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EFFECT OF COLOSTRUM QUALITY ACROSS DIFFERENT PARITIES ON GROWTH PERFORMANCE, IMMUNE RESPONSE, ANTIOXIDANT STATUS, AND HEMATOLOGICAL PROFILES IN EGYPTIAN BUFFALO CALVES

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SUMMARY

This investigation was conducted to 1) assess the effect of dam parity on colostrum quality and 2) evaluate the influence of calf sex and colostrum quality on growth performance, immune function, antioxidant status, and blood profiles of Egyptian buffalo calves. Thirty Egyptian buffalo dams with various parties. According the quality of colostrum, calves were divided into two groups, the first group (G1, n=16) was given low-quality colostrum, while the second group (G2, n=14) was given high-quality colostrum. The results demonstrated that the dam parity (primiparous vs. multiparous) significantly influenced colostrum composition, growth parameters, and immune functions. Multiparous dams produced colostrum with a higher protein content (7.3 g/100 mL) compared to primiparous dams (4.9 g/100 mL). The male calves exhibited the highest values across all growth metrics compared to female calves. Furthermore, calves nourished on high-quality colostrum presented superior growth performance traits. Furthermore, the colostrum quality (low vs. high) significantly (P<0.003) affected several blood parameters of the calf, particularly total antioxidant (0.5 vs. 0.7 nmol/L) and immunoglobulin-G (2.5 vs. 3.9 g/dL), respectively. Meanwhile, the levels of blood glucose and triglycerides were unaffected by colostrum quality. Additionally, significant (P<0.000) differences between male and female calves were observed only in body height, serum glucose, total lipids, haemoglobin, RBC, and platelet count. The results highlight the significance of providing high-quality colostrum to neonatal calves to optimize growth, immunity, and all health status.

Keywords: Buffalo Calves, Colostrum, Antioxidant, Growth performance, Haematological parameters.

INTRODUCTION

Buffalo plays a pivotal role in rural areas in many countries around the world, particularly in Egypt, which is considered a valuable genetic resource that generates income and employment for countless farmers. These animals are a cornerstone of milk and beef production, as well as other by-products, in addition to their use in fieldwork activities (El Attar *et al*., 2017; Shahin *et al*., 2018; Salem *et al*., 2021).

The rearing of buffalo calves from birth to weaning age is a crucial stage in buffalo farming. This period is a delicate and precise phase in animal growth, as it establishes the calves' growth potential and the quality of animals that will serve as future property matrices. It is, however, a vulnerable stage characterized by high mortality and morbidity rates, which can reach up to 30%. Such losses negatively affect the profitability of buffalo farming by reducing the number of animals available for reproduction or fattening and limiting herd selection opportunities (Puppel *et al*., 2019).

Optimal growth and adequate immunity are crucial to dairy farming operations, which help calves to exit their full genetic potential (Silva *et al*., 2024). However, throughout the calves' early life, these aspects are often overlooked. Weaned buffalo calves frequently have poor growth, high morbidity, and elevated mortality rates (Zicarelli *et al*., 2024).

A calf's growth rate is strongly influenced by the quality and quantity of colostrum intake. The quality of colostrum significantly impacts neonatal survival and health. Colostrum contains high levels of essential components such as immunoglobulins (Ig), antioxidants, lactoferrin, proteins, vitamins, and minerals, as well as hormones and related growth factors. These components work as stimulants and mediators in numerous processes occurring in cells (Puppel *et al*., 2019, and Sturaro *et al*., 2020).

Neonatal buffalo calves are more susceptible to infections compared to other kinds of mammals. They are born without blood immunoglobulins (Igs); they do not acquire immunoglobulin in gestation and must rely on colostrum antibodies for passive immunity, so they depend on their dam's colostrum to obtain immunity. The transfer of passive immunity throughout the colostrum is critical for the calf's health and survival during its first days of life; otherwise, neonates suffer severe scours and high mortality (Saucedo *et al*., 2003, and Sutter, 2023).

Many researchers supported that colostrum ingestion is linked to enhanced average daily gain in heifers and increased milk yield; also, it affects the metabolic and endocrine systems, promotes

gastrointestinal tract growth and development, as well as enhances neonate feeding. Furthermore, it enables calves to adapt to their new environment and helps in thermogenesis and maintenance of body temperature (Faber *et al*., 2005; Abd El-Hady *et al*., 2006, and Contarini *et al*., 2014).

