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Quality evaluation of muffins prepared by replacing sugar with natural sweeteners

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Abstract
The use of natural sugar replacer in bakery products has now become a new establishments in the market to produce low calorie bakery product. The present study was carried out to develop muffins prepared by replacing sugar with other natural sweeteners such as jaggery (0, 25, 50, 75 and 100 percent level) and honey (0, 10, 20, 30, 40 and 50 percent) and stevia (0. 25, 50, 75 and 100 percent level) on the basis of sweetness alone or in combination. Based on baking, textural along with organoleptic evaluation (using 9- Point Hedonic Scale), standard recipe was formulated by using maltodextrin as a bulking agent. Muffins prepared in combination with jaggery, honey and stevia in the ratio of 15:10:75 were found to be best. Estimated cost for low calorie muffins in combination with jaggery, honey and stevia was 105 Rs/kg which was found economically profitable as compared to other market products.

Keywords: Jaggery, honey, stevia, maltodextrin and muffins

1. Introduction
History of human endeavour in improving food palatability is in fact as old as the civilisation itself. It goes back to times unknown; though our understanding of mechanism of taste perception remains preliminary. For several years, high calorific sugars remain main source of sweetening agent. With the society getting more affluent and people doing more and more white collar jobs with their lifestyle almost sedentary, by having food like this, people have become more prone to health related disorders such as obesity, diabetes and other coronary ailments but at the same time, the desire and liking of people for foods like desserts, sweet baked goods, confections etc., cannot be neglected. Due to these factors replacement of these high calorific sugars by low calorific intense sweeteners has become necessary. Specific recommendations have been made on the basis of extensive clinical and epidemiological data by various health organizations to reduce the energy intake by 30 percent (AHA 1986) [2]. These factors made the consumers to think about healthier options which lead to the establishment of new trends in the market like low fat, low sugar and finally low calorie food. All these factors have led to the use of low calorie or natural sweeteners in place of sugar. Low calorie artificial sweeteners are being used in the beverage and confectionary industry with maintained palatability but use of natural sugar replacer is comparatively new line of thought for bakery industry and for the consumers who are trying to lose their weight, by convention bakery products as the key products to be avoided (Chan 2006) [6]. Bakery products contain about 40-50 percent fat and 50 percent sugar and hence are categorized as high calorie food and apparently this category is relished by almost everyone, therefore, replacing the sugar of these products with low calorie sweeteners will lead to a credible decrease in the calorie intake. Sweeteners that can be used in different food products are jaggery, honey and stevia. Because of the therapeutic uses of jaggery and along with high intensity sweetness of stevia, these natural sweeteners can be used in bakery products in place of sugar. Besides their sweetening capacity, these natural sweeteners are also nontoxic and are safe to use.

2. Materials and methods

2.1 Raw Materials

Wheat flour/ whole wheat flour, sugar, honey, jaggery, stevia powder, fat, sodium bicarbonate, baking powder, skim milk powder, eggs and essence were procured from the local market.

2.2 Preparation of muffins

Muffns were prepared by using standard procedure (AACC, 2000) [1]. Fat and sugar were whipped in Hobart mixer at high speed for 3 minutes. Whipped egg, mixed with essence were added and whisked again at high speed for 1 min. Finally sieved flour, baking powder and milk were added and the batter was mixed slowly to desire consistency. Batter was poured in muffin trays (50 g by weight in each mould) and baked at 400°F for 20 minutes. It is then cooled and packed. In formulations sugar was replaced by weight with jaggery and honey and stevia on the basis of sweetness along with maltodextrin as a bulking agent. The replacement levels for jaggery and stevia were 0, 25, 50, 75 and 100 percent and for honey were 10, 20, 30, 40 and 50 percent. The basic formula and percent substitution is listed in Table 1 and 2.

2.3 Quality evaluation

2.3.1 Physical quality: Selected muffins were analysed for physical parameter such as weight, volume and specific volume by using standard procedures (AACC, 2000) [1].

2.3.2 Sensory analysis: Sensory evaluation of muffins was done by semi trained and untrained panel of judges for colour, appearance, texture, flavour and overall acceptability using 9-point hedonic scale.

