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ESTIMATION OF STARCH AND SUGARS FOR DETECTION OF POTENTIAL ADULTERATION IN *KAJU KATLI*, A POPULAR CASHEW NUT BASED INDIAN CONFECTION

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ABSTRACT

India has rich varieties of different confections, amongst them *kaju katli* is highly popular and has great commercial values. Many small and medium scale manufacturers produce *kaju katli* because of high consumer demand. Because of expensive ingredients, it is more prone to adulteration. This work has attempted to detect starch, sugar, lactose and skim milk powder (SMP) in *kaju katli* which are most easily available and cheap ingredients for adulterations or dilutions. Cashewnut (65%), and sugar (35%) were the optimum ingredients for *kaju katli* preparation as studied from sensory analysis. Further, the amount of adulterant and/or diluent in the prepared *kaju katli* was determined by varying the ingredients and along with adulterant and/or diluent viz. starch (5-35%), sugar (25-50%), lactose (5-30%) and SMP (5-30%), respectively. The quantification of amount of adulterant and/or diluent added and their actual value determined were determined by the correlation and regression studies. The values quantified had very strong relations with quantity added (R^2>0.99). This method will be very useful in quantifying the adulterants and/or diluents in *kaju katli*.

Keywords: confections, *kaju katli*, adulteration, correlation and regression

INTRODUCTION

'Traditional food' refers to a product made with specific raw materials, and/or with a recipe known for a long time, and/or using a specific process (**Cayot, 2007**). Sweets make an in dispensable part of the cuisine of cultures around the world and so also in India. In India, sweets also symbolize celebration, ceremony, festivity and sweetness of tongue as well as mind. When added along with sweets, dry fruits are considered to be an indication of richness of food products to which they are added and symbolize overall affluence (**Ananthanarayan *et al.* 2019**).

In India, traditional sweets are sold by local sweet-makers called *halwais* on a small to retail-level scale. There are few Indian sweets mostly made with *khoa* which is concentrated milk such as *Dharwad peda*, *Kesar peda*, and *Brown peda* (**Jha *et al.* 2014**), There is very little modernization and very few companies have grown in this sector of manufacturing traditional sweets. The sector is therefore relatively unexplored due to unavailability of structured knowledge, lack of standardization, inadequate attention to food safety, improper quality control measures and use of inadequate packaging options (**Baig and Balasubramaniam, 2003**). Industrialization of food production, laws on food safety and even the development of innovative products makes it a necessity for the characterization of traditional food products.

Among the various popular Indian sweets, *kaju katli* is made by thickening fine cashew nut powder, with sugar by heating (**Parmar and Sharma, 2016**). The mixture is further sheeted, cut into rhomboid shapes, and then coated with silver foil (optional). It is the most favored sweet during commemorative occasions with a huge consumer appeal due to its delightful taste, mild nutty flavor, pleasant aroma, and richness of appearance (**Brahmbhatt *et al.* 2017**). *Kaju katli* has a great demand in Indian as well as overseas market (**Sharma *et al.* 2017**). Several flavored variants of *kaju katli* are available depending on additional ingredients used such as saffron, pistachio and cocoa powder.

India is a leading producer in cashewnut (*Anacardium occidentale*) with almost 45 different varieties in eight states with an annual production of around 817 thousand metric tons **(Directorate of cashew and cocoa development, Govt. of India, www.dccd.gov.in)**. Total value added product made annually is 320 thousand metric tons **(Small Farmers' Agri-Business Consortium, Ministry of Agriculture and Farmers Welfare, Govt. of India", www. sfacindia.com)**. Export value of cashewnut based products is around 27,20,982 USD with 64% of the exports aimed at the US market.

The principal ingredient used in preparation of *Kaju katli is* an expensive dry fruit (cashew nut), which makes it susceptible to dilution with other inferior ingredients. Milk, milk powder, sugar and starch may be potentially used as diluents with starch being reported in some samples (**Mirza and Kasim, 2005**). These diluents go easily with the recipe providing bulk to the sweet, resulting in higher margin of profit to manufacturers (**Mirza and Kasim, 2015**).

The study or manufacture of Indian traditional sweets is scientifically and industrially less explored field. There are very few established or standardized procedures available in scientific journals or in trade magazines for their preparation. The objective of this work was to establish the methodology for identification of presence of commonly used diluents in *kaju katli* formulation by preparing *kaju katli* samples with deliberate addition of the potential diluents in fixed proportions and subjecting the samples to different analytical methods for estimation of added sugars and starch. Further the robustness and accuracy of analytical methods employed for detection of added diluents was established.

MATERIALS AND METHODS

Materials

Cashewnut (Vengurla variety) and sugar (Madhur™) were procured from the local market of Matunga, Mumbai and used for the preparation of *kaju katli*. Food grade skim milk powder (SMP) (Sagar™), AR grade lactose (SDFCL, India) and corn starch (SDFCL, India) were used besides sugar as potential diluents in the preparation of *kaju katli*. Zinc acetate, phosphotungstic acid, glycine, NaOH, methylamine-HCl, sodium sulphite, iodine, dinitrosalicylic acid (DNSA) were procured from SDFCL, India and used for analysis.