Colostrum's immunological quality and factors controlling it have been widely studied. Colostrum quality varies according to buffalo breed, parity of the cow, litter size of calves, pre-partum nutrition, length of the dry period of cows, vaccination history, and time post-partum. Besides, colostrum volume, collection duration, and the concentration of colostrum total protein and immunoglobulin G (IgG) (Abd El-Hady *et al*., 2006; Ali and Sayed-Ahmed, 2020, and Soufleri *et al*., 2021).

Continuously assessing colostrum management during the neonatal period is vital for predicting calf health outcomes. The amount of total protein and immunoglobulin is considered the most valuable component in determining colostrum quality. Lombard *et al*. (2020) mentioned that we can classify colostrum quality according to the amount of IgG obtained after colostrum ingestion into four categories: excellent (≥25.0 g/L), good (18.0–24.9 g/L), fair (10.0–17.9 g/L), and poor (<10 g/L). In the current study, colostrum quality was assessed based on its total protein content.

Therefore, this study was conducted to 1) assess the effects of dam parity on colostrum quality and 2) evaluate the influence of calf age, sex, and colostrum quality on growth performance, immune function, antioxidant status, and blood profiles.

MATERIALS AND METHODS

Ethical of approval:

The experimental procedures for this research project have been approved (CU-IIF-3224) by Cairo University's Institutional Animal Care and Use Committee (CU-IACUC).

Study location and Animals:

The current research was conducted at the Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Egypt. The study included thirty Egyptian buffalo cows (550-600 kg of body weight) of various parities: 16 primiparous (first parity) and 14 multiparous (fourth parity), as well as their calves. The dams' feed requirements were calculated based on their body weight (BW) and milk production according to NRC (2001). The ration consists of Egyptian clover, rice straw, and a concentrate feed mixture, with free access to water.

The calves were kept in open shed yards and suckled whole buffalo milk (10% on their BW) twice a day via a nipple and pail until they reached four weeks of age. Calves were reared from birth to weaning (90 days of age). Calves were divided into two groups according to colostrum quality. The first group, G1 (n=16), consumed low-quality colostrum that contains low levels of total protein (3.70 mg/L), and the second group (n=14) consumed high-quality colostrum that contains high levels of total protein (5.70 mg/L).

Body weight and measurements:

Body weight was measured monthly by using a digital scale. Body measurements, including heart girth, body length, and height were recorded. Body length referred to the distance between the point of the shoulder and pin bone (Ibrahim 2015). Heart girth is measuring a circumference around the chest just behind the front legs and withers (Abd-Allah *et al*., 2018). Animal height was measured as the vertical distance from the top of the hip to the ground level (Musa *et al*., 2012).

Blood sampling and assay:

Blood samples were collected from buffalo calves' jugular veins using a sterile needle in heparinized tubes. Samples were collected at birth, after two hours of colostrum suckling, and then at a weaning age before feeding. Blood samples were centrifuged at 3000 rpm for 20 minutes to collect plasma, then stored at -20°C until biochemical assays were conducted.

Blood hematological parameters included hemoglobin (Hb, g/dL) concentration, red blood cell (RBC) count ($x10^6/\mu L$), white blood cell (WBC) count ($x10^3/\mu L$) and platelet count (PLT) ($x10^3/\mu L$), all determined using a hematological analyzer (HA-CLINDIAG, China).

Total protein (TP), albumin (Alb), glucose, triglycerides, total lipids, and total antioxidants were determined using commercial test kits (Spectrum Biodiagnostic, Egypt) and a spectrophotometer (T80 UV/VIS PG instrument Ltd., Lutterworth, UK). Total globulin (Glb, g/dL) was calculated by subtracting the Alb value from the TP value. Serum immunoglobulin G (IgG, mg/dL**)** levels were determined using a commercial enzyme-linked immunosorbent assay (ELISA) kit according to Abdel Hady *et al*. (2022).

Colostrum sampling and assay:

Colostrum samples from each buffalo cows were collected after parturition in plastic tubes to assay the chemical composition and total antioxidant capacity (TAC).

