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CHEMICAL COMPOSITION OF BOVINE MILK DURING THE FIRST WEEK POSTPARTUM AND ITS INFLUENCE BY SOME HEAT TREATMENTS

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ABSTRACT

Bovine colostrum is the early milk produced by cows during the first several days postpartum. This early milk has a nutrient profile and immunological composition substantially different from mature milk. In the present study the chemical composition and immunoglobulin G (IgG) of bovine milk during the first week of postpartum were determined and the effect of heat treatments on bovine milk IgG contents was evaluated. Individual milk samples were collected from five cows at 0- 0.5, 1, 2, 3, 4, 5, 6 and 7 days postpartum. The obtained results showed that the total solids, total protein, fat and ash contents decreased irregular with time after parturition, while the lactose content increased. The concentrations of IgG were significantly higher during 0-0.5 and 1st days than those of other days postpartum, where the mean±SD of IgG concentrations were 122.60±5.24 and 118.44±5.90 g/L during 0-0.5 and 1st days postpartum, respectively. However, IgG concentrations were dropped markedly with time progress of lactation at the end of the first week (7th day), the mean±SD of IgG concentration was 55.16±17.30 g/L that dropped to 55.01% when compared with its concentrations at 0-0.5 day. IgG of bovine milk was influenced by heat treatments, where the concentrations of IgG in thermal treated milk were decrease to 28.24, 30.27 and 30.18% at 63°C/30 min and 57.33, 73.54 and 95.1% at 72°C/15 sec during 1, 2 and 3 days postpartum, respectively. On the other hand, the most thermal influence on IgG in milk was during thermal heated at 100°C/10 min, where the percentages of losses were 95.72% at 1st and 100% at 2 and 3 days postpartum.

Key words: Bovine milk, colostrum, immunoglobulin G (IgG), heat treatments.

INTRODUCTION

Colostrum is the secretion of the mammary gland produced immediately after parturition through four days post-parturition. Within each species, colostrum is the first natural food for the newborn calf. The nutritional and physiological needs of the neonate during this period of very early life are typically quite specialized and correspondingly. The composition of the maternal colostrum is tailored to meet these unique requirements Martin *et al.*, 2001; Martin-Sosa *et al.,* 2003; Kehoe *et al.,* 2007; Tsioulpas *et al.,* 2007; Christiansen *et al.*, 2010 and Abd El-Fattah *et al.*, 2012. The colostrum composition and its quality are influenced by a variety of factors, including maternal age, parity, breed, nutritional status, season, premature parturition, premature lactation, colostral handling factors, induction of parturition and health status. During transition from colostrum to normal milk, gradual or sometimes sudden changes may occur in composition and properties (Gulliksen *et al.*, 2008; Abd El-Fattah *et al.*, 2012 and Morrill *et al.*, 2012).

Colostrum is not only a source of nutrients such as proteins, carbohydrates, fat, vitamins and minerals, but it also contains several biologically active molecules which are essential for specific functions. Most of the biologically active substances in complete bovine colostrum

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that can convey significant health benefits are proteins (Pakkanen and Aalto, 1997).

In recent years, bovine colostrum has become popular as a product for human consumption, because it is an excellent source of bioactive proteins. The latter would have the ability to prevent bacteria and viruses and to improve the gastrointestinal and body condition. Really, the exploitation of the beneficial properties of colostrum is not a new concept (Conte and Scarantino, 2013).

The immunoglobulins (Igs), or antibodies, found in colostrum or milk are the same as those found in the blood or mucosal secretions. They are used by the immune system to identify and neutralize foreign objects, such as bacteria and viruses. For cattle, Igs are grouped into four isotypes, IgG (IgG_1 and IgG_2), IgA, IgM and IgE, based on the heavy chain they possess (Butler, 1983; Korhonen *et al.*, 2000a,b and Gapper *et al.*, 2007). IgG, IgA and IgM are present in high levels in milk, especially in colostrum. The IgG is dominant in colostrum, milk and blood (about 80-90%, 60-70% and 90% of total Igs, respectively) (Marnila & Korhonen, 2002; Mix *et al.*, 2006 and Zhao *et al.*, 2010).

IgG concentrations change throughout the first 6 milking's postpartum (Foley and Otterby, 1978). The relatively high levels of IgG in early bovine colostrum thus provide an essential source of this nutrient to the calf immediately following parturition and until it can establish immunosufficiency. IgG antibodies express multifunctional activities, including complement activation, bacterial opsonisation and agglutination as well as act by binding to specific sites on the surfaces of most infectious agents or products, either inactivating them or reducing infection (Lilius & Marnila, 2001 and Gapper *et al.*, 2007).