2.3.3 Texture analysis: The compression force for muffins was analysed by 'Ta-H di plus' Texture Analyser (Stable Micro Systems Ltd., Surrey, UK) using settings given in Table 3.

2.3.4 Colour analysis

The colour was measured in accordance with CIE L*, a*, b* colour space system (Lab Scan XE Hunter Lab Instrument Virginia, USA) based on the tri- stimulus value. The L*, a*, b* values were recorded (Kimura and co-workers, 1993) [11].

2.4 Statistical analysis

The data collected on different characteristics were analysed with the help of factorial design in CRD using the software CPCS-1 (Singh and co-workers, 1991). All results were expressed at 14 percent moisture basis unless otherwise stated. Each value is mean of three observations and is expressed as Mean ± SD.

3. Result and discussion

3.1 Effect of sugar substitute on muffin quality

Study was carried out to replace sugar in the standard formulation with natural sugar substitute i.e., jaggery, honey and stevia along with maltodextrin as a sugar replacer.

3.1.1 Effect of jaggery on the muffin quality

Sugar in the muffin formulation was replaced by jaggery as a sugar replacer at different levels i.e., 25, 50, 75 and 100 percent on weight basis (Table 4). It was observed that there was no significant change in the weight of muffins with increasing level of jaggery. The volume of the muffins was measured by rye displacement method, where a significant increase in volume was observed. With this increase in volume, a significant increase in specific volume was observed with increasing replacement level from 1.95 of control muffins to 2.65 at 100 percent replacement level.

The compressibility of muffins was evaluated by using Microsystem Texture Analyser Model (TA-H-di England) at 250 kg load cell. It was observed that with increase in replacement level in the formulation, the compression force increased at 25 percent replacement of sugar with jaggery, further it decreased as the replacement level increased.

The organoleptic evaluation of the muffins (Table 7) showed significant variation on the various parameters such as colour, texture, flavour and overall acceptability of muffins. Muffins with jaggery showed no significant changes in colour, flavour, texture and overall acceptability. However, in terms of texture the score for 25 percent replacement was found to be the highest followed by 50 percent replacement in comparison to control. The overall acceptability score was highest for 25 percent replacement level after control muffins which significantly decreased as the replacement level increased. Overall the muffins with jaggery were well accepted by the panelists in terms of colour, texture and flavour. The least acceptable muffins were in which 50 percent sugar was replaced by honey in terms of all the parameters.

3.1.2 Effect of honey on the muffin quality

Sugar in the muffin formulation was replaced by honey as a sugar replacer at different levels viz., 10, 20, 30, 40 and 50 percent on weight basis (Table 5). There was no significant difference in weight, volume and specific volume of the muffins but an increasing trend was observed in volume with increasing replacement level. This increase in volume resulted in the increase in specific volume.

It was observed that in Table 6 with increase in replacement level, a significant variation was observed in toughness of muffins. As replacement level increased, the toughness required during texture analysis had also increased. Initially when there was 10 percent replacement of sugar with honey, a reduction in force was observed than the normal. Further with increasing replacement level up to 50 percent the compression force increased significantly and was highest at 50 percent replacement level.

The organoleptic evaluation of the muffins (Table 7) showed the significant variation in the various parameters such as colour, texture, flavour and overall acceptability of muffins. In case of muffins substituted with honey, significant variations were observed for colour, texture, flavour and overall acceptability. The colour of 25 percent replacement was most liked by most of the panelists, further a decrease in score was observed with increasing replacement level. The texture and flavour of 20 percent replacement was found to be the best among all the replacement levels. The overall acceptability of 20 percent honey substituted muffins was highest followed by 30 percent honey substituted muffins. The least acceptable muffins were in which 50 percent sugar was replaced by honey in terms of all the parameters.

3.1.3 Effect of stevia on the muffin quality

Muffins were prepared by replacing the sugar with the natural sweetener stevia. Sugar in the formulation was replaced by stevia on the basis of sweetness at different levels viz., 25, 50, 75 and 100 percent and the bulk was made by addition of maltodextrin (Table 6). With increasing replacement of sugar, no significant change was observed in weight of muffins. The volume of muffins increased till 75 percent level of sugar

substitution after that a sudden decrease in volume was observed. Consequently, an increase in the specific volume was observed till 75 percent replacement followed by a sudden decrease in specific volume at 100 percent substitution level.

