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PHYSICO-CHEMICAL AND RHEOLOGICAL CHARACTERISTICS OF COMMERCIAL CHEESE

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ABSTRACT

Physico-chemical and Rheological characteristics of two varieties of commercial cheese (Cheddar and Mozzarella) each having three brands (Adam's-A, Deen's-B and President's-C) and Pizza with one brand Adam's-A were evaluated in the Department of Animal Products Technology, Faculty of Animal Husbandary and Veterinary Sciences, Sindh Agricultural University, Tandojam, Pakistan during 2014. Proportion of moisture content in brand C of Mozzarella (52.91±0.91%) and brand A of Pizza cheeses (53.83±0.58%) remained relatively similar, and significantly higher from other brands of Cheddar and Mozzarella cheeses. Concentration of protein content was high in brand A of Mozzarella cheese (30.91±0.57%), and considerably low in brand-C of Cheddar cheese (19.08±0.67%). Fat contents (32.21+0.30% and 32.88+0.31%) of brand-B of Mozzarella and Cheddar cheeses and also calorific value (391.17 + 3.32 and 390.31 + 3.14 Kcal/100g) in both these cheeses. A total of six samples (n=6) from each brand were examined (nine tests were performed) during the year 2014 remained statistically similar and comparatively high from other brands of their corresponding cheeses. Ash content in brands B (5.01±0.17%) and C (4.68±0.51%) of Cheddar cheese was recorded considerably high, and markedly low in brand A (2.50±0.16%) of Mozzarella cheese. Brand-A of Pizza cheese appeared markedly less acidic (0.42±0.013%) compared to other brands of Mozzarella and Cheddar cheeses. Meltability of brand-A of Mozzarella (2.43±0.62cm), Cheddar (2.57±0.62cm) and Pizza cheeses (2.60±0.57cm) and stretchability of brand-A of Mozzarella cheese (66.75±1.46cm) found considerably better than that of other brands of their corresponding cheeses. It was concluded that, chemical composition, calorific values and physical as well as rheological characteristics of commercial cheese varied brand to brand.

KEYWORDS: Cheese; brands; characterization; chemico - physical - proporties; rheological analysis; Pakistan.

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INTRODUCTION

Dairy foods such as milk, cheese, and yogurt are consumed by billions of people around the globe. Whole milk is primarily water (~88 %) and contains on an average 4% fat, 3% protein, 5% carbohydrate (as lactose), and less than 1 % vitamins and minerals (Muehlhoff *et al.,* 2013). Cheese is one of the oldest fermented foods created by man. It has been produced and consumed for thousands of years and has been adopted to match the technical, social and economic conditions in various parts of the world (Montel *et al.,* 2014). It may support metabolism by encouraging normal flora of gastro intestinal tract (GIT) and providing all macros (proteins, lipids, and saccharides) and micro nutrients (vitamins, minerals and enzymes) (Ataro *et al.,* 2008). Many dairy products including cheese are biologically, biochemically and chemically stable if these are properly manufactured and stored (Banks, 1998). The basic technology for the production of all types of cheese is same with relatively small changes resulting significant differences in the final cheese. Its quality and variety depends upon various factors like composition of milk, extent of acid production, moisture, curd handling and ripening conditions (Lucey *et al.,* 2003).

Among the cheese varieties, Mozzarella cheese is one of the most popular varieties in the world because of its primary use on the pizza topping (Kind stedt *et al.,* 2004). Cheddar is a hard ripened cheese, and is popular throughout the world due to its distinct flavor, taste and aroma. It was firstly manufactured in a town, Cheddar George (England) but nowadays it is being manufactured in many parts of the world. Cheddar produced by acidification and concentration of milk following gel formation with rennet (Banks, 2002). The assessments of consumer behaviour through evaluation criteria can contribute to a better understanding of consumer's behaviour in respect of dairy products (Hysen *et al.,* 2008). Pakistan is functioning as much attention to planners and policy makers of milk and its products (Qasim *et al.,* 2005).