Interest has been given to the effect of heat treatments on different immunoglobulin classes. Detectable IgG in colostrum or colostral whey are reduced by heat treatment, however at a slower rate than for isolated IgG. Thermal protectants such as sugars or glycerol can increase the stability of isolated IgG to heat treatment (Chen & Chang, 1998; Chen *et al.*, 2000 and Zagorska & Ciprovica, 2012). According to Chen and Chang (1998) immunoglobulins are thermolabile. Exposure to temperatures of 75°C can reduce detectable isolated bovine IgG by 40% in 5 min, and by 100% at 95 °C for 15 sec. The explanation of it is conformational changes in the IgG molecule causes by heat exposure (Calmettes *et al.*, 1991).

The aim of the current research is to study the chemical composition of bovine milk during the first week postpartum, precipitate the immunoglobulins from bovine milk samples to determine the IgG concentrations and evaluate the effect of heat treatments on bovine milk IgG.

MATERIALS AND METHODS

Sample Collection and Storage

Study design

This study was conducted from February 2010 till December 2012 aiming at estimation of the concentration of total protein and IgG in bovine milk during the first week postpartum.

Sample selection

Individual milk samples were collected from five Frisian cows of El-Sadeen village, Menia Al-kamh center, Sharkia Governorate, Egypt. Milk samples were obtained at 0-0.5, 1, 2, 3, 4, 5, 6 and 7 days postpartum. Samples (500 ml) were collected in sterilized bottles by supervised manual expression at the end of the milking and transported to the laboratory in an ice box. All samples were stored at (-20°C) immediately on arrival and kept frozen till analysis.

Determination of Chemical Composition

The total solids, total protein and fat contents were determined according to AOAC (2000). Lactose content was determined colorinemetrically according to Barnett and Abd El-Tawab (1957). Ash content was determined according to the method described by Ling (1963).

Determination of Immunoglobulins in Bovine milk

Samples preparation

Bovine milk samples were defatted by centrifugation at 4000 r.p.m for 3 min. Milk whey was prepared from the skim milk by adjusting pH to 4.6 using 1 *N* HCl solution and centrifuging at 10000 r.p.m. for 15 min. to remove casein precipitate.

Total Igs were prepared from whey samples by using saturated ammonium sulphate solution according to the method described by Hebert, (1974). The ammonium sulphate extract was dialyzed against distilled water for 24 hr., at refrigerator with several changes of distilled water during this period. The dialyzed extract was kept at (-20°C) until analyzed.

Immunoglobulin Quantification by Single Radial Immunodiffusion (SRID)

Single radial immunodiffusion (SRID) kits (the Binding site Limted, England) were used for quantitative determination of IgG in bovine milk samples within 7 days postpartum. It was principally derived from the work of Mancini *et al.* (1965) and Fahey and Mckelvey (1965).

Heat treatments

To investigate the effect of heating methods on the IgG content of bovine milk, the milk samples were defatted and the skim milk was heat treated as follows: Heating was carried out at 63˚C for 30 min., 72˚C for 15 sec. and 100˚C for 10 min. then followed by rapid cooling for all samples to 37˚C.

Statistical analysis

Statistical analysis for the obtained data was carried out using SPSS version 20 computer program (Dominick and Derrick, 2001). All data were expressed by means & standard deviations of 3 replicates and were compared using One-way Anova and least significant deference (LSD). Values with different letters within the same column differ significantly at $p < 0.01$- 0.05.

RESULTS AND DISCUSSION

Gross Chemical Composition of Bovine Milk

Total solids content

Table 1 shows the total solids content of bovine milk during the first week of postpartum. It was noticed that the mean±SD concentrations of total solids was 19.83± 2.12% with a range of 17.31-22.35% during 0-0.5 day postpartum. The total solids content decreased to range from 15.24 to 19.79% with a mean± SD 17.55±1.65% at 1st day postpartum. While a gradual decreases could be noticed on the following days with the ranges of total solids 14.52-16.84, 13.7-15.43, 12.72-14.54, 12.53-14.49, 12.24-14.0 and 11.41, 13.46% with means±SD 15.33±0.96, 14.63±0.68, 13.76±0.80, 13.18±0.80, 12.81±0.70 and 12.22±0.78% at 2, 3, 4, 5, 6 and 7 days postpartum, respectively.

It is clear from the same Table that the mean concentrations of total solids were significantly higher during 0-0.5 day than other days postpartum. But no significant differences were found between 3, 4 and 5 days. No significant differences were found between 4, 5, 6 and 7 days postpartum, in the same order.

Similar results have been reported by Foley & Otterby (1978); Hekmati & Niroumand (1978); Blum & Hammon (2000); Kleinsmith (2011) and Abd El-Fattah *et al.* (2012) who observed that the total solids contents decreased irregularly with time after parturition.