Methods

Standardization of *Kaju katli* preparation

The cashewnuts and sugar were powdered in domestic grinder to get powder which passes through 80 mesh of standard sieve. The optimization of *kaju katli* formulation was done by uniform mixing of cashewnut powder and sugar powder in different proportions such as 75:25, 70:30, 65:35, 60:40, 55:45, 50:50 which was followed by cooking till the mixture started leaving sides of pan. The processing parameters used were: Cooking 80-90 ºC for 5 min, cooling to temperature 45-50 ºC followed by compressing and sheeting. The mixtures were

allowed to cool, sheeted on a rolling board and cut into characteristic rhomboid shaped pieces (side: 1 cm and thickness 0.3 cm).

Sensory evaluation to standardize *kaju katli* formulation

Sensory analysis was conducted using a nine point hedonic scale (ranging from 1=dislike extremely to 9= like extremely) for sweetness and overall acceptability by a semi-trained panel consisting of 20 members to select the best proportion of cashewnut to sugar in the formulation.

Preparation of *kaju katli* variants by partial replacement of cashewnut with added diluents

The partial replacement of cashewnut ingredient in the optimized *kaju katli* formulation was done. Corn starch, lactose and SMP were used for replacement of cashewnut ingredient at 5–30 % of total material used in the formulation. Sugar (sucrose) which is a part of the *kaju katli* formulation was varied between 25 to 50% of total material used in the formulation. The different self-diluted variants of *kaju katli* so generated were subjected to analysis as described below.

Estimation of Starch in *kaju katli*

Starch in the sample was estimated using an official method prescribed by FSSAI, India for milk and milk products with some modification (***fssai* manual methods of food, 2016**). One gram of *kaju katli* sample was added with 20 mL of ethanol (80%) to curdle the *kaju katli*. Precipitate was filtered through a filter paper (Whatman #1) and then washed with 80 % ethanol till the precipitate was free from reducing sugars (i.e. when the washings gave a negative test with Benedict's solution for reducing sugar). Precipitate was dispersed and made to 100 mL with distilled water (DW) and hydrolyzed by refluxing in a boiling water bath for 150 min with addition of 5mL of concentrated HCl. The solution was then cooled and neutralized with 10 N NaOH. Neutralized solution was made up to 500 ml with DW and filtered through a filter paper (0.45 µm) (***fssai* manual methods of food, 2016**). Reducing sugars was estimated in the filtrate by DNSA method (**Miller, 1959**). Standard curve was prepared using glucose (500-2000mg).
Starch content in the sample was calculated as follows:

$$\text{Starch (\%)} = \text{Reducing sugar (\%)} \times 0.9$$

Estimation of Sucrose in *kaju katli*

Kaju katli sample (1 g) was weighed and added to 80% ethanol (20 ml) to curdle the *kaju katli*. Precipitate was filtered through Whatman #1 filter paper and residue washed with 80 % ethanol till the filtrate was free from reducing sugars (i.e. when the washings gave a negative test with Benedict's solution for reducing sugar). Filtrate was concentrated by rotary evaporator (IKA, Germany) at 50 ºC under vacuum to 25 mL to remove ethanol. To 5 mL of concentrated filtrate, 20 mL DW and 3mL of 6.34N HCl was added and mixture refluxed in boiling water bath for 20 minutes. The mixture after hydrolysis was neutralized with 10% NaOH, cooled and made up to 100 mL with DW. The reducing sugars was estimated in this by DNSA method (**Miller, 1959**). Standard curve was prepared using glucose (500- 2000mg). Total sucrose was calculated using following formula:

$$\text{Total Sucrose} = 0.95[\text{Total redsucing sugars} - (1.05 \times \text{redcuing sugards from lactose})]$$

Estimation of lactose in *kaju katli*

Lactose in the sample was estimated using an official method prescribed by FSSAI, India for milk based sweets (***fssai* manual methods of food, 2016 and Nickerson *et al*., 1976**). Eight gram of *kaju katli* sample was mixed with 1 mL of zinc acetate- phosphotungstic acid (ZAPT) reagent, dispersed and made to 10 mL with DW and after 10 min. the samples were filtered using Whatman # 1 filter paper. To 0.5 mL of the filtrate, 0.5 mL of 1 N NaOH solution was added, further it was diluted to 10 mL with DW and filtered using Whatman # 1 filter paper. Five mL of this filtrate was diluted to 10mL. To 5 mL of this solution was added 5 mL of glycine- NaOH buffer (pH 12.8), 0.5 mL of methylamine solution and 0.5 mL of 1 % sodium sulphite. Tubes were heated in water bath at 65 ºC for 25 min and cooled immediately in an ice bath to stop the reaction. Absorbance was read against blank at 540 nm in a spectrophotometer (UV1800, Shimazdu Corp., Japan). Standard curve was prepared using lactose (50-350mg) and the results were expressed as lactose g/g of sample.

Estimation of SMP in *kaju katli*

Milk powder is more likely to be added as a diluent than lactose which is an isolated constituent from milk available at a higher price. The major constituents of SMP are milk proteins and lactose. So the lactose content of SMP was determined by using ZAPT reagent as already described in section 2.2.6. The amount of SMP added to the *kaju katli* formulation was then determined based on lactose estimated in the sample using ZAPT reagent.

Statistical Analysis

All experiments were performed in triplicates and analyzed in duplicates, results are reported as mean ± standard deviation. The data was subjected to analysis of variance (ANOVA) and Duncan multiple range tests were used to compare differences between treatments at 95 % confidence level (IBM SPSS statistics 23 for windows).