The rise in popularity of pizza and other relevant foods has immensely increased the use of cheese in daily life. Quality characteristics of cheese sold in market is

also be incorporated due to the opening of multinational restaurants in current era. But there are some of well-known multinational companies in Pakistan which are producing and selling different varieties of cheese of good quality. According to high production and nutrition value of cheese, investigation in its properties is important. Therefore, the present study are undertaken to evaluate the Physico-chemical and Rheological characteristics of different types of commercial cheese.

MATERIALS AND METHODS

This study was conducted in the Department of Animal Products Technology, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam during the year 2014. Commercially available cheese varieties i.e. Cheddar and Mozzarella each of with three different brands (A = Adam's, B = Deen's and C = President) and Pizza with one brand (A = Adam's) were evaluated. A total of six samples (n=6) from each brand purchased from local market of Hyderabad were examined. Physico-chemical characteristics like moisture, ash and acidity [10], protein [11], fat and calorific values [12] and pH values through pH meter; (EUTECH Instruments ECPH 501plus) were analyzed. Rheological characteristics like meltability and stretchability were also evaluated (MuthuKumarappan *et al.,* 1999).

Preparation of cheese sample

Cheese sample (100g) was mashed to make homogeneous using a pestle mortar and bring it to a temperature of 25ºC.

Chemical characteristics

Moisture content (%): Moisture content was observed according to the method of Association of Official Analytical Chemists (AOAC, 2000). The pre-prepared fresh cheese sample (3g) was transferred in pre-weighed flat bottom dish. It was transferred into hot air oven (101±1°C) for drying and dried sample was transferred to desiccator. After one hour the dish was weighed and returned to the hot air oven for further drying (30 minutes). Moisture content was calculated using the following formula.

$$\text{Moisture\%} = \frac{W2 - W3}{W2 - W1} \times 100$$

Here,

W1 = Weight of empty dish
W2 = Weight of dish + sample
W3 = Weight of dried sample

Total protein content (%): Protein content was determined according to the method of British Standards Institution (BSI, 1990). Cheese sample (3g) was digested using Micro-Kjeldhal digester in the presence of catalyst (0.2g Copper Sulfate and 2g Sodium Sulfate), where sulfuric acid (30ml) was used as an oxidizing agent. The digested sample was diluted with distilled water (250 ml), then 5 ml portion from the diluted sample was distilled with sodium hydroxide (40%) using Micro-Kjeldhal distillation unit where steam was distilled over 2% Boric acid (5 ml) containing an indicator for three minutes. The ammonia trapped in boric acid was determined by titrating with 0.1N hydrochloric acid. The nitrogen percentage was calculated using following formula.

$$\text{Nitrogen\%} = \frac{1.4\ (V1 - V2) \times \text{normality of HCl}}{\text{Weight of sample taken} \times \text{weight of diluted sample}} \times 250$$

Here,

V1 = titrated value
V2 = blank value

Protein percentage was determined by conversion of nitrogen percentage to protein assuming that all nitrogen in milk was present as protein i.e. protein percentage = N% ×CF, where conversion factor (CF) = 100/N % in protein of milk and dairy products (i.e. 100/15.66 = 6.38).

Fat content: Fat content was determined by Gerber method as described by James (1995). In mashed cheese sample (3g) in which sufficient quantity (7ml) of distilled water at 40oC was added and mixed with 65% Sulfuric acid (10 ml) and Amyl alcohol (1 ml) in Butyrometer and closed with rubber cork. The mixture was placed in water bath at 65°C. Sample was centrifuged (1100 rpm) in Gerber centrifuge machine for five minutes and again placed in water bath (65°C). The fat percentage was noted on the Butyrometer scale.

Ash content: Ash content was determined according to the method of AOAC, (2000). Sample (5g) was ignited (550°C) in a muffle furnace and transferred into desiccator for one hour. The sample was measured, using following formula:

$$\text{Ash content (\%)} = \frac{\text{Wt. of ash}}{\text{Wt. of sample}} \times 100$$

Calorific values: Calorific values of cheese samples were calculated by using energy conversion factors

of major components like 4 for each of protein and carbohydrate, and 9 for fat as reported by James (1995).

Physical characteristics

pH value: pH of pre-prepared cheese samples was determined using pH meter (EUTECH Instruments ECPH 501plus).