Total solids content at 1st day postpartum in the present study was higher than those reported by Foley & Otterby (1978); Hekmati & Niroumand (1978) and Kleinsmith (2011).

Kehoe *et al.* (2007) and Bar *et al.* (2010) found that the mean of total solids contents in bovine colostrum were 27.64 and 23.56% with ranges 18.3-43.3 and 21.6-29.15%, respectively, while in mature milk were 12.7 and 12.9% (Fox & McSweeney, 2003 and Walstra *et al.,* 2006).

Kleinsmith (2011) found that total solids contents in bovine colostrum were 26.99, 20.46, 14.53, 12.77, 12.22 and 11.46% at 0, 6, 12, 24, 36 and 48 hr., postpartum, respectively. Also, Abd El-Fattah *et al.* (2012) stated that the mean of total solids content in bovine colostrum at calving was 24.19%.

Total protein content

The data in Table 2 show that the mean±SD total protein concentration in bovine milk was significantly higher during 0-0.5 day postpartum (10.65±1.71%) than other days, followed by 1st day postpartum (9.26±1.32%). No significant differences were found between the mean± SD concentrations of total protein at 2nd day (7.36±0.53%) and 3rd day (6.67±0.13%),

Table 1. Total solids content of bovine milk during the first week postpartum

Lactation period (days)	Total solids (%)					Range	Mean±SD*	SE**
	Cows							
	1	2	3	4	5			
0-0.05	20.01	18.14	17.31	21.35	22.35	17.31-22.35	19.83±2.12[a]	0.946
1	17.55	17.06	15.24	18.12	19.79	15.24-19.79	17.55±1.65[b]	0.739
2	15.65	14.52	14.54	15.11	16.84	14.52-16.84	15.33±0.96[c]	0.431
3	15.15	14.57	13.70	14.32	15.43	13.70-15.43	14.63±0.68[cd]	0.306
4	14.54	13.83	12.72	13.20	14.52	12.72-14.54	13.76±0.80[de]	0.360
5	12.53	14.49	12.74	13.39	12.73	12.53-14.49	13.18±0.80[de]	0.359
6	12.71	14.00	12.24	12.75	12.35	12.24-14.00	12.81±0.70[e]	0.314
7	11.41	13.46	11.75	12.19	12.27	11.41-13.46	12.22±0.78[e]	0.348
LSD* **						**1.45**		

SD*:Standard deviation; **SE****: Standard error; **LSD*****: The least significant difference.
Means with different superscript within the same column are significantly different.

Table 2. Total protein content of bovine milk during the first week postpartum

Lactation period (days)	Total protein (%)					Range	Mean±SD*	SE**
	Cows							
	1	2	3	4	5			
0-0.5	10.88	9.57	8.43	12.85	11.50	8.43-12.85	10.65±1.71[a]	0.765
1	9.20	8.68	7.52	11.09	9.80	7.52-11.09	9.26±1.32[b]	0.592
2	7.26	6.78	7.27	8.22	7.26	6.78-8.22	7.36±0.53[c]	0.235
3	6.79	6.70	6.73	6.65	6.46	6.46-6.79	6.67±0.13[cd]	0.056
4	6.12	6.04	5.47	5.31	5.90	5.31-6.12	5.77±0.36[de]	0.160
5	5.44	6.12	5.35	4.90	4.11	4.11-6.12	5.18±0.74[ef]	0.332
6	5.36	5.62	5.04	4.85	4.15	4.15-5.62	5.00±0.56[ef]	0.251
7	4.02	5.48	4.60	4.40	3.90	3.90-5.48	4.48±0.63[f]	0.280
LSD* **						**1.11**		

SD*: Standard deviation; **SE****: Standard error; **LSD*****: The least significant difference.
Means with different superscript within the same column are significantly different.

but significant differences were found between 2nd (7.36±0.53%) and 4th days (5.77±0.36%). Also, no significant differences were found between the mean± SD concentrations of total protein at 5 (5.18±0.74%), 6 (5.00±0.56%) and 7 (4.48±0.63%) days of postpartum.

Table 2 shows that the ranges of total protein concentrations were 8.43-12.85, 7.52-11.09, 6.78-8.22, 6.46-6.79, 5.31-6.12, 4.11-6.12, 4.15-5.62 and 3.9, 5.48% at 0-0.5, 1, 2, 3, 4, 5, 6 and 7 days postpartum, respectively.

These results are in agreement with those found by Elfstrand (2000); Tsioulpas *et al.* (2007); Kleinsmith (2011) and Abd El-Fattah *et al.* (2012) who found that the protein content decrease gradually with time after parturition.

Protein content after 1st day postpartum in this study was higher than those reported by Foley & Otterby (1978); Hekmati & Niroumand (1978) and Klimes *et al.* (1986) and lower than those reported by Tsioulpas *et al.* (2007).