RESULTS AND DISCUSSION

Kaju katli variants were prepared by using various combinations of cashewnut and sugar such as 75:25 to 50:50 in which 65:35 w/w combination (sample C) scored highest in terms of sweetness (7.65±0.86) and overall acceptability (7.83±0.0.88). As the proportion of sugar increased beyond 35% the scores for sweetness and overall acceptability decreased (Table 1) as the samples were found to be too sweet while as the proportion of cashewnut increased above 65% the scores for sweetness and overall acceptability again decreased (Table 1) as the samples were found to be less sweet (**Parmar and Sharma, 2016**).

Table 1 Sensory analysis of *kaju katli* variants for sweetness and overall acceptability

No.	Sample Code	Kaju: Sugar (% w/w)	Score for sweetness	Score for overall acceptability
1	A	75: 25	$6.80 \pm 0.88^{a,b}$	6.58 ± 0.88^{b}
2	B	70:30	$6.90 \pm 1.36^{a,b}$	$7.30 \pm 1.36^{a,b}$
3	C	65:35	7.65 ± 0.86^{a}	7.83 ± 0.86^{a}
4	D	60:40	6.33 ± 1.00^{b}	5.86 ± 1.00^{c}
5	E	55:45	6.33 ± 1.67^{b}	6.25 ± 1.67^{b}
6	F	50:50	5.80 ± 1.91^{c}	5.83 ± 1.91^{c}

All the values in the table are expressed as mean ±standard deviation.
This optimized formulation of 65% cashewnut and 35% sugar was selected for all further studies involving addition of diluents in which the cashewnut ingredient was replaced weight by weight with the diluent. Corn starch, sucrose, lactose, and SMP were the diluents selected for this work. Analysis of starch, sucrose and lactose was performed by methods described in methods section. A correction had to be applied for all results of analysis. The value of the correction to be applied was worked out on the basis of the amount of cashewnut ingredient present in the *kaju katli* formulation after partial substitution by the diluent. This was based on the knowledge that pure cashewnut on analysis resulted in values for starch (60.72mg/g as given in Table 2), sucrose (134.65mg/g as given in Table 4) and lactose (i.e. reducing sugars by ZAPT) (325.54mg/g as given in Table 3). Cashewnut analysis has revealed that it has a starch content of 4.6 to 11.2% and sucrose content of 6.3 % while it may have reducing sugars of 1-3% (**Rico *et al*., 2015**).

Table 2 Effect of replacement of cashewnut ingredient with corn starch, sucrose and lactose in varying proportions on the estimated starch content in *kaju katli* formulations

Sr. No	*Kaju katli* Formulation (1 g)				Starch content on as is basis (mg)	Moisture content (%)	Starch content on moisture free basis (mg/g)	Correction Value (to be subtracted)	Corrected Value of starch content on moisture free basis (mg)
	Cashew nut (mg)	Corn starch (mg)	Sucrose (mg)	Lactose (mg)					
1	1000	0	0	0	55.33 ± 2.72	9.70 ± 0.10	60.72 ± 3.03	--	--
2	0	1000	0	0	946.73 ± 13.01	3.50 ± 0.10	979.55 ± 13.46	--	--
3	0	0	1000	0	-4.63 ± 0	0.60 ± 0.40	-5.20 ± 0.04	--	--
4	0	0	0	1000	-4.60 ± 0	0.00 ± 0.10	-4.61 ± 0.01	--	--
Cashewnut ingredient replacement with corn starch									

5	350	300	350	0	295.67 ± 3.63	7.70 ± 0.90	318.42 ± 3.13	19.37	298.79 ± 3.13^{g}
6	400	250	350	0	258.53 ± 3.97	8.40 ± 0.30	280.26 ± 5.07	22.13	258.13± 5.07^{f}
7	450	200	350	0	202.53 ± 9.32	8.70 ± 0.30	220.14 ± 9.63	24.90	195.24± 9.63^{e}
8	500	150	350	0	165.07 ± 5.14	9.07 ± 0.12	180.03 ± 5.63	27.67	152.37± 5.63^{d}
9	550	100	350	0	116.40 ± 3.74	8.23 ± 0.25	125.98 ± 3.76	30.43	95.06± 3.00^{c}
10	600	050	350	0	73.93 ± 4.92	7.80 ± 0.90	80.02 ± 5.43	33.20	46.83± 5.43^{b}
11(CS)	650	0	350	0	32.67 ± 0.61	7.73 ± 0.06	35.19 ± 0.66	35.96	-0.77± 0.66^{a}
Cashewnut ingredient replacement with sucrose									
12	500	0	500	0	31.93 ± 1.60	9.67 ± 0.15	35.02 ± 1.72	27.67	7.35± 1.72^{d}
13	550	0	450	0	24.93 ± 1.53	7.23 ± 0.21	26.74 ± 1.68	30.43	-3.69±1.68^{a}
14	600	0	400	0	34.80 ± 1.71	9.70 ± 0.10	38.18 ± 1.91	33.20	4.98± 1.91^{b,c,d}
15(CS)	650	0	350	0	34.33 ± 1.70	9.80 ± 0.10	37.70 ± 1.83	35.96	1.73± 1.83^{b}
16	700	0	300	0	38.87 ± 2.23	7.23 ± 0.21	41.68 ± 2.43	38.73	2.95± 2.43^{b,c}
17	750	0	250	0	44.27 ± 2.25	8.23 ± 0.25	47.91 ± 2.32	41.50	6.41± 2.32^{b,d}
Cashewnut ingredient replacement with lactose									
18	350	0	350	300	29.93 ± 1.81	8.87 ± 0.15	32.59 ± 2.02	19.37	13.22± 2.02^{d}
19	400	0	350	250	28.00 ± 3.75	8.33 ± 0.29	30.34 ± 4.12	22.13	8.21± 4.12^{c}
20	450	0	350	200	24.53 ± 1.36	8.20 ± 0.20	26.54 ± 1.44	24.90	1.65± 1.44^{b}
21	500	0	350	150	17.33 ± 1.72	7.90 ± 0.72	18.71 ± 1.93	27.67	-8.96± 1.93^{a}
22	550	0	350	100	29.67 ± 0.99	8.43 ± 0.06	32.17 ± 1.09	30.43	1.74± 1.09^{b}
23	600	0	350	50	30.93 ± 2.80	7.90 ± 0.72	33.39 ± 3.24	33.20	-1.19± 3.24^{b}
24(CS)	650	0	350	0	32.60 ± 1.40	7.83 ± 0.15	35.15 ± 1.48	35.96	-0.81± 1.48^{d,b}

