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Using Principle Component Analysis for Evaluation of the Camel Burger quality

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Abstract

In the present study the cow meat was replaced with camel meat (0, 25, 50, 75 and 100%) in burger formulation. Principal component analysis (PCA) was performed to understand quality variables differences and similarities of thirty-five sample burgers. Score plot, represents Principal component analysis of datasets derived from evaluated variables of thirty-five samples (samples contain of 0, 25, 50, 75 and 100% camel meat). Overall, six principal component was obtained which 65.8% of the total variance was concentrated into three first PCs. Cooked L*, cooked b* shrinkage, springiness, flavor, texture, juiciness, color and overall acceptability were the variables which separated by the first PC. The PC2 is characterized by the rest of instrumental texture parameters and the third by cooked a* and fat. The evaluation of score plot shows burgers contain higher amount of camel meat (50, 75 and 100%) had the higher moisture and fat content after cooking, higher scores in flavor, texture, juiciness and overall acceptability.

Keywords: Camel meat burger, Principal component analysis, Overall acceptability

Introduction

Today industry and research are involved with interpretation of large data sets. Usually we face with such data sets which have numbers of columns and rows. In order to interpret such data, one needs statistical methods that can extract the most important information. Principal components analysis (PCA) originally introduced by Pearson (1901) and independently by Hotelling (1933), is a technique used to display patterns in multivariate data. It aims to graphically display the relative positions of data points in fewer dimensions while retaining as much information as possible, and explore relationships between dependent variables. In other word, we can use principal component analysis (PCA), as a useful multivariate statistical method to analyze the variations among physical, color, and sensory properties of meat. The procedure is based on the fact that when there are many measures on a particular object then some of these are likely to be correlated. Variables that are inter-correlated can 'represent' one another. For instance, if variables 1, 2, 3 and 4 are highly correlated with variable 5, then they will all change as variable 5 changes. A composite variable derived from these, could reduce these five variables to one. In PCA analysis, this could constitute the first component. A second component (uncorrelated with the first) can then be derived to examine more variation.

Camelus dromedaries which belong to *Camelus* genera are very important in the case of economy, health and food security in many countries. They have unique properties which help them to stand with the harsh environmental situation, produce milk and meat. Compare to other farm animal it can produce large quantity of meat which is comparable in taste and texture to beef. It characterized by low fat and high moisture content, low content of cholesterol and valuable source of vitamins and some important minerals. In spite of these advantages, public have negative perception and except that arid and semi- arid people, others avoid consumption of the camel meat. However, camel meat can be more acceptable by using in processed meat products such burger and sausage. The present study evaluated various chemical, physical and sensory variables of burgers by Principal Component Analysis (PCA) in order to

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determine the relationship between them and describe camel burger quality.

Material and methods

Burger preparation:

Five formulations of burger were produced and burgers were different in the level of camel meat 0% (beef only), 25%, 50%, 75%, 100% (camel only). 75% Meat was ground through a 5-mm plate in a grinder (Kenwood, MK-G20NR, Spain) and with the other ingredients consist of 12.5% flour, 10% onion, 1.1% sodium chloride and 1.4% spices (black pepper, red pepper, nut Meg, thyme, cinnamon, garlic powder) was thoroughly mixed to obtain a homogenous mixture. Thereafter mixture was shaped by using hamburger patty forming machine (Zophre Co., Ltd., Esfahan, Iran) to obtain patties of approximately 70 g and 1cm thickness. Finally, until analysis in designated times (once every two weeks during 3 months storage) the burgers were placed in plastic containers and were kept under frozen condition (–18 ºC).