Frome some previous studies, the mean of total protein content in bovine colostrum was 14.92% with range 7.1-22.6% within 4 hr., of calving (Kehoe *et al.*, 2007), 9.47% with range 6.59-11.66% at first milked after calving (Bar *et al.*, 2010), 13.45% at calving (Abd El-Fattah *et al.*, 2012) and 12.2% with range 8.85-21.85% after 2-3 days postpartum (Conte and Scarantino, 2013), while in mature milk, the protein contents were 3.4% (Jensen, 1995 and Gopal & Gill, 2000), 2.9% (Fox and McSweeney, 2003) and 3.3% (Walstra *et al.,* 2006).

Fat content

Fat content of bovine milk during the first week postpartum is presented in Table 3. The mean ± SD concentrations of fat was 5.68 ± 0.72% during 0-0.5 day postpartum with a range of 4.9 to 6.8%, and dropped to range from 3.8 to 6.1% with a mean ± SD 4.76 ± 0.89% at 1st day postpartum. Then a gradually decreasing could be noticed on the following days, where the ranges of fat concentrations were 3.5-5.5, 3.1-4.6, 3.1-4.3, 2.8-4.0, 2.5-3.6 and 2.5, 3.7% with means±SD 4.26±0.86, 3.90±0.64, 3.70±0.56, 3.30±0.48, 3.10±0.46 and 2.94±0.50% at 2, 3, 4, 5, 6 and 7 days postpartum, respectively.

Results in the same Table indicates that a significant difference was found between the fat content during 0-0.5 day and other days, but no significant differences were found between 1 & 2; 2, 3 & 4 and 4, 5, 6 & 7 days postpartum.

These results are in quite agreement with those of Foley & Otterby (1978) and Abd El-Fattah *et al.* (2012) who observed that the fat content decrease with time after parturition, and in contrast with the study of Elfstrand (2000), Tsioulpas *et al.* (2007) and Kleinsmith (2011).

Fat content at 1st day postpartum in the present study was higher than those reported by Foley & Otterby (1978); Hekmati & Niroumand (1978) and Tsioulpas *et al.* (2007). Fat content of the first milking colostrum varies over a wide range and was reflected in values for total solids Elfstrand (2000).

The mean of fat contents in bovine colostrum were 6.7% with range 2.0-26.5% within 4 hr., of calving (Kehoe *et al.*, 2007), 3.51 (4.6-5.78%) of first milked after calving (Bar *et al.*, 2010), 8.04% at calving (Abd El-Fattah *et al.*, 2012) and 7.86 (2.55-16.09%) after 2-3 days postpartum (Conte and Scarantino, 2013), while in mature milk, it was 3.7% (Jensen, 1995), 4.6% (Gopal and Gill, 2000), 4.5% (Fox & McSweeney, 2003) and 4.0% (Walstra *et al.* 2006).

Lactose content

It is evident from Table 4 that the mean±SD of lactose concentrations at 0-0.5, 1st and 2nd days were 2.50 ± 0.45, 2.59 ± 0.34 and 2.83 ± 0.38%, respectively with ranges 1.9-3.0, 2.2-2.94 and 2.25-3.2%, in the same order, without significant differences between the first two days of lactation. The lactose content increased to range from 3.02 to 3.5% with a mean ± SD 3.22 ± 0.24% at 3rd day, 3.34-3.67% with a mean ± SD 3.49±0.15% at 4th day and 3.5-4.4% with a mean ± SD 3.90 ± 0.35% at 5th day. These differences were in significant between 3 and 4 days, also, between 4 and 5 days, but it had significant between 2 and 4 days, also, between 3 and 5 days. Results in the same Table also indicates that the mean ± SD concentrations of lactose at 6 and 7 days were 3.94 ± 0.44 and 4.04 ± 0.29 with ranges 3.48-4.6 and 3.77-4.5%, respectively without significant differences between them.

Table 3. Fat content of bovine milk during the first week postpartum

Lactation period (days)	Fat (%)					Range	Mean±SD*	SE**
	Cows							
	1	2	3	4	5			
0-0.5	5.9	4.9	5.3	5.5	6.8	4.9-6.8	5.68±0.72[a]	0.323
1	5.1	4.6	4.2	3.8	6.1	3.8-6.1	4.76±0.89[b]	0.398
2	4.8	3.8	3.5	3.7	5.5	3.5-5.5	4.26±0.86[bc]	0.383
3	4.5	3.6	3.1	3.7	4.6	3.1-4.6	3.90±0.64[cde]	0.285
4	4.3	3.4	3.1	3.4	4.3	3.1-4.3	3.70±0.56[cdef]	0.251
5	2.8	3.5	2.9	3.3	4.0	2.8-4.0	3.30±0.48[def]	0.217
6	3.1	3.5	2.8	2.5	3.6	2.5-3.6	3.10±0.46[ef]	0.207
7	2.9	3.1	2.5	2.5	3.7	2.5-3.7	2.94±0.50[f]	0.223
LSD* **	**0.82**							

SD*: Standard deviation; **SE******:** Standard error; **LSD*******:** The least significant difference.
Means with different superscript within the same column are significantly different.

