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Extended Abstract

Detecting Adulteration in Camel Milk Using Color Change Modeling by Image Processing and Mixture-process Variable Experiments

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Abstract

Nowadays, food ingredient fraud and economically motivated adulteration are emerging risks, being addition of low cost ingredients creates not only an economical problem but also a health risk for consumers. Due to the limitations of camel milk production and high economic value has traditionally been done in the fraud. Therefore, rapid analysis methods has gained increased interested for analytical chemistry applications due the simplicity, low-cost, speed and a performance that is similar to those instruments normally found in the laboratory. The aim of this study was to detect fraud, adding water, caustic soda to camel milk with thermal process, color detector and color parameter modeling (L*, a*, b*, ΔE, chroma Index, shade angel and browning index) using mixture-process experiments. Due to the significant effects mentioned it can be concluded that to detect of adding cow milk to camel milk can be used heating a mixture and browning index. adding cow milk and water to camel milk can be detect by L*, a*, b*, ΔE, shade angel and browning index also adding caustic soda to camel milk can be detect by L*, a*, b*, ΔE, Chroma index, shade angel and browning index.

Keywords: Adulteration, Camel Milk, Color Parameter, Mixture-Process Experiments

Introduction

Nowadays frauds are wildly emerged by jobber intentionally and by purpose. Milk, especially camel milk, is subjected to adulteration from past due to its limitation of production and high economic value. Any means of manipulation in milk (adding water, salt, whey protein, dried milk powder, urea and fat separation) or even addition of microbial inhibitors (such as hydrogen peroxide, formalin, borat, sorbates, antibiotics, etc.) counts as adulteration. On the other hand, fraud determination experiment is costly and time-consuming. So demand for a quality control method with high accuracy and speed increased by increasing demand for high quality food.

A lot of researches based on color parameters evolution of different product were conducted in order to quality assessment of various stage of process, production and grading. One of the interesting products is milk and dairies. Borin *et al*. (2007) performed quantitative assessment of lactobacillus in fermented milk by digital image analysis and concluded that digital image analysis is a cheap and low-risk method for microorganism counts. Santos *et al*. (2011) evaluated water and caustic soda in cow milk by digital images and chemometrics. Sullivan *et al*. (2012) showed that digital images could represent useful information about Infectious cells count in milk. Kucheryavskiy et al. (2014) evaluated fat and protein content of cow milk with ordinary digital images captured by scanner.

There is no research about fraud detection in camel milk with thermal process, through color evolution by image analysis technique. Therefore, the aim of this study was to detect fraud, adding water, caustic soda to camel milk with thermal process, color detector and color parameter modeling with color changer of digital images through mixture-process technique.

Material and methods

Sample preparation

Camel and cow milk provide from Mashhad local markets with defined component (Table 1).

Table 1. Chemical analysis of camel and cow milk

Milk type	Dry matter (%)	Fat (%)	Protein (%)	Lactose (%)	Sematic cells
cow	11/05	3/3	2/56	4/67	318
camel	9	4/1	2/7	3/1	1507

Mixture-process experiment design

In this research mixture design parameters consist of camel milk (0-100%), cow milk (0-100%) and water (0-100%) were defined in such way that constitute 100% of formulation. Process factors were thermal treatments (0-90 °C) and caustic soda (0-10 mgr.) which total number of treatments from mixture-process design were 70 treatments (Table 2 and 3). Then two images were captured from all treatment, one image immediately after samples preparation and one after adding 0.5 cc phenolphthalein in order to detect color changes due to adulteration. Results were analysis by design-expert (Version 9) with mixture-process experiment methodology and each response was reported based on regression model which came from combination of mixture design and respond surface methodology.