The chemical composition of colostrum (fat, total solid, protein, and lactose) was measured by using a lactoscan (SP-CA-010438, Bulgaria) according to the manufacturer for buffalo. The TAC was determined by using a specialized kit (Spectrum Biodiagnostic, Egypt) and a spectrophotometer (T80 UV/VIS PG Instrument Ltd., Lutterworth, UK).

Statistical Analysis:

The statistical analysis of data was statistically declared by general liner model (GLM) using IBM SPSS statistics for Windows, version 22.0. (2013) according to the following models:

Model 1:$Y_{ij}=\mu+P_i+e_{ij}$, where Y_{ij}=dependable variable "colostrum composition and TAC"; μ= overall mean; P_i= effect of dam parity; and e_{ij} =the random error.

Model 2: $Y_{ijkmn} = \mu + Ai + S_j + P_k + C_m + e_{ijkmn}$, where Y_{ijkmn} = dependable variable, μ = overall means; A_i = the effect of calve age, S_j = the effect of calf sex, P_k =the effect of buffalo cow parity, C_m = the effect of colostrum quality and e_{ijkmn}= the random error.

RESULTS

Colostrum composition and the amount of total antioxidant capacity (TAC):

The differences in colostrum composition between the first and fourth parties are presented in Table 1. Our results showed a highly significant effect of cow parities on colostrum fat (P<0.0001), cows at the first parity recorded the highest values of fat, more than 50%, compared to the subsequent parity. A similar trend of parity effect was recorded with total solid. However, the levels of total protein were lower in the first parity, then tended to increase with advanced parities, and there were no differences in lactose and TAC levels between the first and the fourth parities.

Table 1. Effect of parity on colostrum composition and the total antioxidant capacity (TAC)

Parities	Fat %	Total Solid %	Protein %	Lactose %	TAC (mmol/L)
Primiparous	4.890^{a}±0.28	18.269^{a}±1.05	4.943^{b}±0.33	7.891±0.59	4.726±0.24
Multiparous	2.030^{b}±0.30	13.814^{b}±1.12	7.280^{a}±0.38	7.889±0.63	4.390±0.23
P-value	< 0.0001	< 0.006	< 0.0001	< 0.998	< 0.329

L.S Means (± SE) with different superscript letters in the same columns are significantly different at P<0.05 and ns-not significant

Growth parameters:

Table 2, indicates that age had a beneficial impact on all growth parameters, and there weren't any differences between males and females in all growth parameters except body height. Nonetheless, across all growth metrics, male calves exhibited the highest values. Moreover, calves born from primiparous cows had the lowest values of body weight, body length, and height compared to calves born from multiparous. However, there was no discernible difference in heart girth between the two parity groups, and calves of buffaloes with the greater parity had the tallest heart girth (P=0.073). Our results demonstrated that calves nourished with high-quality colostrum presented the best values of growth performance.

Table 2. Factors influence calves Growth Parameters

Item	Weight (kg)	Length (cm)	Height (cm)	Heart girth (cm)
Calf Age:	**P<0.000**	**P<0.000**	**P<0.000**	**P<0.000**
Birth	36.45^{b}±0.75	72.69^{b}±1.04	79.38^{b}±0.83	78.27^{b}±1.20
Weaning	96.90^{a}±0.40	97.49^{a}±0.75	105.05^{a}±0.44	112.79^{a}±0.64
Calf Sex:	**P<0.275**	**P<.0.826**	**P<0.000**	**P<0.289**
Male	67.11±0.66	85.25±1.23	93.86^{a}±0.57	96.21±0.83
Female	66.24±0.52	84.92±0.97	90.57^{b}±0.73	94.85±1.05
Parity:	**P<0.000**	**P<0.000**	**P<0.043**	**P<0.073**
Primiparous	61.77^{b}±0.61	71.97^{b}±1.13	90.82^{b}±0.97	93.75±1.14
Multiparous	71.58^{a}±0.88	98.21^{a}±1.64	93.60^{a}±0.67	97.31±0.97
Colostrum quality:	**P<0.000**	**P<0.000**	**P<0.000**	**P<0.000**
Low	62.5^{b}1±0.79	80.31^{b}±1.08	89.77^{b}±0.88	85.52^{b}±1.27
High	70.84^{a}±0.57	89.85^{a}±1.49	94.65^{a}±0.63	105.53^{a}±0.92

L.S Means (± SE) with different superscript letters in the same columns are significantly different at P<0.05.