*CS is control *kaju katli* formulations of optimized composition

Table 3 Effect of replacement of cashewnut ingredient with corn starch, sucrose and lactose in varying proportions on the estimated lactose content in *kaju katli* formulations

Sr. No	*Kaju katli* Formulation				Lactose content on as is basis (mg)	Moisture content (%)	Lactose content on moisture free basis (mg)	Correction Value (to be subtracted)	Corrected Value of lactose content on moisture free basis (mg)
	Cashew nut (mg)	Corn starch (mg)	Sucrose (mg)	Lactose (mg)					
1	1000	0	0	0	296.67 ± 0	9.70 ± 0.10	325.54 ± 0.34	--	--
2	0	1000	0	0	304.44 ± 1.92	3.50 ± 0.10	315.00 ± 1.81	--	--
3	0	0	1000	0	286.67 ± 0	0.60 ± 0.40	288.29 ± 1.19	--	--
4	0	0	0	1000	892.22 ± 19.53	0.00 ± 0.10	893.41 ± 19.24	--	--
Cashewnut ingredient replacement with corn starch									
5	300	350	350	0	283.33± 1.92	9.13 ± 0.55	314.06 ± 2.56	361.48	-47.42 ± 2.56^{a}
6	350	300	350	0	287.78 ± 5.09	7.70 ± 0.90	307.55 ± 4.48	299.23	8.32 ± 4.48^{b}
7	400	250	350	0	288.89 ± 0	8.40 ± 0.30	310.75 ± 0.86	298.32	12.43 ± 0.86^{b}
8	450	200	350	0	291.11 ± 1.92	8.70 ± 0.30	312.82 ± 2.87	297.40	15.42 ± 2.87^{c,d}
9	500	150	350	0	291.11 ± 3.33	9.07 ± 0.12	312.66 ± 3.65	296.48	16.17 ± 3.65^{c,d}
10	550	100	350	0	287.78 ± 3.85	8.23 ± 0.25	311.47 ± 2.69	295.57	15.90 ± 2.69^{c,d}
11	600	50	350	0	285.56 ± 1.92	7.80 ± 0.90	311.47 ± 1.56	294.65	16.82 ± 1.56^{c,d}
12(CS)	650	0	350	0	290.00 ± 3.33	7.73 ± 0.06	312.43 ± 3.74	293.73	18.69± 3.74^{d}
Cashewnut ingredient replacement with sucrose									
13	500	0	500	0	285.56 ± 1.92	9.67 ± 0.15	313.16 ± 2.53	291.67	21.49 ± 2.53^{b,c}
14	550	0	450	0	286.67 ± 3.33	7.23 ± 0.21	307.40 ± 3.17	292.90	14.50 ± 3.17^{a}
15	600	0	400	0	288.89 ± 3.85	9.70 ± 0.10	316.91 ± 4.23	293.32	23.60 ± 4.23^{c}
16(CS)	650	0	350	0	287.78 ± 3.85	9.80 ± 0.10	308.59 ± 3.98	293.73	22.24 ± 3.98^{b}
17	700	0	300	0	287.78 ± 1.92	7.23 ± 0.21	311.47± 1.49	294.15	14.44± 1.49^{a,b}
18	750	0	250	0	287.78 ± 1.92	8.23 ± 0.25	322.30 ± 2.12	294.57	16.90 ± 2.12^{a}
Cashewnut ingredient replacement with lactose									
19	350	0	350	300	466.67 ± 3.33	8.87 ± 0.15	508.05 ± 4.33	204.17	303.88 ± 4.33^{a}
20	400	0	350	250	424.44 ± 5.09	8.33 ± 0.29	459.82 ± 6.49	219.57	240.25 ± 6.49^{b}
21	450	0	350	200	403.33 ± 3.33	8.20 ± 0.20	436.41 ± 4.41	234.40	202.01± 4.41^{c}
22	500	0	350	150	373.33 ± 8.82	7.90 ± 0.72	402.81 ± 8.74	249.23	153.57 ± 8.74^{d}
23	550	0	350	100	331.11 ± 5.09	8.43 ± 0.06	359.03 ± 5.38	264.07	94.97 ± 5.38^{e}
24	600	0	350	50	305.56 ± 3.85	7.90 ± 0.72	329.68 ± 2.11	278.90	50.78 ± 2.11^{f}
25(CS)	650	0	350	0	274.44± 1.92	7.83 ± 0.15	295.94 ± 2.04	293.73	2.21± 2.04^{g}

