed for 1 min with a food processor (speed 1) and then salt, sugar, lemon juice and vinegar were added and further blended for 4 min. The konjac/xanthan solution (previously hydrated in water for 30 min) was gradually added into the mixture, followed by vegetable oil, chopped celery and pepper. After 2 min mixing, the mayonnaise was packed in sterile glass bottles and kept in a refrigerator (10±2°C) prior to analysis.

Physical analysis

pH: The pH-meter (Model 320, Mettler-Toledo Ltd., Essex, UK) was used to measure pH of each sample according to AOAC (1990) procedure.

Penetrometer value: Each mayonnaise sample was measured using a penetrometer (Model H-1200 Paul N. Gardner Company, Inc, USA). The immersed distance of a test cell in a specific time (10 sec) was determined and recorded as the 'firmness' of the sample.

Viscosity: A 200 g of sample was filled into a 250-mL beaker and viscosity was measured by using a Brookfield viscometer (Model RVDV-II, Brookfield Engineering Laboratories, USA). The viscometer was operated with a spindle no.7 at 100 revolutions per minute (rpm).

Colour: A Hunter Lab digital colorimeter (Model D25M, Hunter Associates Laboratory, Reston, VA) was used for colour determination. CIE colour scales L*a*b* values were recorded. Hue and chroma values were calculated using the formula, ($\tan^{-1}$ b/a) and $(a^2+b^2)^{½}$, respectively.

Sensory evaluation: A 9-point hedonic scale test (1 = extremely dislike, 9 = extremely like) was used to evaluate sensory attributes for thickness, colour, flavour, sweetness and overall acceptability of celery mayonnaises. Forty untrained panelists were seated in individual sensory booths and were provided distilled water to rinse their palates between samples. All samples were coded with random 3-digit numbers (Lawless and Heymann, 1998).

Statistical analysis: The production of light mayonnaises with different levels of erythritol-sucralose was carried out in triplicate. Data were analyzed statistically by Analysis of Variance (ANOVA) using SPSS for Window version 14.0. Means with a significant difference ($p<0.05$) were compared by Duncan's new multiple range test (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Physical analysis

pH: As shown in Fig. 1a, there was a significant difference ($p<0.05$) in pH among light celery mayonnaises with varying levels of sugar replacement. The pH was increased with increasing level of erythritol-sucralose, probably due to an amount of added water used for adjusting each reduced-sugar formulation to 100% total weight composition (Table 1) may dilute acid concentration of vinegar and lemon juice which are ingredients in the mayonnaises.

Penetrometer value: Firmness of mayonnaise, expressed as 'penetrometer value', was measured by the distance of a test cell immersed into a sample in a specific time, the shorter distance defines the higher firmness. As shown in Fig. 1b, it was clear that all erythritol-sucralose mayonnaises were significantly higher ($p<0.05$) in penetrometer values than that of the control, meaning that they were less firm texture. However, various levels of erythritol-sucralose did not produce the samples with different firmness. This was attributed to the difference in bulking property and water-holding capacity between sugar and erythritol-sucralose. In general, the sugar reduction alone usually causes a decrease in bulk volume of many food products, which can be compensated by adding bulking agents such as hydrocolloids, starches and sugar alcohols along with low-calorie sweeteners. Also, increased amount of water used in reduced-sugar mayonnaises may affect the emulsion system leading to decrease intermolecular network (protein-protein interaction) that forms a more stable emulsion (Sathivel *et al.*, 2005). This finding implies that the proper bulking agent for improving firmness of erythritol-sucralose mayonnaises is required and should be investigated.

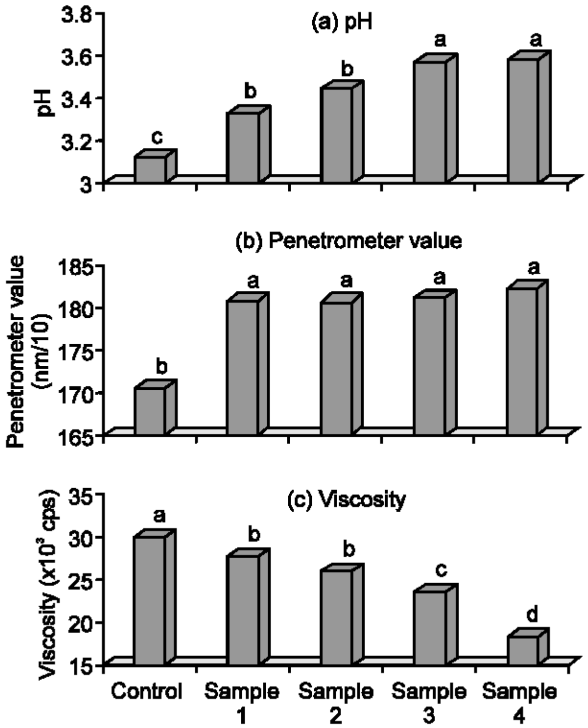

Fig. 1: Physical properties of light celery mayonnaises with sugar replacement: (a) pH (b) penetrometer value and (c) viscosity. Control = 100% sugar added and sample 1-4 are 25, 50, 75 and 100% sugar replacement with erythritol-sucralose, respectively