Blood Biochemical Measurements:

Blood biochemical concentrations were assessed at birth and again at weaning age (90 days). Table 3 shows that blood glucose levels and total lipids were significantly higher at birth than at weaning age while there was no significant impact of calf age and triglycerides. Nevertheless, as the calf get older, the concentration of TAC increased considerably. Highly significant changes (P<0.001) were observed in the concentrations of serum protein profiles (total protein, albumin, and globulins) with advanced ages. At the same time, the level of IgG did not differ between birth and weaning ages.

Additionally, male calves had significantly higher blood glucose levels and total lipids than female calves. Cow parity did not impact all biochemical parameters, except for total lipids and albumin. The first lactation cows had higher values of total lipids than multiparous, while albumin levels were increased with advanced parity. Colostrum quality had a significant effect on blood total lipids, TAC, protein profile, and IgG. Moreover, the levels of blood glucose and triglycerides were not affected by colostrum quality.

Table 3. Factors influence calves' blood biochemical measurements

Item	Glucose (mg/dL)	Lipids (mg/dL)	Triglycerides (mg/dL)	TAC (mmol/L)	TP (g/dL)	Albumin (g/dL)	Total globulin (g/dL)	IgG (mg/dL)
Calf Age:	**P<0.000**	**P<0.05**	**P<0.57**	**P<0.003**	**P<0.001**	**P<0.000**	**P<0.000**	**P<0.14**
Birth	86.49^{a}±1.69	584.59^{a}±20.67	83.69±2.14	0.547^{b}±0.03	4.95^{b}±0.10	2.19^{a}±0.06	2.75^{b}±0.12	4.39±0.13
Weaning	74.68^{b}±1.69	531.19^{b}±20.67	82.10±2.14	0.699^{a}±0.03	5.34^{a}±.05	1.90^{b}±0.03	3.43^{a}±0.06	4.12±0.13
Calf Sex:	**P<0.018**	**P<0.04**	**P<0.66**	**P<0.225**	**P<0.06**	**P<0.28**	**P<0.29**	**P<0.79**
Male	83.93^{a}±2.11	592.48^{a}±25.73	82.13±2.67	0.587±0.04	5.25±0.07	2.08±0.04	3.16±0.08	4.28±0.12
Female	77.24^{b}±1.58	523.30^{b}±19.25	83.66±2.00	0.659±0.03	5.04±0.09	2.01±0.05	3.02±0.85	4.23±0.16
Parity:	**P<0.239**	**P<0.03**	**P<0.14**	**P<0.79**	**P<0.57**	**P<0.050**	**P<0.55**	**P<0.79**
Primiparous	78.06±1.92	613.66^{a}±23.37	86.83±2.42	0.635±0.04	5.09±0.08	1.94^{b}±0.05	3.15±0.10	4 .19±0.14
Multiparous	83.11±2.92	502.12^{b}±35.51	78.95±3.68	0.611±0.06	5.19±0.12	2.15^{a}±0·07	3.03±0.14	4.23±0.22
Colostrum quality:	**P<0.073**	**P<0.03**	**P<0.67**	**P<0.003**	**P<0.000**	**P<0.03**	**P<0.000**	**P<0.000**
Low	83.96±2.16	509.29^{b}±31.77	81.92±3.3	0.502^{b}±0.05	4.63^{b}±0.11	2.15^{a}±0.07	2.48^{b}±0.13	2.85^{b}±0.20
High	77.21±1.80	606.49^{a}±21.9	83.86±2.27	0.744^{a}±0.03	5.66^{a}±0.08	1.94^{b}±0.05	3.871^{a}±0.09	5.66^{a}±0.14

LS Means (± SE) with different superscript letters in the same columns are significantly different at P<0.05. TAC: Total antioxidant capacity; TP: Total protein; IgG: immunoglobulin G.

Haematological profiles:

Table 4 presents the changes in haematological analysis across different ages, sexes, parties, and colostrum quality. Calve age had a significant effect on all haematological parameters except RBC's. Furthermore, male calves significantly varied from females in all haematological traits except WBC's.