*CS is control *kaju katli* formulations of optimized composition

Analysis of added starch (diluent) in *kaju katli* variants

Cashewnut is about 50 times the price of corn starch and so corn starch can serve as a potential diluent for cashewnut in *kaju katli* formulation as it is a bland ingredient which can act as a thickening agent and can blend in the *kaju katli* formulation without being sensorially discernible.

For estimation of added starch (corn starch: 5 to 35%) in the *kaju katli* formulations (Table 2), starch content on as is basis was firstly determined. This was then expressed as starch content on moisture free basis. The correction value (to be subtracted) was arrived at based on the starch content in the cashewnut ingredient in the formulation. For example if 1g of *kaju katli* contains cashew (300 mg), sucrose (350 mg) and corn starch (350 mg), the correction value was calculated from 30% of 1g of cashew i.e. 16.60 mg + 35 % of 1g of sucrose i.e. 0, which gave a correction factor of 16.60 mg. So, as the proportion of cashewnut ingredient in the formulation increased the correction value also increased, as seen in Table 2. No correction was required for sucrose or lactose with respect to starch analysis, as they did not give any value for starch on analysis (small negative values reported in the tables). The correction value was then subtracted from starch content on the basis of free moisture to arrive at the final corrected value of added starch on moisture free basis.

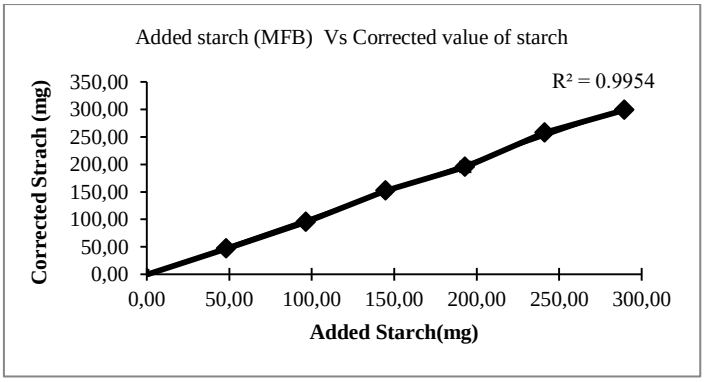

Figure 1a Correlation between added corn starch (MFB)* vs corrected value of starch

On comparing the values of added starch (on moisture free basis) with final values obtained on analysis (Correlation plot Fig. 1a) it can be seen that with the high R^2 value (0.9954) obtained the correlation is good. Thus estimation of starch in *kaju katli* sample by the FSSAI method can lead us to detecting the presence of added starch in the *kaju katli* formulation even at relatively low levels of addition.

Analysis of added lactose/ milk powder (diluent) in *kaju katli* variants

In India milk is added in various sweet dishes and can be an important basic ingredient for sweets preparation. For *kaju katli* various recipes suggest addition of milk or milk powder because it contributes to a milky taste and softness in texture. However, addition of milk or milk powder in more quantity to replace cashewnut ingredient in *kaju katli* formulation can be considered a questionable practice. Cashewnut would be almost 4 times the price of SMP.

For analysis of added lactose (5-30%) or SMP (5-30%) in the *kaju katli* formulation (Tables 3 and 4 respectively) lactose content on as is basis was firstly determined using ZAPT reagent. This was then expressed as lactose content on moisture free basis. The correction value (to be subtracted) was arrived at based on the lactose value obtained by analysis in the cashewnut ingredient, in corn starch and in sucrose added in the formulation. So in this case the correction value (to be subtracted) was a total of correction value for lactose in cashewnut ingredient and correction value for lactose in corn starch/ sucrose depending on which was added as a diluent. For example if 1g of *kaju katli* contains cashew (350 mg), sucrose (350 mg) and lactose (300 mg), the correction value was calculated from 35% of cashew i.e. 103.83 mg + 35 % of sucrose i.e. 100.33 mg which gave a correction factor of 204.17 mg.

Table 4 Effect of replacement of cashewnut ingredient with corn starch, sucrose and SMP in varying proportions on the estimated lactose content in *kaju katli* formulations