Table 2. Coded levels of processing and mixture variables

variable name	name	variable type	Variable levels	
			-1	+1
Camel milk (%)	X1	mixture	0	100
Cow milk (%)	X2	mixture	0	100
Water (%)	X3	mixture	0	50
Thermal process (˚C)	X4	process	0	90
Caustic soda (mg)	X5	process	0	10

Table 3. Uncoded levels of processing and mixture variables

NO	Mixture			Process	
	Camel milk	Cow milk	Water	Thermal process	Caustic soda
1	100	0	26.7551	11.7	0.566325
2	100	0	0	49.5	0.2
3	54.5735	0	0	33.75	10
4	100	0	45.4265	18.2054	6.44716
5	72.5623	0	0	0	0
6	72.4045	0	27.4377	87.75	4.6
7	73.1433	0	27.5955	76.95	0
8	71.0991	0	26.8567	60.75	8.1
9	100	0	28.9009	10.8189	0.879006
10	100	0	0	0	0
11	100	0	0	2.25	5.5
12	73.0995	0	0	49.5316	5.5
13	100	0	26.9005	36	10
14	72.4643	0	0	90	3.85558
15	72.4643	0	27.5357	46.8	4.9
16	100	0	27.5357	46.8	4.9
17	70.987	0	0	90	10
18	70.1433	0.844127	28.1689	90	10
19	70.9962	1.1897	28.667	90	4.25
20	72.154	1.35415	27.6497	37.35	10
21	97.5	2.1723	25.6737	0	7.65
22	95	2.5	0	90	0
23	36.5066	5	0	0	10
24	36.4565	13.4934	50	1.8	4.5
25	36.3807	13.5435	50	90	0
26	35.6063	13.6193	50	33.75	0
27	34.9494	14.3937	50	0	10
28	32.9851	15.0506	50	90	10
29	32.0289	17.0149	50	0	10
30	31.7377	17.9711	50	0	0
31	30	18.2623	50	49.5	4.45
32	29.8192	20	50	49.5	9.8
33	29.1229	20.1808	50	90	6.25321
34	44.9126	20.8771	50	63.9	2.68376
35	43.771	45.3111	9.77631	0	0
36	32.0943	45.3702	10.8589	90	0
37	42.2733	46.2824	21.6233	81	6.65
38	43.5153	46.4683	11.2584	0	10
39	46.8783	46.7893	9.69545	0	0
40	46.8783	46.8937	6.22795	49.5	5.5
41	46.6495	46.8937	6.22795	49.5	5.5
42	46.6495	47.287	6.06349	49.5	0.15
43	46.5387	47.287	6.06349	49.5	0.15
44	46.4779	48.0342	5.42707	35.1	10
45	46.4779	48.2468	5.27535	2.25	5.5
46	46.4317	48.2468	5.27535	2.25	5.5
47	45.2506	48.4486	5.11967	90	3.84052
48	6.88426	48.7758	5.97358	90	10
49	5.68017	62.1232	30.9925	90	0
50	5.82258	65.2313	29.0885	90	10
51	3.98377	65.2909	28.8865	0	10
52	0	65.4047	30.6116	90	10
53	0	67.5918	32.4082	88.4285	4.5
54	0	67.929	32.071	0	0
55	0	68	32	40.5	9.75

Table 3. Uncoded levels of processing and mixture variables

NO	Mixture			Process	
	Camel milk	Cow milk	Water	Thermal process	Caustic soda
56	0	68.0179	31.9821	0	6.05
57	0	68.9158	31.0842	54.45	0
58	0	69.355	30.645	40.5	4.5
59	22.0669	69.355	30.645	40.5	4.5
60	0	77.9331	0	45	5.33646
61	0	100	0	90	0
62	0	100	0	56.4187	10
63	0	100	0	0	0
64	0	100	0	0	3.7
65	0	100	0	40.5	5.5
66	0	100	0	0	10
67	0	100	0	90	10
68	0	100	0	88.2	5.5
69	0	100	0	40.5	0.2
70	100	100	0	90	0

Image feature extraction of samples

20 mL of samples poured in petri dish with Syringe. Image acquisition equipment was consist of dark box (in order to prevent noises and reflection during image acquisition) and 6 fluorescent lamps. Digital camera (Canon power shot 1000D) was employed for capturing images.