A progressive hardness was observed with increasing level of sugar replacement. The force required to compress muffin with 25 percent sugar replacement was lesser than control muffin thereafter an increase in hardness was observed as the replacement level increased. The results can be correlated with the physical observation that samples become tougher with sugar replacement (Table 6). The hardness was mainly due to substitution of sugar with sweetener and maltodextriin used as a bulking agent.

The organoleptic evaluation of the muffins (Table 7) showed the significant variation on the various parameters such as colour, texture, flavour and overall acceptability of muffins. On conducting the organoleptic evaluation of above said muffins, it was observed that there was no significant variation in the colour with increasing replacement level. Colour of the control was more preferred over substituted muffins. The texture of muffins with 75 percent replacement with stevia and maltodextrin has found to be the best among other substituted samples. The taste and overall flavour of muffins were appreciated by all the panelists but the most preferred amongst all sugar substituted sample were the muffins in which sugar was replaced at the rate of 75 percent with stevia and maltodextrin. Although the overall acceptability of 75 percent substituted sample was highest but it was followed byclose margin by muffins with 50 percent substituted muffins. The least acceptable muffins were those in which 100 percent sugar was replaced by stevia.

3.2 Effect of combination of sugar substitutes on the quality of muffins

Based on baking, textural and organoleptic evaluation, a best combination of muffin was selected and muffins were prepared with or without preservative in which sugar was replaced in combination of jaggery, honey and stevia in the ratio of 15:10:75 which were further analysed for different quality parameters.

3.2.1 Pasting properties of flour

Studies were carried out to observe and analyse the effect of sugar substitution on pasting properties of flour (Table 8). Blends of various respective compositions were prepared and the pasting properties were determined by using the rapid visco analyser (RVA) starch master R & D pack V 3.0 (Newport scientific Narrabean Australia). The RVA parameters measured were Pasting temperature (the temperature at which the viscosity of paste starts to increase), peak viscosity (maximum viscosity attained by the slurry) holding viscosity (the trough at minimum hot paste viscosity) and final viscosity (the viscosity of the slurry after cooling to 50 °C and holding the temperature), final viscosity, break down viscosity and set back viscosity in accordance with the method given by Walker *et al.* (1987) [15] and Batey *et al.* (1997) [4]. The effect of natural sugar substitute and their combination on pasting properties of flour used of muffin making is shown in Table 8.

Statistically significant variation was observed in pasting properties (pasting temperature (°C); peak viscosity (cP); holding viscosity (cP); final viscosity (cP); break down viscosity (cP); set back viscosity (cP) of the formulations containing 100 percent sugar, 100 percent jaggery and 100 percent stevia with maltodextrin as a bulking agent and one formulation with combination of jaggery, honey and stevia with maltodextrin as a bulking agent.

A significant difference was found in the pasting temperature of formulation with highest in the formulation containing sugar followed by formulation containing jaggery and with lowest of stevia. The order of pasting temperature was sugar>jaggery> combination >stevia.

An increase in peak viscosity was observed in the formulation where sugar is completely replaced by stevia and maltodextrin as a bulking agent and formulation with combination of jaggery, honey and stevia containing maltodextrin as a bulking agent except for the formulation containing 100 percent jaggery. The peak viscosity for the formulation containing stevia with maltodextrin as a bulking agent was found to be highest (10213 cP) followed by formulation with combination jaggery, honey and stevia (10145 cP).

Similar patterns were observed for hold and final viscosity. A significant decrease in breakdown viscosity was observed with 100 percent replacement of sugar with natural sugar substitute. The values for setback viscosity were found to be negative for the formulation containing maltodextrin as a bulking agent. So we can say that the samples containing maltodextrin were thicker as compared to the sample containing 100 per sugar or jaggery.