Table 4. Lactose content of bovine milk during the first week postpartum

Lactation period (days)	Lactose (%)					Range	Mean±SD*	SE**
	Cows							
	1	2	3	4	5			
0-0.5	2.20	2.80	2.60	1.90	3.00	1.90-3.00	2.50±0.45[e]	0.200
1	2.31	2.94	2.62	2.20	2.90	2.20-2.94	2.59±0.34[e]	0.150
2	2.69	3.12	2.89	2.25	3.20	2.25-3.20	2.83±0.38[de]	0.170
3	3.03	3.45	3.02	3.10	3.50	3.02-3.50	3.22±0.24[cd]	0.105
4	3.34	3.58	3.34	3.67	3.50	3.34-3.67	3.49±0.15[bc]	0.065
5	3.50	4.10	3.71	4.40	3.80	3.50-4.40	3.90±0.35[ab]	0.157
6	3.48	4.15	3.67	4.60	3.80	3.48-4.60	3.94±0.44[a]	0.198
7	3.77	4.14	3.90	4.50	3.90	3.77-4.50	4.04±0.29[a]	0.129
LSD* **	**0.42**							

SD*: Standard deviation; **SE******:** Standard error; **LSD*******:** The least significant difference.
Means with different superscript within the same column are significantly different.

The obtained results in this study are closely similar with those of Hekmati & Niroumand (1978); Tsioulpas *et al.* (2007); Kleinsmith (2011) and Abd El-Fattah *et al.* (2012) who observed that the lactose content increase with time after parturition. This difference is an advantage because lactose can induce the young to scour (diarrhea) with subsequent death or unthriftiness (Roy, 1970). In contrast with the study of Elfstrand (2000) who found that the lactose contents were 3.0, 2.9, 3.5, 3.2, 3.5, 3.5 and 3.8% during 0-6, 7-10, 11-20, 21-30, 31-40, 41-50 and 51-80 hr., respectively.

It was noteworthy found that the changes in lactose content in colostrum showed the opposite trend than the corresponding values in the mature milk, probably due to the knowledge of the mechanisms of lactose synthesis (Kuhn, 1983) suggests that the lower availability of plasma glucose and colostral lactalbumin is a possible cause of the lower percentage of lactose in colostrum immediately after parturition.

Lactose contents in the present study were lower than those reported by Tsioulpas *et al.* (2007) at 1st to 5th day, Kleinsmith (2011) at 1st and 2nd days and Klimes *et al.* (1986) at 3rd and 5th days postpartum. Lactose contents in this study were higher than those reported by Klimes *et al.* (1986) at 1st day postpartum.

Kehoe *et al.* (2007); Bar *et al.* (2010) as well as Conte and Scarantino (2013) showed that the mean of lactose contents in bovine colostrum were 2.49, 3.5 and 2.04% with ranges 1.2-5.2, 3.37-3.94 and 1.46-3.19%, in the same order, while in mature milk, it were 4.1 and 4.6% (Fox & McSweeney, 2003 and Walstra *et al.,* 2006).

Ash content

Ash contents of bovine milk during the first week postpartum are given in Table 5. The mean ± SD concentrations of ash were significantly higher during 0-0.5 day (1.01 ± 0.09%) than those of other days postpartum. The range of ash concentrations was 0.87-1.1% during 0-0.5 day, and then dropped to range from 0.84 to 1.03% at 1st day postpartum with a mean ± SD 0.94 ± 0.07%, while at 2nd day postpartum ranged from 0.82 to 0.94% with a mean ± SD 0.88 ± 0.04%, without significant differences between 1st and 2nd day. A gradual decrease could be observed on the following days, where the ranges of ash concentrations were 0.82-0.87, 0.78-0.82, 0.77-0.82, 0.73-0.80 and 0.72, 0.79% with means ± SD 0.85 ± 0.02, 0.81 ± 0.02, 0.79 ± 0.02, 0.77 ± 0.04 and 0.75 ± 0.03% at 3, 4, 5, 6 and 7 days postpartum, in order.

Results in Table 5 show that there were significant differences between ash content at 2nd and 4th days postpartum, but insignificant variations were found between 4, 5, 6 and 7 days postpartum.