Acidity (%): Acidity percentage was determined according to the method AOAC, (2000). Pre-prepared cheese sample (10g) was measured and warm distilled water (40ml) was added. Sample was mixed thoroughly and more (40ml) warm water was added and mixed to make it homogenous. Sample was transferred to 100ml volumetric flask, mixed well and filtered. After filtration, sample (25ml) was taken, 1% phenolphthalein (1ml) as indicator was added. Finally, it was titrated with N/10 sodium hydroxide solution using titration kit and burette reading was noted. Following formula was used for calculation:

$$\text{Acidity \%} = \frac{\text{Volume of 0.1N NaOh x 0.009}}{\text{Sample taken}} \times 100$$

Rheological characteristics

Meltability: Meltability of cheese was detected according to the method as reported by Muthukumarppan et al. (1999) with minor modification. Cheese sample (5g) was cut into small pieces and placed in the middle of glass petri dish. The initial diameter of the cheese specimen was measured (3.5cm) and heated (60ºC) in microwave oven for five minutes. The cheese specimen was taken out from the microwave oven and cooled to room temperature for 30 minutes before measuring the diameter by Vernier Caliper. Meltability was calculated by detecting the initial diameter of specimen cheese sample from the diameter of melted specimen of cheese.

Stretchability: Pre-prepared cheese sample (200g) was put into a large diameter glass container and heated at 60 ºC. The specimen cheese sample was manually stretched with finger till cheese string was nearly to break and the length was measured using measuring scale. The result was calculated by detecting the initial length of specimen cheese from the length of final stretchable specimen cheese.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) Significant differences of the means were computed using least significant difference (LSD) through computerized statistical package i.e. Student Edition of Statistix (SXW), Version 8.1 (Copyright 2005, Analytical Software, USA).

RESULTS AND DISCUSSION

Moisture content

The data (Table 1) indicate that moisture content of Mozzarella cheese of brand C (52.91±0.91%) was considerably higher ($P<0.05$) than Mozzarella cheese of brand A (38.38±0.61%) and brand B (34.17±0.39%). Whereas, moisture content of Cheddar cheese of brand C (52.04±0.79%) was higher ($P<0.05$) followed by Cheddar cheese of brand A (45.00±0.27%) and brand B (33.79±0.38%). Pizza cheese had higher moisture content (53.83±0.58%) than all the cheese varieties except brand C of Mozzarella variety, where differences existed statistically non significant ($P>0.05$). A significant influence of milk source on the composition of Mozzarella cheese and significantly higher moisture content was observed in cheese prepared from each of bovine and caprine milk contrast to that of cheese prepared from ovine milk (Shaker *et al.,* 2012). There is considerable influence of milk source, whereby higher moisture content in Mozzarella cheese made from goat milk v/s from that of cow milk and/or from cow + buffalo milk v/s buffalo milk, respectively (Sulieman *et al.,* 2012; Sameen *et al.,* 2008). The range of moisture contents with regard to Cheddar cheese observed in this study agree to other scientists While, moisture content in pizza cheese found to be higher (46.74%) than that of present study (Murtaza *et al.,* 2008 Kuo *et al.,* 2001).

Protein content

In same variety of cheese, protein content of Mozzarella cheese of brand-A (30.91±0.57%) was significantly ($P<0.05$) higher than that of brand-B (24.38±0.43%) and brand-C (20.19 ± 0.69%). Protein content of Cheddar cheese of brand-B (22.96 ± 0.52%) was higher ($P<0.05$) followed by brand-A (20.73 ± 0.52%) and brand-C (19.08 ± 0.67%). Pizza cheese with 19.33 ± 0.51% protein content showed statistically non - significant ($P > 0.05$) differences with Mozzarella cheese of brand-C and Cheddar cheese of brand-A and C. It is interesting to note that final pH, moisture, salt-in-moisture content, temperature, and time of ripening could be used to control proteolysis in cheese. Changes in these control parameters could be the reason for variation in levels of protein degradation in cheeses (Singh *et al.,* 2003). Significant differences in the composition of cheese manufactured by different companies existed due to the fact that

those may probably be prepared from milk of different cows (breeds) or from different species (Johnson et al., 1998).