No impact of cow parity or colostrum quality was observed with the haematological profile except for platelets, where there was a significant inverse effect on the number of platelets with advanced parity. In contrast, calves that were nourished with high-quality colostrum tended to have the highest platelet count value.

Table 4 Factors influence calves' blood hematological profiles

Item	Hemoglobin (g/dL)	RBC's (x10^{6}/µL)	WBC's (x10^{3}/µL)	PLT (x10^{3}/µL)
Calf Age:	**P<0.018**	**P<0.54**	**P<0.001**	**P<0.000**
Birth	13.13^{b}±0.28	4.08±0.92	16.41^{a}±0.16	113.69^{b}±3.16
Weaning	13.87^{a}± 0.15	4.14±0.49	15.64^{b}±0.16	134.83^{a}±1.69
Calf Sex:	**P<0.006**	**P<.0.001**	**P<0.78**	**P<0.001**
Male	13.92^{a}±0.19	4.28^{a}±0.81	16.06±0.15	129.85^{a}±2.19
Female	13.09^{b}±0.24	3.94^{b}±0.64	15.99±0.20	118.68^{b}±2.78
Parity:	**P<0.14**	**P<0.90**	**P<0.27**	**P<0.003**
Primiparous	13.16±0.22	4.10±0.75	16.25±0.18	139.09 ^{a}±2.56
Multiparous	13.84±0.33	4.12±1.09	15.79±0.28	116.43^{b}±3.71
Colostrum quality:	**P<0.59**	**P<0.49**	**P<0.86**	**P<0.05**
Low	13.61±0.21	4.16±0.71	15.99±0.25	119.88^{b}±3.35
High	13.39±0.29	4.07±0.98	16.05±0.17	128.64^{a}±2.42

LS Means (± SE) with different superscript letters in the same columns are significantly different at P<0.05. RBC: Red blood cell; WBC: White blood cell; PLT: Platelet count.

DISCUSSION

This research was assessed to evaluate the effect of cow parity and colostrum quality on growth performance, antioxidant status, and calves' immunity. The neonatal buffalo calves require fundamental management to reduce the high mortality rate. Calves should ingest enough volumes of high-quality colostrum during their initial hours of life to acquire transfer of passive immunity. The quality of colostrum is connected to its levels of total protein and IgG; cow parity plays a significant factor in colostrum quality.

Consistent with the present study (Zarei *et al*., 2017; Aydogdu and Guzelbektes, 2018, and Mendoza *et al*., 2024), found that fat levels significantly decreased with the advanced parity for Holstein cows. On the other hand, Abd El-Hady *et al*. (2006) recorded a decline in colostrum fat levels with advanced parity for Egyptian buffalo. However, Grodkowska *et al*. (2023) reported that cow parity did not affect colostrum fat content.

Many investigations support our findings that colostrum total protein increased significantly with advanced parity (Zarei *et al*., 2017; Aydogdu and Guzelbektes, 2018; Djoharjani *et al*., 2020; Grodkowska *et al*., 2023, and Brereton *et al*., 2024) for dairy cows. Also, Marcato *et al*. (2022) and El-Malky *et al*. (2023) found a strong positive effect of cow parity on IgG levels through advanced parities, which is considered a part of colostrum total protein. While Abd-Allah (2013) reported that parity of ewe does not affect ewe colostrum composition, except that total solids was higher in multiparous ewes. An inverse trend was reported by Abd El-Hady *et al*. (2006), and An *et al*. (2023), who recorded that the levels of colostrum total protein in buffalo cows were greater at the first parity compared with advanced parities. Additionally, fat percentage in the first parity was lower than in advanced parities.

The current study is consistent with that of An *et al*. (2022), who recorded the average calf birth weight was 36.12 kg and its heart girth was 76.72 cm. In contrast, Bharti *et al*. (2018) reported higher values of growth parameters compared to our results, which recorded that the average (birth weight, weaning weight, body length at birth, body length at weaning, heart girth at birth, and weaning) of Murrah buffalo calves was (34.58 ± 0.84 kg, 79.71 ± 2.42 kg, 59.35 ± 0.58 cm, 80.50 ± 0.69 cm, 75.71 ± 0.75 cm, and 101.00 ± 1.23 cm), respectively. Hassan *et al*. (2019) mentioned that average birth and weaning weights for Egyptian buffalo calves were (34.56 ± 0.39 and 99.23 ± 1.04 kg), respectively. Moreover, Rashid *et al*. (2013) recorded that the average birth weight for Nili-Ravi buffalo calves was 30.3 kg, and the average heart girth was 71.5 cm. Consistent with our findings of growth measurements, Shahin *et al*. (2018) recorded that body length, heart girth, and rump height were increased with advanced age. Moreover, An *et al*. (2022) mentioned that calves skeletal growth wasn't influenced by supplemented Capsicum but increased with advanced age.