These results are in agreement with the previous reports by Foley & Otterby (1978); Klimes *et al.* (1986); Tsioulpas *et al.* (2007) and Abd El-Fattah *et al.* (2012) who observed that the ash content decrease with time after parturition. This is may be attributed to increase of mineral in colostrum compared to mature milk. Howevere, in colostrum, high protein and salt, low sugar content, are ideal for the neonate's immature digestive system (Hamosh, 1996).

Kehoe *et al.* (2007) and Bar *et al.* (2010) showed that the mean values of ash content in bovine colostrum were 0.05 and 1.48% with ranges 0.02-0.07 and 1.10-1.33%, respectively, while in mature milk were 0.7 and 0.8% (Gopal & Gill, 2000 and Fox & McSweeney, 2003).

Concentrations of IgG in bovine milk during the first week postpartum

Individual milk samples were taken from five cows within 7 days postpartum. The IgG concentrations of bovine milk samples were quantified by the SRID technique at 0-0.5, 1, 2, 3, 4 and 7 days postpartum. The relation between the Igs concentrations and the diameter of the precipitated antigen-antibody reaction are found in Figs. 1, 2 and 5 (wells No. 1 & 2). It is clear that the IgG concentrations were highest in colostrum, which falls drastically with the first few days of lactation.

Figs. 3 and 4 and Table 6 show the concentrations of IgG in bovine milk during the first week postpartum. The data showed that the concentrations of IgG were significantly higher during 0-0.5 and 1st days than those of other days postpartum, where the mean ± SD of IgG concentrations were 122.60 ± 5.24 and 118.44 ± 5.90 g/L during 0-0.5 and 1st days postpartum, respectively.

Table 5. Ash content of bovine milk during the first week postpartum

Lactation period (days)	Ash (%)					Range	Mean ± SD*	SE**
	Cows							
	1	2	3	4	5			
0-0.5	1.03	0.87	0.98	1.10	1.05	0.87-1.10	1.01±0.09^{a}	0.087
1	0.94	0.84	0.90	1.03	0.99	0.84-1.03	0.94±0.07^{b}	0.075
2	0.90	0.82	0.88	0.94	0.88	0.82-0.94	0.88±0.04^{bc}	0.043
3	0.83	0.82	0.85	0.87	0.87	0.82-0.87	0.85±0.02^{cd}	0.023
4	0.78	0.81	0.81	0.82	0.82	0.78-0.82	0.81±0.02^{def}	0.016
5	0.79	0.77	0.78	0.79	0.82	0.77-0.82	0.79±0.02^{def}	0.019
6	0.77	0.73	0.73	0.80	0.80	0.73-0.80	0.77±0.04^{ef}	0.035
7	0.72	0.74	0.75	0.79	0.77	0.72-0.79	0.75±0.03^{f}	0.027
LSD* **						**0.6**		

SD*: Standard deviation; **SE******:** Standard error; **LSD*******:** The least significant difference.
Means with different superscript within the same column are significantly different.

Table 6. Concentrations of IgG in bovine milk during the first week postpartum

Lactation period (days)	Concentration of IgG (g/L)					Mean±SD*	SE**	% of decrease
	Cows							
	1	2	3	4	5			
0-0.5	122.00	120.80	115.10	128.20	126.90	122.60±5.24^{a}	2.34	-
1	110.80	119.70	114.00	124.50	123.20	118.44±5.90^{a}	2.64	3.39
2	88.07	104.70	96.50	85.42	94.00	93.74±7.57^{b}	3.39	23.54
3	76.60	83.00	89.50	63.40	84.18	79.34±10.02^{bc}	4.48	35.29
4	50.00	78.20	88.80	38.00	83.58	67.72±22.38^{cd}	10.01	44.77
7	35.80	64.80	67.70	36.90	70.60	55.16±17.30^{d}	7.74	55.01
LSD***					**16.986**			

SD*: Standard deviation; **SE******:** Standard error; **LSD*******:** The least significant difference.
Means with different superscript within the same column are significantly different.

Fig. 1. Single radial immunodiffusion analysis of IgG for individual bovine milk samples during the first week postpartum

Wells No: 1, 2, 3, 4, 5 and 6 represent samples of cow number 1 at 0-0.5, 1, 2, 3, 4 and 7 days postpartum, respectively.

Wells No: 7, 8, 9, 10, 11 and 12 represent samples of cow number 2 at 0-0.5, 1, 2, 3, 4 and 7 days postpartum, respectively.

Wells No: 13 and 14 represent samples of cow number 3 at 0-0.5 and 1 days postpartum, respectively.

Fig. 2. Single radial immunodiffusion analysis of IgG for individual bovine milk samples during the first week postpartum

Wells No: 1, 2, 3 and 4 represent samples of cow number 3 at 2, 3, 4 and 7 days postpartum, respectively.