Results and discussion

Effect of cow milk addition

Linear effect of cow milk addition was not significant on all dependent variables (L*, a*, b*, ΔE, Chroma index, hue angle and browning index), (*P*>0.01). Interaction effect of cow milk and caustic soda on variables (L*, b*, ΔE and hue angle) and effect of cow milk-thermal process-camel milk on browning index were significant. Among linear and interaction effect with presence of reagent, in addition to interaction effect of cow milk-caustic soda, cow milk-water-thermal process were significant on variables (L*, a*, b*, ΔE, hue angle and browning index). According to the mentioned meaningfulness, it could be resulted that for detecting adulteration of cow milk addition, browning index could be used if the mixture was heated and other variable (L*, a*, b*, ΔE and hue angle) could be used beside browning index in the presence of reagent. Figure (1) shows the changes of browning index by alteration of cow milk/camel milk ratio and thermal process.

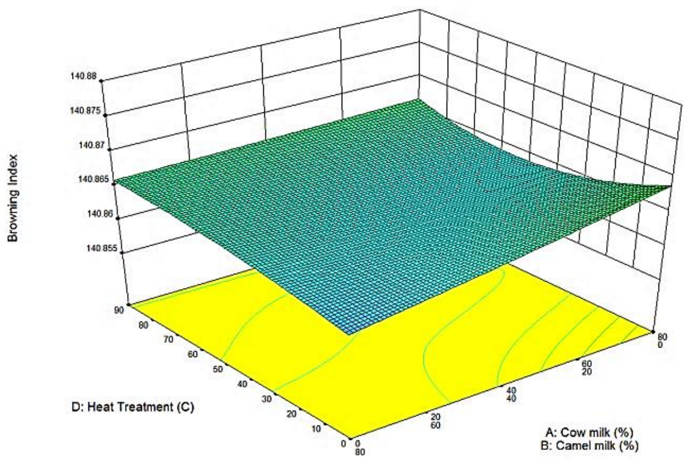

Figure 1. Effect of alteration of cow milk/camel milk ratio and thermal process on browning index

According to Figure (1) it could be concluded that the highest browning index was observed in sample with 80% cow milk and 0% camel milk in condition of 20% water and 5 mgr. caustic soda and thermal process of 90 °C. By addition of cow milk and thermal process to camel milk, browning index increased.

Addition of water

Table (4) and (5) showed that interaction of water addition to camel milk on variables at the presence of reagent was significant. It means that if water added as adulteration it could be detected by adding reagent and evaluation of L*, b* and hue angle. Santos et al. (2012) showed that addition of 7% water to cow milk, chromatic parameters (B, S and H) changed which showed reduction in S parameter. Figure (2) shows the changes of L* by alteration of cow milk/camel milk ratio and thermal process

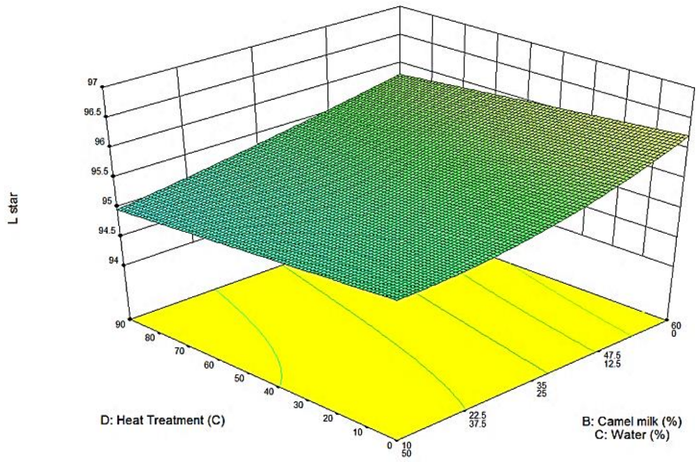

Figure 2. Effect of alteration of cow milk/camel milk ratio and thermal process on L*

According to Figure (2), addition of water decreased L* especially in samples with more intense thermal process.