Sr. No	*Kaju katli* Formulation				Lactose content on as is basis (mg)	Moisture content (%)	Lactose content on moisture free basis (mg)	Correction Value (to be subtracted)	Corrected Value of lactose content on moisture free basis (mg)
	Cashew nut (mg)	Corn starch (mg)	Sucrose (mg)	SMP (lactose**) (mg)					
1	1000	0	0	0	296.67 ± 0	9.70 ± 0.10	325.54 ± 0.34	--	--
2	0	1000	0	0	304.44 ± 1.92	3.50 ± 0.10	315.00 ± 1.81	--	--
3	0	0	1000	0	286.67 ± 0	0.60 ± 0.40	288.29 ± 1.19	--	--
4	0	0	0	1000	528.89 ± 5.09	4.40 ± 1.27	536.64 ± 7.69	--	--
Cashewnut ingredient replacement with corn starch									
5	300	350	350	0	283.33 ± 1.92	9.13 ± 0.55	314.06 ± 2.56	295.89	18.17± 2.56[a]
6	350	300	350	0	287.78 ± 5.09	7.70 ± 0.90	309.95 ± 6.77	295.50	14.45± 6.77[a]
7	400	250	350	0	288.89 ± 1.92	8.40 ± 0.30	313.16 ± 2.26	295.11	18.04± 2.26[a]
8	450	200	350	0	288.89 ± 1.92	8.70 ± 0.30	314.03 ± 2.87	294.72	19.30± 2.87[a]
9	500	150	350	0	286.67 ± 0	9.07 ± 0.12	312.66 ± 0.33	294.33	18.32± 0.33[a]
10	550	100	350	0	287.78 ± 3.85	8.23 ± 0.25	311.47 ± 3.52	293.94	17.52± 3.52[a]
11	600	050	350	0	287.78 ± 1.92	7.80 ± 0.90	311.47 ± 1.56	293.56	17.91± 1.56[a]
12(CS)	650	0	350	0	286.67 ± 3.33	7.73 ± 0.06	308.84 ± 3.59	293.17	15.67± 3.59[a]
Cashewnut ingredient replacement with sucrose									
13	500	0	500	0	286.67 ± 3.33	9.67 ± 0.15	314.38 ± 3.82	291.67	22.71 ± 3.82[b,c,d]
14	550	0	450	0	287.78 ± 1.92	7.23 ± 0.21	308.59 ± 1.49	292.17	16.42 ± 1.49[a,b]
15	600	0	400	0	290.00 ± 5.77	9.70 ± 0.10	318.13 ± 6.58	292.67	25.47 ± 6.58[c,d]
16(CS)	650	0	350	0	292.22 ± 1.92	9.80 ± 0.10	320.86 ± 2.13	293.17	27.69 ± 2.13[d]
17	700	0	300	0	286.67 ± 3.33	7.23 ± 0.21	307.40 ± 3.00	293.67	13.73 ± 3.00[a]
18	750	0	250	0	290.00 ± 3.33	8.23 ± 0.25	313.87 ± 2.88	294.17	19.70 ± 2.88[a,b,c]
Cashewnut ingredient replacement with SMP									
19	350	0	350	300 (160.80)	342.22 ± 1.92	8.40 ± 0.26	370.97 ± 2.76	204.17	166.80± 2.76[a]
20	400	0	350	250 (134.00)	327.78 ± 5.09	8.63 ± 0.51	356.08 ± 5.94	219.00	137.08± 5.94[b]
21	450	0	350	200 (107.20)	322.22 ± 3.85	8.20 ± 0.20	348.64 ± 3.62	233.83	114.81± 3.62[c]
22	500	0	350	150 (80.40)	305.56 ± 3.85	7.90 ± 0.72	329.71 ± 5.95	248.67	81.04± 5.95[d]
23	550	0	350	100 (53.60)	296.67 ± 3.33	8.24 ± 0.37	318.68 ± 2.72	263.50	55.18± 2.72[e]
24	600	0	350	50 (26.80)	285.56 ± 3.85	8.63 ± 0.23	310.21 ± 3.89	278.33	31.87± 3.89[f]
25(CS)	650	0	350	0 (0)	275.56 ± 1.92	7.87 ± 0.71	297.24 ± 3.96	293.17	4.07± 3.96[g]

*CS is control *kaju katli* formulations of optimized composition
**Lactose content of SMP is 53.64%

As the *kaju katli* formulation changed in composition the correction value also changed as seen in Tables 4 and 5. The correction value was then subtracted from lactose content on moisture free basis to arrive at the corrected value of lactose on moisture free basis.

On comparing the values of added lactose/SMP (on moisture free basis) with final values obtained on analysis (Correlation plot Fig. 1b and 1c) it can be seen that with the high R^2 values (0.9978/0.9973) obtained the correlation is good. Thus estimation of lactose in *kaju katli* sample by the FSSAI method can lead us to detecting the presence of added lactose/ SMP in the *kaju katli* formulation.