Fat content

The results (Table 1) revealed that fat content varied among different varieties of cheese with different brands. The fat content in Mozzarella cheese of brand B (32.21±0.30%) appeared significantly higher (P<0.05) than brand-A (27.58±0.43%) and brand-C (21.21±0.41%). Fat content of Cheddar cheese of brand B (32.88±0.31%) was recorded considerably high (P<0.05) followed by Cheddar cheese of brand A (28.21±0.55%) and brand-C (22.33±0.68%). Pizza cheese had markedly (P<0.05) lower fat content (19.67±0.75%) than all cheese varieties. Significant variation in composition of cheeses manufactured by different companies may be attributed to milk of different breeds or species from which those Cheeses were prepared. However, non-significant variation in composition of cheese was related with the use of standardized milk according to the specifications of cheese and/or with the use of standard manufacturing and ripening practices during the production of cheeses (Johnson *et al.,* 1998). Moreover, fat contents evaluated under current study were within the range reported by different researcher studies i.e. 15.07 to 32.33% of either Mozzarella and/or Cheddar cheese of different brands (Shaker *et al.,* 2012; Murtaza *et al.,* 2008) while Pizza cheese revealed lower fat content from other scientist's observations (Kuo *et al.,* 2001).

Ash content

Ash content of different varieties of Mozzarella cheese of brand-C (4.34±0.51%) was remarkably higher (P<0.05) than that of brand-A (2.50±0.16%), while it was relatively similar to that of brand-B (3.96±0.21%). Ash content of Cheddar cheese of brand-B (5.01±0.17%) was significantly higher (P<0.05) then brand-A (4.91±0.41%) but statistically not varied from that of brand-C (4.68±0.51%). Pizza cheese had ash content of 4.56±0.12%. Moreover, brand-B of Cheddar cheese appeared significantly high in ash content (5.01±0.17%) from all the brands of Cheddar, Mozzarella and Pizza cheeses except brand-C of Cheddar cheese where differences in ash content existed non-significant. Ash content in brand-A of Mozzarella cheese was observed considerably low (P>0.05) compared to that of examined in all other brands of Mozzarella, Cheddar and Pizza cheeses. Significant variation in ash content of different brands of cheese could be attributed to manufacturing processes and/or type of milk that was used during production of cheese. The variation in ash content probably rose from different salt levels used by different producers and the method of cheese manufacture (Cylan *et al.,* 2013). Several studies show significant influence of milk source on ash content of Mozzarella and/or Cheddar cheese (Sulieman *et al.,* 2012; Murtaza *et al.,* 2008).

Calorific values

The data (Table 1) indicate that calorific value in Mozzarella cheese of brand B (391.17±3.32kcal/100gm) was significantly higher (P<0.05) than that of brand-A (374.44±4.52kcal/100gm) and brand-C (277.04±5.60kcal/100gm). Among the Cheddar cheese brands, calorific values of brand-B (390.31±3.14kcal/100gm) was considerably (P<0.05) high followed by brand-A (344.28±3.20kcal/100gm) and brand-C (284.76±5.55kcal/100gm). Pizza cheese had statistically similar (P>0.05) calorific value (264.75±5.74kcal/100gm) to that of Mozzarella variety of brand-C, whereas, Mozzarella and/or Cheddar variety of brand-B were statistically similar (P>0.05) with each other. This high variation in commercial brands of cheese presumably be correlated with their corresponding milk from which those were manufactured. Milk source has significant influence on the quality of products made from them (Harding, 1998).

pH values

Result regarding pH values of commercial cheese (Table 2) indicate no any countable (P>0.05) difference in pH values of brand-B (4.59±0.02) and brand-A (4.58±0.03) of Mozzarella cheese. However, both of these brands showed significantly low pH than that of brand-C (5.74±0.03).