Burger quality measurement:

Cooking properties:

Cooking characteristics was evaluated using a process of measure and remeasuring of thickness and diameter before and after cooking of burgers by contact grilling on a preheated electric grill (Delonghi, model 31100, Italy), then calculate as follow:

$$\%\text{Diameter reduction} = ((\text{raw diameter} - \text{cooked diameter})/(\text{raw diameter}))\times 100 \quad (1)$$

$$\%\text{Thickness increase} = \left(\frac{\text{cooked thickness} - \text{raw thickness}}{\text{raw thickness}}\right)\times 100 \quad (2)$$

$$\%\text{Fat retention} = \frac{(\text{cooked weight} \times \%\text{fat in cooked burger})}{\text{raw weight} \times \%\text{fat in raw burger}}\times 100 \quad (3)$$

$$\%\text{Moisture retention} = \frac{(\text{cooked weight} \times \%\text{moisture in cooked burger})}{\text{raw weight} \times \%\text{moisture in raw burger}}\times 100 \quad (4)$$

$$\%\text{Cocking yield} = \frac{\text{cooked weight}}{\text{raw weight}}\times 100 \quad (5)$$

$$\%\text{Shrinkage} = \frac{(\text{raw thickness} - \text{cooked thickness}) + (\text{raw diameter} - \text{cooked diameter})}{\text{raw thickness} + \text{raw diameter}}\times 100 \quad (6)$$

Color attributes:

Color was described by coordinates: lightness (*L**), redness (*a**, ±red-green) and yellowness (*b**, ±yellow-blue) using a colorimeter (Chroma Meter CR-410, Japan) equipped with a light source Illuminant *C* (2° observer).

Texture profile

Hardness (kg), *cohesiveness*, *springiness* (cm), *gumminess* (kg) and *chewiness* (kg× cm) were evaluated as texture profile parameters with a Texture Analyzer QTS following AMSA (1995) procedures. Cubic samples (1×1×1 cm) were cut from patties and subjected to a two-cycle compression test. Samples were compressed to 70% of their original height with a cylindrical probe of 3.5 cm diameter at a compression load of 25 kg, and a cross-head speed of 20 cm/min (modified method of Sánchez-Zapata *et al*, 2010).

Sensory properties:

The appraisal of color, texture, flavor, juiciness and overall acceptability was done using a 5-point structured hedonic scale for sensory evaluation. Evaluation was performed by 30 trained panelists and each of them evaluated two replicates of all formulas.

Statistical analysis:

The data were analyzed with XLSTAT package (XLSTAT, 2013), after standardization of the variables to mean of zero and variance of one.

Results & Discuction:

Table 1 shows the correlation coefficients between the 17 variables of burger quality. Results show that these variables are significantly correlated in some cases. For instance, cooked L* showed high positive correlation with cooked b*(r=0.86, $p<0.05$), also cooked L* had positive correlation with sensory color (r=0.64 ,$p<0.05$) that it can be reasonable on the basis of Valin, *et al* (1992) who reported that myoglobin content is important factor in meat redness and darkness. Meat color affected the Panelists judgment positively on sensory color and ultimately negatively on overall acceptability. This means that they recognize the degree of darkness or lightness, redness and yellowness and to give score samples based on them. Camel meat have lower L* than beef and it made a negative concept in terms of color acceptance on panelist. Otherwise cooked a* had a negative and positive correlation with cooked moisture and fat respectively. Other remarkable correlation coefficient is: positive correlation between instrumental texture that all of them changed in one direction, besides; among them just springiness was fairly impressive on the data derived from sensory evaluation such as texture, juiciness, overall acceptability and color, its negative correlation with the first three means sensorial evaluation scores increase with decreasing springiness and vice versa. Since shrinkage has the positive correlation with springiness and negative with juiciness, texture and overall acceptability, springiness is the other unpleasant effective variable on these sensory scores.