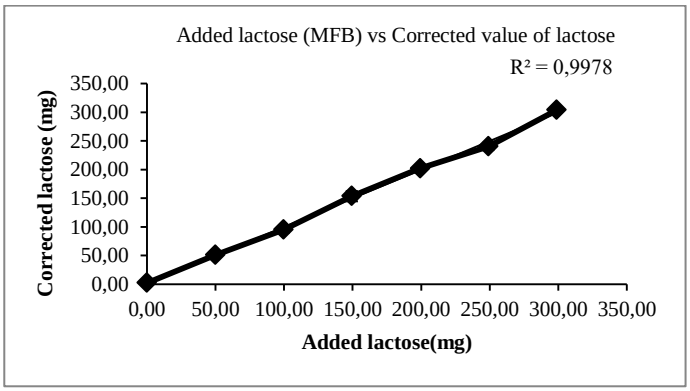

Figure 1b Correlation between added Lactose (MFB) vs corrected value of lactose

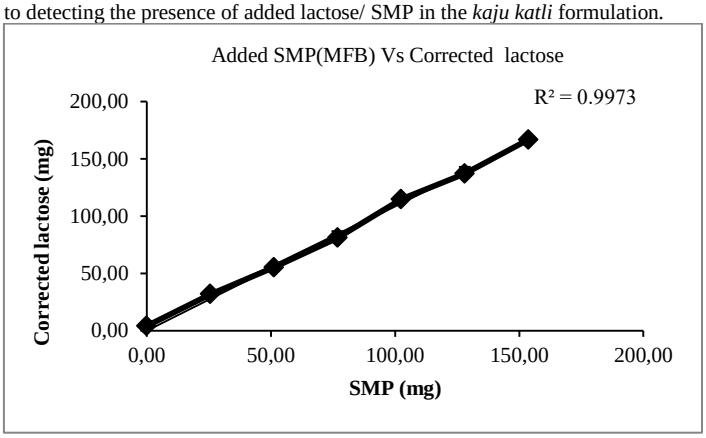

Figure 1c Correlation between added SMP (MFB) vs corrected value of Lactose

Analysis of added sucrose (diluent) in *kaju katli* variants

Sucrose is a natural ingredient in *kaju katli* formulation where it contributes to both bulk and sweetness. Cashewnut one of the main ingredients in *kaju katli* formulation is about 25 times the price of sugar. On standardization of *kaju katli* formulation it was observed that 35% sugar contributed to appropriate sweetness and maximum overall acceptability. However some manufacturers of this Indian confection may prefer to incorporate higher amounts of sugar in the formulation which is to their economic advantage while also most likely to be not detected by the consumer.

For analysis of added sucrose (25 to 50 %) in the *kaju katli* formulation (Table 5) TRS on as is basis was firstly determined. This was then expressed as TRS content on moisture free basis. The correction value (to be subtracted) was arrived at based on the sucrose value obtained by analysis in the cashewnut ingredient, in corn starch and in lactose added in the formulation. So in this case the correction value (to be subtracted) was a total of correction value for sucrose in cashewnut ingredient and correction value for sucrose in corn starch/ lactose depending on which was added as a diluent. For example, if 1g of *kaju katli* contains cashew (300 mg), sucrose (350 mg) and corn starch (350 mg), the correction value was calculated from 30% of cashew i.e. 132.20 mg + 35 % of corn starch i.e. 111.07 mg, which gave a correction factor of 243.27 mg.

Table 5 Effect of replacement of cashewnut ingredient with corn starch, sucrose and lactose in varying proportions on the estimated sucrose content in *kaju katli* formulations

Sr. No	*Kaju katli* Formulation				Total Reducing sugar (TRS) on as is basis (mg)	Moisture content (%)	Total Reducing sugar (TRS) on moisture free basis (mg)	Correction Value (to be subtracted)	Corrected Value of total reducing sugars (TRS) on moisture free basis (mg)	**Reducing sugar (RS) from lactose/ other ingredients****	**Total Sucrose= 0.95(TRS-(1.05 X RS from lactose/ other ingredients) (mg)**
	Cashewnut (mg)	Corn starch (mg)	Sucrose (mg)	Lactose (mg)							
1	1000	0	0	0	440.67 ± 15.28	9.70 ± 0.10	483.56 ± 16.68	--	--	325.54	134.65 ± 15.91
2	0	1000	0	0	317.33 ± 20.82	3.50 ± 0.10	328.33 ± 21.49	--	--	315.00	-2.29 ± 20.01
3	0	0	1000	0	1187.33 ± 20.82	0.60 ± 0.40	1194.03 ± 19.00	--	--	172.58	962.19 ± 22.89
4	0	0	0	1000	970.67 ± 11.55	0.00 ± 0.10	971.95 ± 10.43	--	--	893.41	32.18 ± 18.80
Cashewnut ingredient replacement with corn starch											
5	300	350	350	0	640.67 ± 15.28	9.13 ± 0.55	699.20 ± 18.33	243.27	455.94 ± 18.33	314.06	350.97 ± 18.54[a]
6	350	300	350	0	647.33± 15.28	7.70 ± 0.90	697.09 ± 10.75	249.43	447.65 ± 10.75	307.55	355.45 ± 14.68[a]
7	400	250	350	0	647.33± 11.55	8.40 ± 0.30	701.69 ± 10.90	255.60	446.09 ± 10.90	310.75	356.64 ± 11.06[a]
8	450	200	350	0	644.00 ± 17.32	8.70 ± 0.30	700.03 ± 18.92	261.77	438.26 ± 18.92	312.82	352.99 ± 18.95[a]
9	500	150	350	0	644.00 ± 10.00	9.07 ± 0.12	702.38 ± 10.27	267.93	434.45 ± 10.27	312.66	355.39 ± 8.74[a]
10	550	100	350	0	647.33 ± 11.55	8.23 ± 0.25	700.63 ± 12.79	274.10	426.53 ± 12.79	311.47	354.91 ± 14.73[a]
11	600	50	350	0	647.33 ± 5.77	7.80 ± 0.90	700.62 ± 5.03	280.27	420.36 ± 5.03	311.47	354.90 ± 3.23[a]
12(CS)	650	0	350	0	647.33 ± 11.55	7.73 ± 0.06	697.39 ± 12.07	286.43	410.96 ± 12.07	312.43	350.87 ± 14.85[a]
Cashewnut ingredient replacement with sucrose											
13	500	0	500	0	787.33 ± 5.77	9.67 ± 0.15	863.45 ± 7.29	220.33	643.11 ± 7.29	313.16	507.90 ± 5.67[a]
14	550	0	450	0	754.00 ± 17.32	7.23 ± 0.21	808.52 ± 17.03	242.37	566.15± 17.03	307.40	461.46 ± 13.76[b]
15	600	0	400	0	687.33 ± 20.82	9.70 ± 0.10	754.00 ± 22.68	264.40	489.60± 22.68	316.91	400.18 ± 25.73[c]
16(CS)	650	0	350	0	640.67 ± 15.28	9.80 ± 0.10	703.46 ± 17.40	286.43	417.03± 17.40	315.98	353.10 ± 19.64[d]
17	700	0	300	0	604.00 ± 43.59	7.23 ± 0.21	647.68 ± 46.58	308.47	339.21± 46.58	308.59	307.48 ± 43.59[d]
18	750	0	250	0	554.00 ± 26.46	8.23 ± 0.25	599.61 ± 28.55	330.50	269.11± 28.55	311.47	258.94 ± 29.20[e]
Cashewnut ingredient replacement with lactose											
19	350	0	350	300	824.00 ± 30.00	8.87 ± 0.15	897.04 ± 31.83	445.43	451.61 ± 31.83	508.05	345.41 ± 32.61[a]
20	400	0	350	250	787.33 ± 5.77	8.33 ± 0.29	852.93 ± 3.97	418.93	434.00 ± 3.97	459.82	351.61 ± 9.83[a]
21	450	0	350	200	767.33 ± 15.28	8.20 ± 0.20	830.25 ± 16.10	392.43	437.81 ± 16.10	436.41	353.42 ± 16.91[a]
22	500	0	350	150	744.00 ± 17.32	7.90 ± 0.72	802.80 ± 20.64	365.93	436.86 ± 20.64	402.81	360.85 ± 27.97[a]
23	550	0	350	100	684.00 ± 10.00	8.43 ± 0.06	741.68 ± 10.50	339.43	402.25 ± 10.50	359.03	346.46 ± 9.88[a]
24	600	0	350	050	674.00 ± 10.00	7.90 ± 0.72	727.23 ± 10.56	312.93	414.30 ± 10.56	329.68	362.02 ± 11.57[a]
25(CS3)	650	0	350	0	637.33 ± 15.28	7.83 ± 0.15	687.25 ± 15.99	286.43	400.82 ± 15.99	295.94	357.69 ± 17.04[a]