Viscosity: Results for viscosity of erythritol-sucralose mayonnaises shown in Fig. 1c demonstrates that the highest viscosity was obtained ($p<0.05$) in the control whereas the 100% erythritol-sucralose sample showed the lowest ($p<0.05$). Other samples had significantly ($p<0.05$) different viscosities from each other, except for that with 25 and 50% sugar replacement, showing that the reduction in sugar content has a marked effect on this property. It may be due to the water-holding capacity of sugar, which influences on viscosity of the mayonnaise (Knecht, 1990). This result also indicated that erythritol-sucralose with less than 50% replacement is capable of providing viscosity or body of the products similar to that made by 100% sugar.

Colour: The data for colour L*a*b* values were statistically analyzed and their relationship were illustrated in Fig. 2. The replacement of sugar with erythritol-sucralose significantly affected ($p<0.05$) colour of light celery mayonnaises. When the level of erythritol-sucralose increased, it was observed that values for L* (lightness) significantly increased ($p<0.05$), whereas -a* (negative a*, green) and b* (yellow) values decreased significantly ($p<0.05$) (Fig. 2a), showing that the more

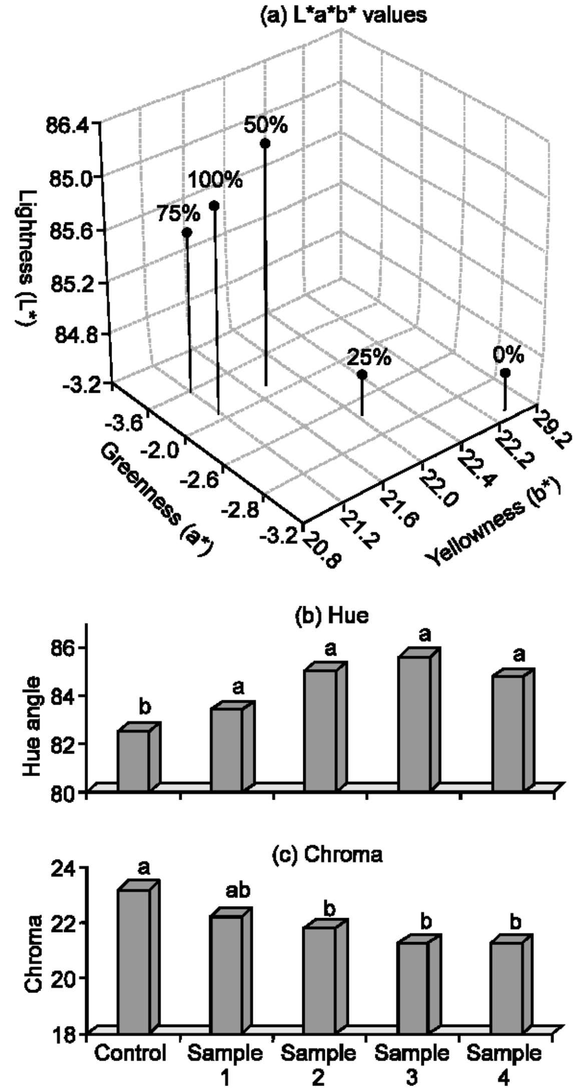

Fig. 2: Colour values of light celery mayonnaises with sugar replacement: (a) L*a*b*values (b) hue and (c) chroma. Control = 100% sugar added and sample 1-4 are 25, 50, 75 and 100% sugar replacement with erythritol-sucralose, respectively

amount of erythritol-sucralose used, the products were more light but less green and yellow than the control formulation (100% sugar). In general, the colour of mayonnaise comes from its ingredients such as vegetable oil and yolk egg and the processing method. This colour change may be probably due to the increased water content in erythritol-sucralose formulations that resulted in the dilution of total colour of mayonnaises. Also, erythritol-sucralose can not participate in Maillard reaction like sugar (Lin *et al.*, 2003). However, the color L*a*b* values of 25% erythritol-sucralose mayonnaise did not differ from that of the control. According to hue value (Fig. 2b), it tended to increase from 83.43° to 85.63° with increasing of erythritol-sucralose from 25-100%, indicating that the products would become less yellowish. The control exhibited a significantly lower hue value (82.25°) or more color than did all other formulations. Chroma, which measures the saturation of colour, decreased with increasing of erythritol-sucralose (Fig. 2c), which was attributed to the decrease in green and yellow colour.