Table 1- Correlation coefficient between burgers quality variables

Variables	Coocked l	Coocked a	Coocked b	ΔE	Shrinkage	Cohesiveness	Chewness	Hardness	Gumminess	Springiness	Cooked Moisture	Cooked Fat	Flavour	Texture	Juiciness	Color	Overal Acceptability
Coocked l																	
Coocked a	-0.299																
Coocked b	**0.864**	0.030															
ΔE	**-0.637**	0.004	**-0.678**														
Shrinkage	**0.449**	0.297	**0.586**	-0.300													
Cohesiveness	0.093	0.277	0.270	-0.074	0.225												
Chewness	0.092	0.244	0.071	0.032	0.101	**0.539**											
Hardness	-0.028	0.148	-0.098	0.096	-0.079	**0.404**	**0.963**										
Gumminess	-0.053	0.169	-0.078	0.063	-0.080	**0.529**	**0.945**	**0.977**									
Springiness	**0.532**	0.118	**0.537**	-0.222	**0.642**	0.185	0.333	0.160	0.075								
Cooked Moisture	0.179	**-0.389**	0.125	0.068	-0.113	0.037	-0.004	0.050	0.079	-0.104							
Cooked Fat	-0.269	**0.482**	-0.037	-0.120	0.169	0.305	-0.036	-0.069	0.056	-0.170	-0.314						
Flavour	**-0.437**	0.137	-0.285	-0.032	-0.112	-0.116	-0.087	-0.007	0.045	-0.293	0.167	0.254					
Texture	**-0.487**	0.002	**-0.566**	0.148	**-0.636**	0.008	0.000	0.146	0.194	**-0.680**	0.085	0.214	**0.376**				
Juiciness	**-0.523**	-0.075	**-0.579**	0.300	**-0.501**	-0.083	-0.022	0.134	0.186	**-0.718**	0.262	0.171	**0.549**	**0.826**			
Color	**0.642**	0.129	**0.715**	-0.307	**0.621**	0.278	0.075	-0.094	-0.079	**0.599**	0.005	-0.049	**-0.444**	**-0.608**	**-0.600**		
Overal Acceptability	**-0.502**	-0.023	**-0.474**	0.066	**-0.370**	-0.188	-0.026	0.128	0.154	**-0.390**	0.109	0.239	**0.790**	**0.547**	**0.543**	**-0.607**	

Values in bold are different from 0 with a significance level alpha=0.05

So springiness and shrinkage were not favorable for panelists. On the other hand sensory evaluation data are inter-dependent with each other. For example, color had significantly negative correlation with overall acceptability, juiciness had positive and negative correlation with color and overall acceptability respectively. Otherwise, texture had positive correlation with juiciness and overall acceptability, finally flavor had positive correlation with texture, juiciness and overall acceptability. In summary we can say flavor had the highest positive effect on overall acceptability and color highest negative effect on it.

The results of the principal component analysis are shown in Table 2 for these 17 principal components (PC). The analysis represents that near 33.6% of the total variation is expressed by the first principal component, 53.6% by the first two principal components and the 65.8% by the first three principal components. In other words, 65.8% of the total variance in the 17 variables can be more concentrated into three first PCs.

Table 2- Results from the principal component analysis for the first six principal components

	F1	F2	F3	F4	F5	F6
Eigenvalue	5.715	3.404	2.080	1.670	1.097	0.942
Variability (%)	33.618	20.023	12.233	9.822	6.454	5.539
Cumulative %	33.618	53.641	65.874	75.696	82.150	87.689

Table 3 shows that the most important variables for the first PC are cooked L*, cooked b* shrinkage, springiness, flavor, texture, juiciness, color and overall acceptability. So, the first PC is defined by the sensory parameters, shrinkage, two colored parameters and one instrumental texture parameter.

Table 3- Squared cosines of the variables

	F1	F2	F3	F4	F5	F6
coocked L	0.648	0.002	0.095	0.151	0.015	0.029
coocked a	0.002	0.128	0.565	0.030	0.001	0.009
coocked b	0.711	0.000	0.000	0.197	0.014	0.000
ΔE	0.206	0.002	0.024	0.465	0.012	0.226
shrinkage	0.506	0.006	0.149	0.013	0.064	0.071
cohesiveness	0.052	0.433	0.030	0.008	0.171	0.084
chewness	0.014	0.928	0.027	0.003	0.009	0.007
hardness	0.006	0.874	0.066	0.002	0.014	0.020
gumminess	0.011	0.924	0.033	0.002	0.000	0.005
springiness	0.600	0.045	0.001	0.007	0.184	0.000
cooked moisture	0.006	0.000	0.339	0.210	0.000	0.355
cooked fat	0.027	0.026	0.638	0.031	0.072	0.002
flavour	0.325	0.001	0.085	0.283	0.198	0.025
texture	0.651	0.018	0.000	0.041	0.130	0.013
juiciness	0.700	0.009	0.005	0.061	0.036	0.028
color	0.719	0.001	0.005	0.000	0.021	0.055
overal acceptability	0.530	0.007	0.018	0.167	0.158	0.010