Lee and Hoseney (1982) [12] concluded that with increasing levels of maltodextrin in the cake batter, makes the batter more viscous which cannot be measured by Brookfield Viscometer. Similar observations were studied by Kim and Walker (1992) [10]. Lufti and Hasnain (2009) [13] reported that the pasting properties of flour can be greatly modified by hydrocolloids. Ryu (1993) [14] concluded that increase in concentration of sugar from 5 to 10 percent greatly affect the pasting properties. The effect of sucrose on wheat starch gelatinization temperature and/ or time by using amylograph was studied by Bean and Yamazaki (1978) [5] and Appolonia (1972) [3], differential scanning calorimeter by Spies and Hoseney (1982) [12] and RVA by Deffenbaugh and Walker (1989) [7] and they reported that sucrose delayed the starch gelatinization time and temperature. Dengate (1984) [8, 9] and Dengate and Meredith (1984) [8, 9] reported that peak viscosity was dependent on swelling, exudation and fragmentation of starch. On the other hand, breakdown viscosity was regarded as measure of degree of disintegration of starch granules or substances.

3.2.2 Baking and textural properties

Sugar in the muffin formulation was completely replaced by stevia, jaggery and honey in the ratio of 75:15:10 and their effects are tabulated in Table 9. In comparison to control, non-significant change was observed in the weight of muffins. A decrease in volume was observed in the muffins in which sugar was replaced in combination with stevia, jaggery and honey as compared to control. A significant decrease in specific volume was observed from 1.95 for control muffins to 1.89 for the muffins in combination with stevia jaggery and honey. The results can be correlated with the physical observation that samples become tougher with sugar replacement.

The compressibility of muffins was evaluated by using Microsystem Texture Analyser Model (TA-H-di England) by using compression probe. A significant increase in compression force was observed in the final selected combination as compared to control. The results showed a significant increase in the yellowness of the crust as compared

to control except in the samples containing 100 percent jaggery, a decrease in the b^* value was observed. The results were similar as that for the crumb colour, except in the muffins with 100 percent jaggery showed highest yellowness in the crumb. The hardness was mainly due to substitution of sugar with sweetener and maltodextrin used as a bulking agent.

3.2.3 Colour values

The colour values for the crust and crumb of muffins is tabulated in Table. The results showed that by replacing 100 percent sugar with stevia and maltodextrin as a bulking agent there was a significant increase in the L^* values of the crust of the muffins. In case of low calorie muffins with combination of jaggery, honey and stevia (15:10:75), the L^*values of the crust was more in comparison to control whereas muffins with 100 percent jaggery were less bright in comparison to other formulation (Table 10).

A significant variation in the crumb value of muffins was also found. The muffins with 100 percent sugar had whiter crumb as compared to other formulation followed by stevia, low calorie muffins with jaggery, honey and stevia in combination and least in muffins with 100 percent jaggery.

There was a significant decrease in the a^*values of the crust as compared to control muffins. The a^*value that is for red colour was highest for the control (19.75) and lowest for the muffins with 100 percent stevia with maltodextrin as a bulking agent. The low calorie muffins with jaggery, honey and stevia in combination showed less red value in comparison to control.

The results for crumb showed negative a^*values for control and muffins with 100 percent stevia and maltodextrin as bulking agent. The muffins in combination with jaggery honey and stevia with maltodextrin as a bulking agent showed very less red value. The muffins with 100 percent jaggery showed highest redness in comparison to all other formulations.

3.3 Product economics

The cost of selected final samples of low calorie muffins was analysed. The cost of raw material was assumed for Flour (Rs. 18/ kg), Fat (Rs. 200/ kg), Sugar (Rs. 32/ kg), Stevia (Rs. 1400/ kg), Jaggery (Rs. 40/ kg), Honey (@ 200/ kg), Dextrose (Rs. 400/ kg) and Maltodextrin (Rs. 32/ kg). Cost of manufacturing *(including all recurring and non-recurring expenditure)* was considered @ 10% of raw material cost. Cost of marketing was considered @15% of raw material cost. The approximate cost of different samples of muffins is described in Table 11.