In the present investigation, there were no significant differences between male and female calves; however, male calves were bigger than females, which is a similar result to that obtained in a study conducted by Kamal El-den *et al*. (2020), and Condori and Cruz-Cruz (2023). Also, Abdel Fattah *et al*. (2019), and Mushtaq *et al*. (2024) reported in previous investigations for Holstein calves that sex does not affect calves' birth or weaning weights. Contrary, Kul *et al*. (2018) reported that calves' sex had a significant effect on calves' birth weight. Additionally, Verma *et al*. (2024) reported that male Gangatiri calves were significantly different than females in birth weight, and there were no significant differences in weaning weights or average daily gains.

The current study supported the substantial effect of cow parity on calves' weight. A similar association has been mentioned in multiple studies for Egyptian buffalo calves (Hassan *et al*., 2019; Kamal El-den *et al*., 2020; Salem *et al*., 2021; ShafiK *et al*., 2022, and Elkaschab *et al*., 2024). Moreover, the same values were observed by Kuthu and Hussain (2020), and Al-Khauzai (2020) for Nili-Ravi buffaloes and Iraqi buffaloes, respectively. In previous studies for Anatolian Water Buffalo, Uğurlu *et al*. (2016), and Erdem *et al*. (2022) recorded lower values of the average birth weight of 26.95 and 29.7 kg respectively. In agreement with our results, Al-Khauzai (2020) and ShafiK *et al*. (2022) reported that the fourth parity recorded the highest values of calf birth and weaning weight. The previous study on Holstein Friesian reported by Elkaschab *et al*. (2020) showed no significant effect of cow parity on calf performance.

The maturity status of the cows may influence the impact of parity on body weight. In greater parties, these buffaloes exhibit a greater body capacity, conducive to enhanced fetal development and growth rates. In addition, cows in older parties will produce colostrum and milk of high quality. This will provide neonatal calves with a greater amount of protein and other useful components that will improve the calf's growth and health.

Calves' body measurements are listed in Table 2. Calves from the fourth parity cows showed higher body length and heart girth than calves from the first parity cows ($P<0.05$), while no significant difference was observed in body height ($P > 0.05$).

Many studies reported that morphological measurements have been used to describe different ruminant species and assess breed performance. Heart girth may be used to accurately estimate the body weight of all dairy cow classes, and there is a strong association between heart girth (HG) and BW for different buffalo breeds.

The results of this study agreed with the results recorded by Elkaschab *et al*. (2024) for Egyptian buffalo and Duncan *et al*. (2023); for Angus calves, they demonstrated that calves born from first paritycows significantly had the lowest birth weight and the lowest body lengths, heart girth, abdominal girth, back length, and withers height.

As seen from Table 2, colostrum quality had a highly significant impact on all growth parameters ($P<0.000$). In this study we classified the colostrum quality according to colostrum protein content. The high level of colostrum protein is mainly referred to the large amount of immunoglobulin.

The quality of colostrum is a critical source of variation in growth performance for raising healthy calves. Colostrum with high quantities of nutrients, including protein, immunoglobulins, and cytokines, is the most important component in determining the quality of colostrum. In the current study, calves that fed high-quality colostrum were heavier, about more than 8 kg, compared to the low-quality group. Similarly, Abdullah and Ahmed (2023) found that calves nourished with high-quality colostrum tend to be insignificantly heavier (20.81 kg) than those nourished with low-quality colostrum (19.53 kg).