Actually, these variables are placed far from the origin of the first PC in the loading plot (Fig. 1). The sensory parameters placed to the left in the loading plot are close together and, therefore, positively correlated and the other ones are in the right of the loading plot completely in contrast with the sensory parameters. The PC2 is characterized by the rest of instrumental texture parameters. These variables are placed on the top in the loading plot, far from the origin of the second PCs and positively correlated with each other. The third PC is defined by cooked a* and fat content, the forth by ΔE and finally the sixth by moisture.

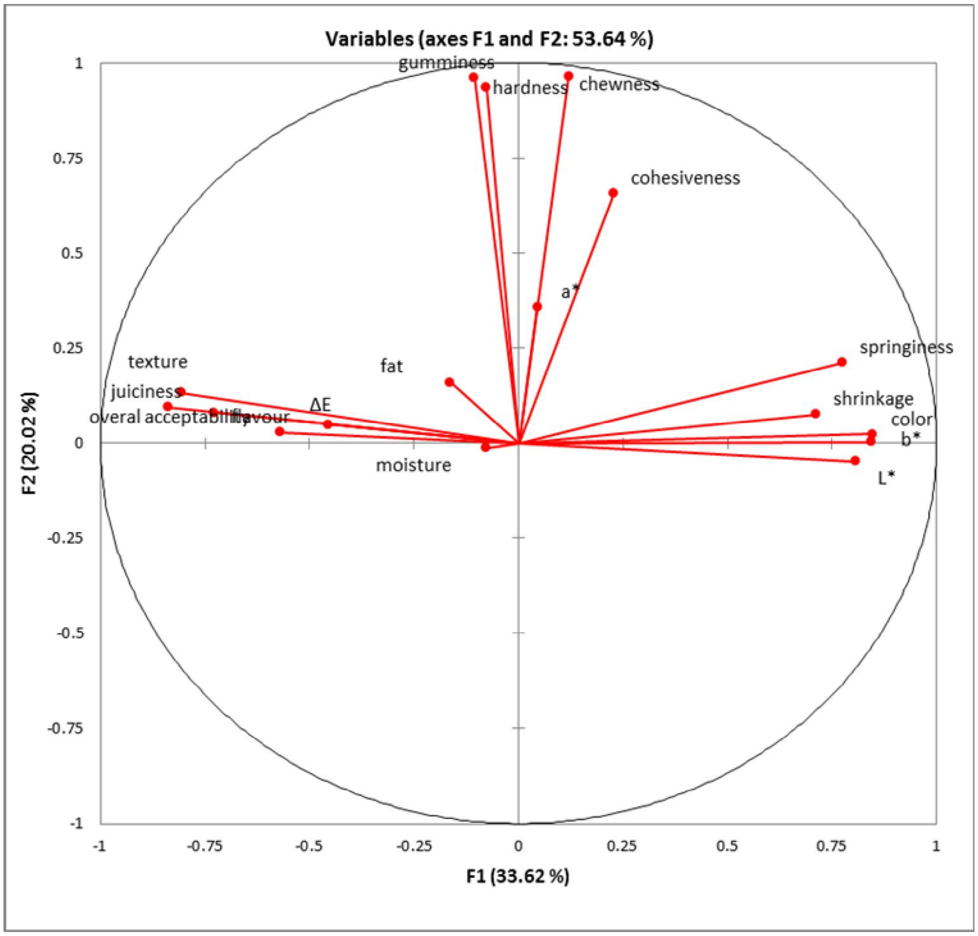

Fig 1: Loading plot

The score plot (Fig. 2) shows the location of the objects in the multivariate space of two first principal component score vectors. It can be seen that the scores are approximately divided in two groups. The first one includes burgers containing 50, 75 and 100% camel meat and the second one mostly includes burgers consist of 25% camel meat and 0 %(beef only). So the burgers containing 50, 75 and 100% camel meat in general show, higher moisture and fat content after cooking which verify the finding by Elsharif (2008) that reported camel meat sausages had higher water and fat retention during cooking compared to beef sausages. Besides, according to the score plot, in this study burgers contain higher amount of camel meat had higher scores in flavor, texture, juiciness and overall acceptability which are in the line with Elsharif (2008) about the increased sensorial scores of camel sausage. In the case of juiciness, McMillin, & Hoffman (2009) mentioned that the difference in juiciness is related primarily to the ability of muscle to retain fat and water during cooking. Listrat *et al* (2016) and Troutt *et al*, (1992) believed that fat is the effective factor in flavor and juiciness. Similarly, fat is important factor in texture (Ahmed *et al*. 1990; Serdaroglu & Sapancı-O zsumer. 2003), flavor and overall acceptability (Serdaroglu *et al*, 2005). On the other side, the burgers consist of 25% camel meat and 0% (beef only) shows higher values of instrumental texture, instrumental color, shrinkage and sensory color. On the basis of Gregg *et al* (1993), Elsharif (2008) and Ahmed *et al* (1990) findings in different research cases, we can attribute the shrinkage and texture properties to the capacity of meat in moisture and fat retention therefore burgers containing higher amount of beef meat had higher value of shrinkage and texture properties. Higher value of both instrumental color and sensory color of these groups is also due to the highest values of lightness in beef meat. Among them, burgers containing 50% camel meat were evaluated in day 0, have poor sensory score and low moisture as the same as the burgers consisting of 25% camel meat and 0%.