Table 1: Basic ingredients of the formulation

Ingredients	Amount
Flour	100
Sugar	100
Fat	60
Baking powder	2.4
Essence	0.5
Egg	110ml
Milk	60ml
Lecithin	0.5g
GMS	0.5g

Table 2: Substitution of sugar with natural sugar replacers and their combinations

Sugar substitute	Percent replacement	Muffins[1]	
		Sweetener (g)	Sugar (g)
Sugar	Control	-	100
	25	25	75
	50	50	50
	75	75	25
	100	100	0
Honey	10	10	90
	20	20	80
	30	30	70
	40	40	60
	50	50	50
Stevia	25	.0825	75
	50	0.165	50
	75	0.2475	25
	100	0.33	0
Stevia: Jaggery : Honey	75:15:10	25.1425	0

[1]Maltodextrin was added to make up the bulk to 100 g

Table 3: Parameters for texture analyser

Parameter	Muffins
Test	Compression disc
Probe	Flat disc
Pre- test sped	1mm/s
Test speed	1mm/s
Post-test speed	1mm/s
Distance	15mm
Force	60g

Table 4: Effect of replacement of sugar with jaggery on the baking and textural properties of muffins

Sugar substitute	Percent replacement	Weight (g)	Volume (cc)	Specific volume (cc/g)	Compression force (g)
Sugar	Control	42.92 ± 0.46	83.67 ± 0.47	1.95 ± 0.02	104.93 ± 0.49
Jaggery	25	44.53 ± 0.43	90.67 ± 0.94	2.04 ± 0.03	112.56 ± 8.21
	50	43.96 ± 1.18	99.00 ± 2.16	2.25 ± 0.11	101.55 ± 8.25
	75	43.92 ± 1.24	105.67±0.94	2.41 ± 0.08	92.26 ± 1.45
	100	42.24 ± 1.67	111.67±1.25	2.65 ± 0.09	76.89 ± 0.25
CD (0.05)		NS	2.85	0.16	11.69

Table 5: Effect of replacement of sugar with honey on the baking and textural properties of muffins

Sugar substitute	Percent replacement	Weight (g)	Volume (cc)	Specific volume (cc/g)	Compression force (g)
Sugar	Control	42.31 ± 0.75	78.33 ± 0.75	1.85 ± 0.10	104.93 ± 0.60
Honey	10	41.88 ± 0.43	81.67± 2.89	1.95± 0.07	89.67 ± 0.81
	20	41.30 ± 0.17	78.33± 2.89	1.90 ± 0.07	124.81 ± 0.53
	30	43.25 ± 2.02	80.00 ± 8.66	1.85 ± 0.18	141.03 ± 1.30
	40	42.42 ± 1.00	83.33 ± 5.77	1.97 ± 0.16	156.43 ± 3.17
	50	42.38 ± 0.30	85.00 ± 0.00	2.01 ± 0.01	231.51 ±6.54
CD (0.05)		NS	NS	NS	5.43

Table 6: Effect of replacement of sugar with stevia on the baking and textural properties of muffins

Sugar substitute	Percent replacement	Weight (g)	Volume (cc)	Specific volume (cc/g)	Compression force (g)
Sugar	**Control**	42.31±0.75	78.33±0.75	1.85±0.10	104.93±0.60
Stevia	**25**	41.44±0.71	90.00±0.00	2.17±0.04	70.89±1.45
	50	41.23±1.04	96.67±2.89	2.34±0.02	93.38±0.75
	75	42.61±1.11	98.33±2.89	2.31±0.09	100.29±3.91
	100	42.47±1.37	89.00±5.00	2.09±0.06	109.53±4.98
CD (0.05)		NS	5.45	7.04	0.14

Table 7: Effect of jaggery, honey and stevia powder on the mean sensory panel scores (Max 9) of muffins