Wells No: 5, 6, 7, 8, 9 and 10 represent samples of cow number 4 at 0-0.5, 1, 2, 3, 4 and 7 days postpartum, respectively.

Wells No: 11, 12, 13 and 14 represent samples of cow number 5 at 0-0.5, 1, 2 and 3 days postpartum, respectively.

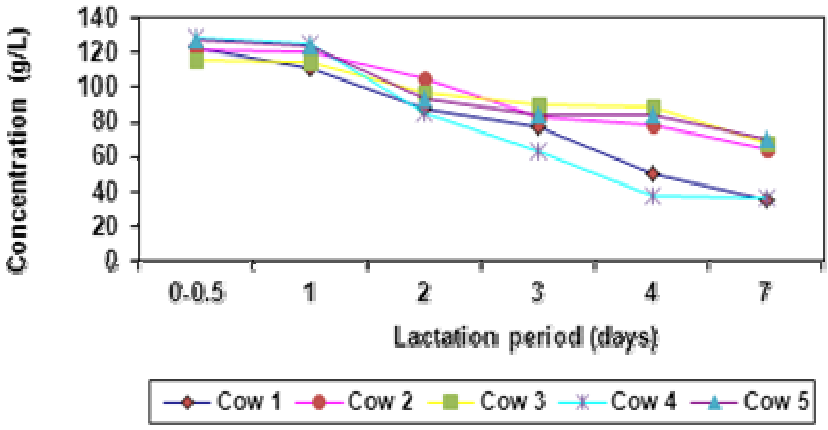

Fig. 3. Concentrations of IgG in individual bovine milk samples during the first week postpartum

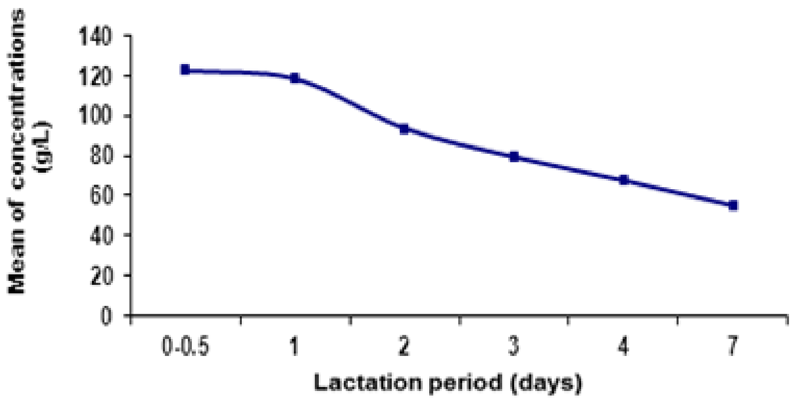

Fig. 4. Mean concentrations of IgG in bovine milk samples during the first week postpartum

However, IgG concentrations dropped markedly with time progress of lactation. At 2nd, 3rd and 4th days, the mean ± SD values of IgG were 93.74 ± 7.57, 79.34 ± 10.02 and 67.72 ± 22.38 g/L, respectively, which had dropped ratios of 23.54, 35.29 and 44.77%, respectively.

At the end of the first week (7th day), the mean ± SD of IgG concentration was 55.16±17.30 g/L that dropped to 55.01% when compared with its concentrations at 0-0.5 day. This change in IgG content indicate the significance of colostrum for the health of the newborn calf where the absorption of IgG during the first 24 hr., after birth was reported occur excessively (Butler, 1971 and 1983).

These results are in good agreement with those of Foley and Otterby (1978), Klimes *et al.* (1986), Elfstrand (2000), Elfstrand *et al.* (2002), Saucedo-Quintero and Avendano-Reyes (2004) and Abd El-Fattah *et al.* (2012).

Elfstrand *et al.* (2002) stated that the major Igs present in bovine milk are IgG with 85% ratio, among which 95% belong to the sub classes IgG_1 and 5% to the IgG_2. The mean concentrations of IgG (IgG_1 + IgG_2) were 92.8, 80.9, 66.8, 25.1, 31.5, 17.7 and 12.2 g/L during 0-6, 7-10, 11-20, 21-30, 31-40, 41-50 and 51-80 hr., respectively.

Similar results were reported by (Quigley *et al.*, 1994; Levieux and Ollie, 1999; Kehoe *et al.*, 2007; Bar *et al.*, 2010; Abd El-Fattah *et al.*, 2012; Morrill *et al.*, 2012 and Quigley *et al.*, 2013), while in mature milk, it was 0.72 and 0.556 mg/ml (Hurley, 2003 and Zagorska & Ciprovica, 2012, respectively).