The pH value of Cheddar cheese of brand-A (6.09±0.05) and brand-B (6.05±0.03) were relatively similar (P >0.05) and appeared to contain less hydrogen ions compared to that of brand-C (5.68±0.05). Mozzarella and/or Cheddar variety of brand C was statistically similar with each other. Pizza cheese had pH value (6.33±0.05) significantly (P<0.05) higher than that of all cheese varieties under present study. It is interesting to note that pH value of cheese is influenced by biochemical changes during ripening and storage of the product (Joshi *et al.,* 2003). Similar findings have been reported by various researchers for Mozzarella, Cheddar and Pizza cheese, (Shaker *et al.,* 2012; Murtaza *et al.,* 2008; Kuo *et al.,* 2005). Another reason could be attributed to source and type of milk that may have significant influence on the pH value of product; for instance buffalo milk has higher buffering capacity to that of cow milk (Ahmad *et al.,* 2008).

Table 1. Chemical characteristics of commercial cheese.

Cheese variety	Cheese brands	Moisture content (%)	Protein content (%)	Fat content (%)	Ash content (%)	Calorific values (kcal/100g)
Mozzarella	A	38.38±0.6^{d}	30.91±0.57^{a}	27.58±0.43^{b}	2.50±0.16^{e}	374.44±4.52^{b}
	B	34.17±0.39^{e}	24.38±0.43^{b}	32.21±0.30^{a}	3.96±0.12^{d}	391.17±3.32^{a}
	C	52.91±0.91^{ab}	20.19±0.69^{cd}	21.21±0.41^{c}	4.34±0.51^{bcd}	277.04±5.60^{de}
Cheddar	A	45.00±0.27^{c}	20.73±0.52^{c}	28.21±0.55^{b}	4.91±0.41^{cd}	344.28±3.20^{c}
	B	33.79±0.38^{e}	22.96±0.52^{b}	32.88±0.31^{a}	5.01±0.17^{a}	390.31±3.14^{a}
	C	52.04±0.79^{b}	19.08±0.67^{d}	22.33±0.68^{c}	4.68±0.51^{ab}	284.76±5.55^{d}
Pizza cheese	A	53.83±0.58^{a}	19.33±0.51^{cd}	19.67±0.75^{d}	4.56±0.12^{bc}	264.75±5.74^{e}
P-value / LSD		1.6899±0.85	1.5958±	1.4574± 0.73	0.2067±0.41	12.885±6.47

*Values superscript with different letter in column varied significantly (P<0.05)

Table 2. Physical and rheological characteristics of commercial cheese.

Cheese variety	Cheese brands	pH values	Acidity (%)	Meltability (cm)	Strechability (cm)
Mozzarella	A	4.58±0.03^{d}	0.62±0.004^{a}	2.43±0.62^{ab}	66.75±1.46^{a}
	B	4.59±0.02^{d}	0.62±0.007^{a}	2.07±0.79^{c}	55.25±2.26^{b}
	C	5.74±0.03^{c}	0.53±0.007^{b}	0.73±0.05^{d}	1.00±0.16^{d}
Cheddar	A	6.09±0.05^{b}	0.48±0.012^{c}	2.57±0.62^{a}	7.55±0.41^{c}
	B	6.05±0.03^{b}	0.44±0.021^{d}	2.38±0.61^{b}	2.42±0.07^{d}
	C	5.68±0.05^{c}	0.56±0.007^{b}	0.59±0.05^{d}	0.71±0.11^{d}
Pizza cheese	A	6.33±0.05^{a}	0.42±0.013^{d}	2.60±0.57^{a}	1.14±0.13^{d}
P-value / LSD		0.1115±0.056	0.0325 ±0.02	0.1771± 0.088	1.4634±2.30

*Values superscript with different letter in column varied significantly (P<0.05)