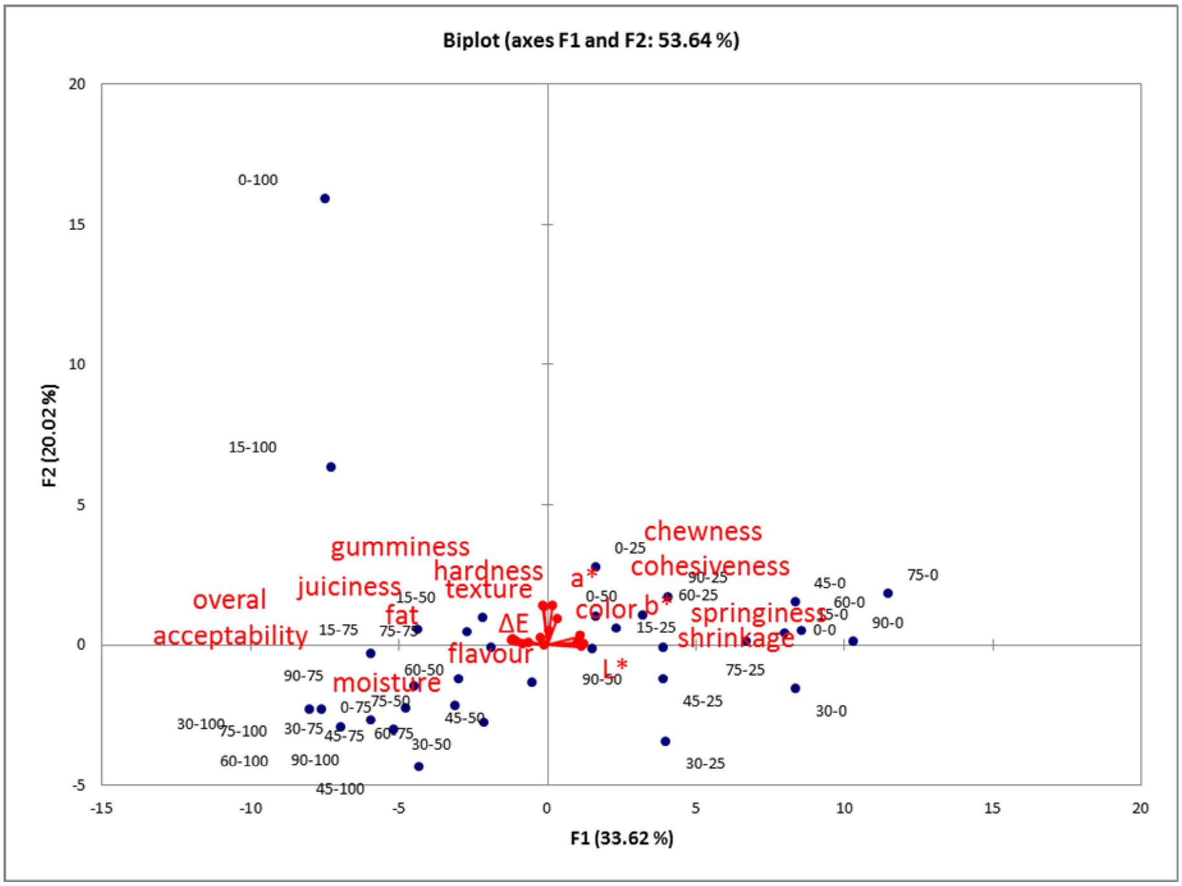

Fig 2: Score plot

Conclusion

The analysis on the basis of PCA showed that amount of meat had a more decisive contribution on the quality difference than the storage time. The results showed that springiness was the most important negative properties on the understanding and acceptance of sensory characteristics. On the basis of the score plot, the samples including the higher amount of camel meat were more acceptable in sensory qualification, so we can conclude the springiness is lower in this type of samples.

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ارزیابی کیفی برگر شتر با استفاده از تجزیه و تحلیل مولفه اصلی

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چکیده

در این تحقیق، گوشت شتر در نسبت‌های مختلف (صفر، 25، 50، 75 و 100) جایگزین گوشت گاو موجود در فرمولاسیون برگر شد. تجزیه و تحلیل مولفه اصلی (PCA) برای درک هر چه بیشتر شباهت‌ها و تفاوت‌ها میان متغیرهای کیفی ارزیابی