Effect of heat treatments on IgG in bovine milk

Table 7 and Fig. 5 show the effect of heat treatments on IgG in bovine milk. From these results, it could be noticed that the concentrations of IgG during thermal treatments were reduced from 125.70, 107.70 and 84.79 g/L in control milk samples during 1, 2 and 3 days postpartum to 90.20, 75.10 and 59.20 g/L in thermal treated milk at 63°C/30 min, in order, it were decrease to 28.24, 30.27 and 30.18%, respectively.

Increasing temperature to 72°C/15 sec, the IgG concentrations in heated milk samples were reduced to 66.20, 28.50 and 4.23 g/L, it were decreased by 52.67, 26.46 and 4.99% during 1, 2 and 3 days postpartum, respectively. On the other hand, the most influence on IgG content at 100°C/10 min, where the percentages losses were 95.72% at 1st and 100% at 2 and 3 days postpartum.

From the obtained data, it could be concluded that the stability of IgG in bovine milk was influenced by thermal treatments. These results are in accordance with those reported by Li-Chan *et al.* (1995); El-Loly (1996) and Zagorska & Ciprovica (2012). Mainer *et al.* (1997) had different research results, HTST pasteurization (72°C for 15 sec) led to 25-40% loss of IgG concentration.

Table 7. Effect of heat treatments on bovine IgG concentrations (g/L)

Lactation period (days)	Control	Heat treatment					
		63°C 30min	Loss%	72°C 15 sec	Loss%	100°C 10min	Loss%
1	125.70	90.20	28.24	66.20	47.33	5.38	95.72
2	107.70	75.10	30.27	28.50	73.54	-	100
3	84.79	59.20	30.18	4.23	95.01	-	100

Fig. 5. Single radial immunodiffusion analysis of IgG for bovine milk samples affected by different heat treatments

Wells No: 1 and 2 represent samples of cow number 5 at 4 and 7 days postpartum, respectively.

Wells No: 3, 4, 5 and 6 represent control, 63°C/30 min, 72°C/15 sec and 100°C/10 min at 1st day postpartum, respectively.

Wells No: 7, 8, 9 and 10 represent control, 63°C/30 min, 72°C/15 sec and 100°C/10 min at 2nd day postpartum, respectively.

Wells No: 11, 12, 13 and 14 represent control, 63°C/30 min, 72°C/15 sec and 100°C/10 min at 3rd day postpartum, respectively.

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دراســة التركيب الكيماوى للبن البقرى خلال الأسبوع الأول بعد الـولادة وتأثير بعض المعاملات الحرارية عليه

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يهدف البحث إلى دراسة التركيب الكيماوى للبن البقرى وتقدير تركيزات الجلوبيولين المناعى من النوع ج (IgG) خلال الاسبوع الأول بعد الولادة، وكذلك تأثير بعض المعاملات الحرارية على كل منهما. تم تجميع عينات اللبن البقرى من خمس بقرات فريزيان خلال ١٢ ساعة الأولى بعد الولادة ومن اليوم الأول حتى اليوم السابع. وتم تحليل العينات لمعرفة محتواها من الجوامد الصلبة الكلية، والبروتين، والدهن، واللاكتوز، والرماد، وأخيراً IgG، وأجريت بعض المعاملات الحرارية على ٦٣°م/٣٠ دقيقة و٧٢°م/١٥ثانية و ١٠٠°م/١٠ دقائق لبعض عينات اللبن المجمعة بعد نزع الدهن منها. وأظهرت النتائج أن أعلى محتوى للبن البقرى من الجوامد الكلية والبروتين والدهن والرماد كان خلال ١٢ ساعة الأولى بعد الولادة يليها نهاية اليوم الأول ثم تناقصت نسب هذه المكونات تدريجيا مع تقدم فترة الرضاعة حتى نهاية الأسبوع الأول. وكانت تركيزات IgG ذات معنويه عاليه خلال ١٢ ساعة الأولى بعد الولادة وكذلك اليوم الأول بمتوسط ١٢٢,٦٠ ± ٥,٢٤ ، ١١٨,٤٤±٥,٩٠ جرام/لتر على التوالى، ثم انخفض تدريجيا حتى وصل فى نهاية الأسبوع الأول إلى ٥٥,١٦±١٧,٣٠ جرام/لتر. وكان لبعض المعاملات الحرارية تأثير واضح على تركيزات IgG. مقارنة بالكنترول انخفض محتوى IgG إلى ٧١,٧٦، ٦٩,٧٣ ، ٦٩,٨٢% فى اللبن المعامل على ٦٣°م/٣٠ دقيقة وإلى ٥٢,٦٧، ٢٦,٤٦، ٤,٩٩% فى اللبن المعامل على٧٢°م/١٥ثانية خلال اليوم الأول والثانى والثالث على التوالى، بينما أدت المعاملة على ١٠٠°م/١٠ دقائق إلى فقد كامل فى محتوى IgG.

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