Sensory evaluation: Sensory scores of light celery mayonnaises prepared with different levels of erythritol-sucralose presented in Table 2 shows that there were significant differences ($p<0.05$) in all sensory attributes, except for colour among all mayonnaises. The result for sensory colour of reduced-sugar light mayonnaises do not support the data on objective colour, measured as L*a*b* (Fig. 2a). The scores given for thickness indicated that panelists significantly accepted ($p<0.05$) the sample with 50% erythritol-sucralose, which exhibited its viscosity in mid-range level between that of the control and 100% erythritol-sucralose samples. With respect to flavour attribute, panelists did not determine the difference between 25% erythritol-sucralose and control samples. When 50% erythritol-sucralose or above were incorporated, the samples were observed for lower ($p<0.05$) scores of flavour as compared with the control. The difference in flavour perception between the control and the sample with 50% erythritol-sucralose replacement or above might be due to the different flavour characteristics in present erythritol-sucralose. Evidently, there was a tendency for decreased sweetness scores with increasing levels of erythritol-sucralose replacement. Sweetness is the main criteria used for mayonnaise quality assessment in this work. As a result, sweetness scores of 75 and 100% erythritol-sucralose mayonnaises were significantly less than ($p<0.05$) those made with 0, 25 and 50% erythritol-sucralose samples. The influence of erythritol-sucralose replacement on sweetness could be due to the reason for sweetness of erythritol being about 60 to 80% compared to that of sugar as well as different sweetness profiles of both sucralose and erythritol in relation to that of the sugar (Newsome, 1993). When considering scores for overall acceptability, it was found that the 50% erythritol-sucralose light mayonnaise was most preferred, equal to 25% erythritol-sucralose and control samples whereas other samples were less acceptable ($p<0.05$). Based on all sensory data shown in Table 2, one can infer that the overall acceptability was mostly influenced by thickness and sweetness characteristic; consequently, the optimum level of 50% erythritol-sucralose replacement can be used in light celery mayonnaise to obtain acceptable sensory quality with respect to the control. In addition, as calculated for calorie from sugar, this formulation provided a 49.7% reduction in energy value from that made with sugar.

Correlation: According to correlation analysis, there was no significant ($p<0.05$) correlation between sensory thickness and penetrometer value ($r = 0.162$) or thickness and viscosity ($r = 0.137$). However, a high negative correlation was observed for the penetrometer value and viscosity ($r = -0.711$) (data not shown). Correlation matrix for sensory attributes of light mayonnaises with erythritol-sucralose replacement presented in Table 3. Strong correlations ($r>0.9$) were observed between colour, sweetness and overall acceptability of the mayonnaises. However, thickness and flavour were weakly correlate to colour, sweetness and overall acceptability. These observations also demonstrated that flavour was not a strong predator for sensory perception of the light mayonnaises with erythritol-sucralose replacement.

Table 2: Sensory scores of light celery mayonnaises with erythritol-sucralose replacement

Erythritol-sucralose replacement (%)	Thickness	Colour^{ns}	Flavour	Sweetness	Overall acceptability
0	6.65±1.27^{b}	7.10±1.15	6.73±1.15^{b}	6.80±1.18^{a}	6.73±1.11^{a}
25	6.78±0.97^{b}	7.10±1.03	6.63±1.03^{ab}	6.48±1.32^{a}	6.68±1.16^{a}
50	7.25±0.95^{a}	7.18±0.98	6.45±0.98^{a}	6.75±1.32^{a}	7.16±1.14^{a}
75	6.85±1.00^{b}	6.95±1.31	6.33±1.31^{a}	5.85±1.61^{b}	6.10±1.35^{b}
100	6.70±1.16^{b}	6.93±1.15	6.56±1.15^{a}	5.90±1.55^{b}	6.10±1.37^{b}

Means in the same column with different superscripts are different ($p<0.05$); ns = non-significant. Based on a 9-point hedonic scale test (1 = extremely dislike, 9 = extremely like)

Table 3: Correlation matrix of sensory attributes of light celery mayonnaises with erythritol-sucralose replacement

Attributes	Thickness	Colour	Flavour	Sweetness	Overall acceptability
Thickness	1.00	0.55	-0.56	0.30	0.62
Colour	0.55	1.00	0.31	0.94*	0.99**
Flavour	-0.56	0.31	1.00	0.55	0.27
Sweetness	0.30	0.94*	0.55	1.00	0.93*
Overall acceptability	0.62	0.99**	0.27	0.93*	1.00

*Significant at 0.05 level, **Significant at 0.01 level

Conclusion: An erythritol-sucralose can be used as sugar replacement in the production of light celery mayonnaises in which they produced lower viscosity and firmness characteristics with more light and less yellowish. When the sugar replacement was more than 50%, the mayonnaises was judged to be significantly ($p<0.05$) less score for sweetness. The optimun level of 50% erythritol-sucralose replacement can be used without any sweetness and texture defect.

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