شده در 35 نمونه برگر انجام شده است. منحنی امتیاز، تحلیل مولفه‌های اصلی را برای مجموعه داده‌های حاصل از اندازه‌گیری متغیرهای شیمیائی برای 35 نمونه (نمونه کنترل، نمونه‌های حاوی 25، 50، 75 و 100) نشان می‌دهد. در مجموع، 6 مولفه اصلی حاصل گردید که مولفه اصلی اول (PC1)، دوم (PC2) و سوم (PC3) در مجموع 65/8% از کل واریانس داده‌ها را پوشش دادند. مولفه اصلی اول امکان جداسازی درجه روشنایی و زردی نمونه پخته، چروکیدگی، خاصیت ارتجاعی و ویژگی‌های حسی (طعم، بافت، آبداری، رنگ و پذیرش کلی) را دارد. مولفه اصلی دوم توسط دیگر ویژگی‌های بافتی و مولفه اصلی سوم توسط درجه قرمزی نمونه پخته و چربی مشخص شده‌اند. امکان تشخیص چه متغیرهای شاخص و در جداسازی کدام گروه‌ها وجود داشت، اشاره شود. بررسی منحنی امتیاز نشان می‌دهد که برگرهای پخته حاوی میزان بالاتر گوشت شتر (50، 75 و 100)، میزان رطوبت و چربی بیشتر و امتیاز طعم، بافت، آبداری و پذیرش کلی بالاتر می‌باشند.

واژه‌های کلیدی: برگر شتر، تحلیل مولفه اصلی، پذیرش کلی

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