Acidity

Acidity of Mozzarella cheese of brand A (0.62 ±0.004%) and brand B (0.62 ±0.007%) was statistically similar (P>0.05) with each other but considerably higher (P<0.05) than that of brand-C (0.53±0.007%) (Table 2). Acidity of Cheddar cheese of brand-C (0.56±0.007%) was significantly higher (P<0.05) followed by Cheddar cheese of brand-A (0.48 ±0.012%) and brand-B (0.44±0.021%). Brand-C of Mozzarella and/or Cheddar cheese were statistically similar (P>0.05). Pizza cheese had markedly lower acidity (0.42±0.013%) (P<0.05) than all the cheese cheese except brand B of Cheddar cheese that was statistically non-significant (P>0.05). Nevertheless, all the commercial cheeses of different brands in the present study, appeared quantitatively mild and found considerably lower in acidity than different researcher observations i.e. 0.93 to 0.95% (Sameen *et al.,* 2008; Murtaza *et al.,* 2008). Cheese being a biochemically dynamic product may undergo significant changes during ripening of cheese (McSweeney and Sousa 2007). The significant one is the metabolism of lactose to lactate and other metabolites by lactic acid bacteria that influence the rate and extent of acidification (McSweeney and Fox 2004). Due to these changes, variation in acidic condition in commercial brands of cheeses may have been occurred.

Meltability

The meltability of Mozzarella cheese of brand-A (2.43±0.62cm) was recorded considerably (P<0.05) betterfollowed by brand-B (2.07±0.79cm) and brand-C (0.73±0.05cm) (Table 2). Whereas, similar trend of meltability was recorded in Cheddar cheese. Brand-A (2.57±0.62cm) was markedly better (P<0.05) in meltability followed by brand-B (2.38±0.61cm) and brand-C (0.59±0.05cm). Mozzarella and/or Cheddar cheese of brand-C were statistically non-significant (P>0.05). Pizza cheese had (2.60±0.57cm) statistically similar (P>0.05) meltability to that of brand A of Cheddar and Mozzarella variety. It is noteworthy that milk pre-heat treatment, pH, moisture content, fat and minerals including salt and extent of proteolysis governed the cheese functionality (Guinee *et al.,* 2002). It has also been reported that there is correlation between changes in various constituents of cheese and cheese meltability (Wang *et al.,* 1998). Nevertheless, present results of cheese meltability found to be in line with other scientist's evaluation that is 2.92 to 3.67cm (Hysen *et al.,* 2008).

Stretchability

Stretchability of Mozzarella cheese of brand-A (66.75±1.46cm) was recorded long (P<0.05), while brand-B (55.25±2.26cm) appeared intermediate and in brand-C it was very short (1.00±0.16cm) (Table 2). Stretchability of Cheddar cheese of brand-A (7.55±0.41cm) was recorded significantly (P<0.05) long compared to that of brand-B (2.42±0.07cm) and brand-C (0.71±0.11cm). However, differences in stretchability of later two brand appeared non-significant. Pizza cheese had 1.14±0.13cm stretchability and statistically similar (P>0.05) with Cheddar cheese variety of brand-B, brand-C and Mozzarella cheese variety of brand-C. In contrast to pasta filata cheese like Mozzarella cheese, most of other cheese types including Analogue Pizza

cheese and Cheddar cheese had been reported relatively low in stretchability and this intravarietal difference in functional properties probably arised from variations in proteolysis, water binding capacity of the cheese proteins, and concentrations of the structural components namely, fat, protein and moisture (Montel *et al.,* 2014).

CONCLUSION

The study concluded that, chemical composition, calorific values and physical as well as rheological characteristics of commercial cheese varied from brand to brand. Brand-A of Pizza cheese and brand-C of Mozzarella cheese appeared significantly high in moisture content. Brand-A of Mozzarella cheese found considerably rich in protein content, low in ash content, more acidic and better in stretchability than that of other brands of Mozzarella and Cheddar cheeses and brand-A of Pizza cheese. Proportion of fat appeared significantly low in brand-A of Pizza cheese and considerably high in brand-B of Mozzarella as well as Cheddar cheese. Meltability of brand-A of Mozzarella, Cheddar and Pizza cheeses remained relatively similar and considerably high and in brand-C of Mozzarella and Cheddar cheeses is low from the other brands of cheeses under present study.

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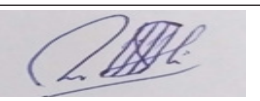
1.	Mehvish Laghari	Performed and conducted the whole experiment	
2.	Muhammad Khaskheli	Supervisor	
3.	Rabia Bano Bhatti	Assisted in drafting research work