Addition of caustic soda

Interaction effects of caustic soda and camel milk for samples without reagent at 0.01 level and cow milk at 0.001 level on some variables (L*, a*, b*, ΔE and hue angle) were significant but this interaction was significant for all variables (L*, a*, b*, ΔE, Chroma index, hue angle and browning index) at 0.01 level with presence of reagent. Also, by evolution of interaction effect of camel milk-caustic soda-thermal process, especially for samples with reagent, it could be concluded that this parameters significantly effected L*, a*, b*, ΔE, Chroma index, hue angle and browning index of all samples at 0.001 level. Santos *et al*. (2012) showed that if caustic soda was added to cow milk it could be detected by Chroma properties and G parameter of images. Figure (3) shows the changes of L* by alteration of cow milk/camel milk ratio and addition of caustic soda by thermal condition of (a) 0 and (b) 90 °C without reagent

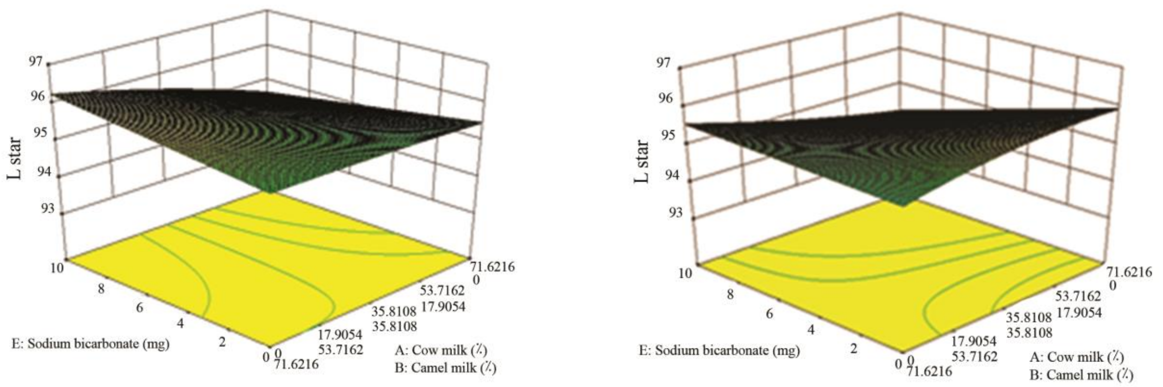

Figure 3. Effect of alteration of cow milk/camel milk ratio and addition of caustic soda by thermal condition of (a) 0 and (b) 90 °C without reagent on L*

As shown in figure (3-a), addition of caustic soda and reduction of camel milk at 0 °C of thermal process increased L* but this changes was sharper at 90 °C (Figure 3-b)

Conclusion

As mentioned, it could be concluded that cow milk addition to camel milk could be detected by applying thermal treatment and evolution browning index so that if just cow milk was added to camel milk as adulteration up to 43.25% it could be detected by thermal process at 90 C and measuring browning index and comparing to control sample and even by measuring L*, a*, b* and hue angle if reagent was added to samples. Adulteration evolution of adding cow milk and water simultaneously could be diagnosed by measuring L*, a*, b*, hue angle and browning index. Also, if water was added to camel milk as adulteration, it could be detected by evaluating L*, b* and hue angle at presence of reagent in a way that 45% of water addition could be detected by comparison of L*, a*, b*, hue angle and browning index of milk with control samples. Although, in order to detect caustic soda addition, L*, a*, b*, ΔE, Chroma index, hue angle and browning index parameters of milk images could be employed. So, if caustic soda and cow milk (up to 3.5 mgr. and 18%, respectively) was added to camel milk simultaneously, applying a mild thermal processing and comparing L*, a*, b*, hue angle and browning index of milk with control sample could reveal this fraud.

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