Sugar substitute	Percent replacement	Parameters			
		Colour	Texture	Flavour	Overall acceptability
Sugar	Control	7.88±0.582	7.63±0.443	7.81±0.530	7.77±0.281
Jaggery	25	7.44±0.496	7.81±0.530	7.75±0.378	7.67±0.388
	50	7.31±0.799	7.63±0.744	7.75±0.463	7.56±0.584
	75	7.19±0.998	7.31±0.458	7.56±0.563	7.35±0.573
	100	7.13±0.835	7.25±0.463	7.75±0.756	7.38±0.555
CD (0.05)		NS	NS	NS	NS
Honey	10	8.13±0.231	7.75±0.535	7.69±0.594	7.85±0.361
	20	8.00±0.535	8.19±0.259	7.94±0.496	8.04±0.231
	30	7.50±0.463	7.38±0.641	7.19±0.651	7.35±0.403
	40	7.44±0.320	7.19±0.594	6.44±1.084	7.02±0.483
	50	7.25±0.267	6.81±0.458	5.88±1.026	6.65±0.288
CD (0.05)		0.425	0.508	0.773	0.354
Stevia	25	7.44±0.496	7.96±0.427	7.69±0.530	7.70±0.268
	50	7.75±0.655	7.76±0.542	7.69±0.530	7.73±0.193
	75	7.75±0.535	8.06±0.563	8.00±0.378	7.94±0.344
	100	7.38±0.582	7.19±0.530	6.75±0.598	7.10±0.417
CD (0.05)		NS	0.513	0.513	0.317

Table 8: Effect of combinations of sugar substitute on the pasting properties of flour used for muffin making

Sugar substitute	Parameters					
	Pasting temperature (°C)	Peak viscosity (cP)	Hold viscosity (cP)	Final viscosity (cP)	Breakdown viscosity (cP)	Setback Viscosity (cP)
Sugar	65.2	6921	1048	8396	5873	7348
Jaggery	64.7	4918	1812	9347	3106	7535
Stevia	57.9	10213	9472	9471	741	-1
Combination	60.5	10145	9443	9438	702	-5
CD (0.05)	0.76	.210555E-05	.210555E-05	.210555E-05	2.66	3.77

Table 9: Effect of combination of sugar substitutes on the baking and textural properties of muffins

Sugar substitute	Percent replacement	Weight (g)	Volume (cc)	Specific volume (cc/g)	Compression force (kg)
Sugar	100	42.92±0.57	83.67±0.58	1.95±0.02	104.93±0.60
Stevia	100	42.47±1.37	100.00±5.00	2.35±0.06	109.53±4.98
Jaggery	100	42.24±2.04	111.67±1.53	2.65±0.11	76.89±0.30
Stevia: Jaggery: Honey	75:15:10	41.43±0.91	78.33±2.89	1.89±0.06	117.91±2.31
CD (0.05)		NS	5.65	0.13	5.20

Table 10: Effect of combination of sugar substitute on the colour values of muffins

Formulation	Percent Replacement	Parameters					
		L* value		a* value		b*value	
		Crust	Crumb	Crust	Crumb	Crust	Crumb
Sugar	Control	43.42 ±0.27	77.20±1.95	19.7±0.66	1.28±0.03	29.66 ±0.56	17.82 ±0.05
Stevia	100	63.58 ±0.28	73.92±0.91	12.61±0.25	-0.08 ±0.16	33.44 ±2.72	19.75 ±0.46
Jaggery	100	32.38 ±0.98	56.79±0.98	17.36±0.71	8.71 ± 0.04	19.73 ±0.28	32.64 ±1.31
Combination	75:15:10	48.37 ±0.36	70.38±0.21	18.89±0.79	0.81 ± 0.01	36.98 ±1.92	25.75 ±0.36
CD (0.05)		1.20	0.16	3.19	1.35	1.05	2.23

Table 11: Approximate cost of the selected sweetener combination based low calorie cookies and muffins

Product	Formulation	Sample	Approximate cost (Rs/kg)
Muffins	Sugar	Control	95
	Stevia	S	98
	Jaggery	J	76
	Stevia: Jaggery: Honey	S:J:H	105

- Britannia cake: 300 Rs/ kg

4. Conclusion

Based on the outcomes of the studies, it was concluded that low cost muffns can be prepared by replacing sugar upto 75 percent level with other natural sweeteners like stevia with jaggery and honey with maltodextrin as a bulking agent. It does not affect organoleptic as well as product quality. In muffin, stevia alone can replace sugar upto 75 percent in muffins with all the quality attributes being intact along with maltodextrin. While jaggery can be substituted upto 100

percent in terms of overall acceptability and honey can be substituted in muffins upto the levels of 20 percent. The best combination for muffins is jaggery: honey: stevia at 15:10:75 levels. The product economics for the muffins showed that the muffins were cheaper as compared to market available product taking into consideration the health benefits offered by the products

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