*CS is control *kaju katli* formulations of optimized composition

**Reducing Sugar obtained from lactose and other ingredients and were calculated by ZAPT method

So as the proportion of cashewnut ingredient in the formulation increased accompanied by a decrease in corn starch (diluent) addition there was a slight increase in the overall correction value as seen in Table 3. This was because the sucrose value analyzed was greater in cashewnut than in corn starch. However when the proportion of cashewnut ingredient in the formulation increased accompanied by a decrease in lactose (diluent) addition there was a marked decrease in the overall correction value as seen in Table 3. This was because the sucrose value analyzed was very high in lactose sample as compared to cashewnut. The correction value was then subtracted from TRS content on moisture free basis to arrive at the corrected value of TRS on moisture free basis. From this the sucrose content was calculated by using the appropriate formula.

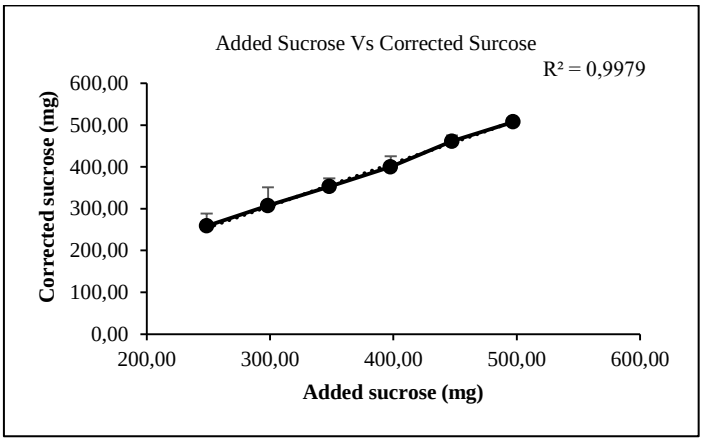

Figure 1d Correlation between added sucrose (MFB) vs corrected value of sucrose

On comparing the values of added sucrose (on moisture free basis) with final values obtained on analysis (correlation plot Fig. 1d) it can be seen that with the

high R^2 value (0.997) obtained the correlation is good. Thus estimation of sucrose in *kaju katli* sample by estimating TRS after hydrolysis can lead us to detecting the presence of added excessive sucrose in the *kaju katli* formulation when sucrose is intended to be used not only as a sweetener but also as a diluent.

CONCLUSION

The study has standardized the *kaju katli* formulation based on sensory evaluation showing a greater preference for formulation prepared by using cashew powder (65%) and sugar (35%). The study has demonstrated the detection of potential diluents such as starch, sucrose, lactose or milk powder in *kaju katli* formulations by using relatively simple chemical analytical methods. Since this is a high priced Indian sweet of great commercial value and demand this study offers a significant opportunity to ensure the quality of this product and prevent its adulteration. Compliance with food standards regulation can also be more effectively implemented.

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