The findings of the current study confirmed the recommendations of Lora *et al*. (2019), who found that calves that received poor-quality colostrum had a lower potential for growth and health compared to those fed good quality. Furthermore, it could be obtained from the result mentioned by Elsohaby *et al*. (2019) that the levels of serum IgG are associated with colostrum quality. Calves that have higher levels of serum IgG were greater in birth weight; he

mentioned that each 10 g/L increase in calves' serum IgG concentration after birth was associated with an increase of 2.19 kg in BW and 0.08 kg ADG. Sutter *et al*. (2023) reported that there was a strong association between transfer passive immunity and calves daily gain; calves with excellent and good transfer passive immunity status had greater ADG compared to poor and fair groups. An opposite result was reported by Erdem *et al*. (2022), who recorded that colostrum with high specific gravity (quality) had the lowest values of birth weight, heart girth, and body height, while body length was greater than in the high specific gravity group for Anatolian Water Buffalo.

Results of several investigations in buffalo calves concluded there was an inverse effect of age on glucose concentration (Abd–El-Moty *et al*., 2007; Abd El-Hady *et al*., 2011; Rashid *et al*., 2013; Singh *et al*., 2013; Fayed *et al*., 2014; Shahin *et al*., 2018, and An *et al*., 2022). This result differs from that reported by Long and Schafer (2013), who recorded a significant positive difference ($P < 0.01$) in plasma glucose with older ages. In the current study, the concentrations of total lipids and triglycerides declined with advanced age. Shahin *et al*. (2018) also found that the concentrations of serum total lipids and triglycerides were significantly ($P< 0.05$) higher at the initial age compared with elder ones. While Abd–El-Moty *et al*. (2007) stated that total lipid concentration started at a low level and then increased progressively with the advancing age of buffalo calves.

An opposite trend for total lipid concentration was reported by Matter *et al*. (2008), who recorded that the levels of TL were elevated with advanced age. Furthermore, Fayed *et al*. (2014) mentioned that age didn't affect lipid concentrations. Also, Aydogdu and Guzelbektes (2018) found that calf age had no effect on the level of triglycerides from birth till 28 days of age. A similar trend was recognized with TAC reported by El-Malky *et al*. (2023) for buffalo calves who stated that the amount of TAC was increased insignificantly from birth till four months of age.

Measuring plasma protein profile and immunoglobulin is a beneficial indicator of passive immunity; the increase of globulin and other protein fractions after the first day is primarily due to the absorption of immunoglobulins, especially IgG, which demonstrates a significant correlation with the values of total protein and globulins.

From the present study, age significantly impacted the protein profile; the level of TP and globulins increased significantly with advanced age, while serum albumin significantly decreased with advanced age, and there weren't any significant differences between IgG concentrations at birth and weaning age. However, the levels of IgG were higher after birth than at weaning age. The present finding agrees with the previous report for buffalo Abd–El-Moty *et al*. (2007), and Couch *et al*. (2017), who indicated that age had a significant positive correlation on TP and globulin and a significant inverse effect on albumin levels. Bharti *et al*. (2018) mentioned that age did not impact TP levels. Additionally, Bharti *et al*. (2018), and El-Malky *et al*. (2023) indicated that the increase in serum IgG after birth is correlated with colostrum ingestion. Our findings contradict the results obtained by Souza *et al*. (2019), and by Enculescu *et al*. (2024), who reported a decline in serum concentrations of total protein and globulins with older ages. Also, Abd El-Hady *et al*. (2006) recorded an insignificant increase in the levels of IgG with advanced age.

In the current study, male buffalo calves showed superiority for all biochemical parameters except triglycerides and total antioxidant capacity, similar observation reported by Hassan*et al*. (2019) for buffalo calves and Prisacaru (2014) for cattle. However, Long and Schafer (2013) found that female calves tendency ($P = 0.07$) greater plasma glucose compared with male calves.

Our study revealed that calf sex didn't affect levels of protein profile and IgG concentration. The obtained results confirm the observations of Mortazavi *et al*. (2024) for dairy calves and Couch *et al*. (2017), who stated that sex had no significant impact on the protein profile in African buffalo. Furthermore, Martin *et al*. (2021) recorded that calf sex had no differences with IgG levels; however, there was a positive correlation between sex and IgM levels. A positive correlation was found by Cavirani *et al*. (2024), who mentioned that the concentration of serum IgG was significantly higher in females than in males.

Cow parity showed an insignificant increase in blood glucose level; however, triglycerides and TAC were higher in first parity compared to fourth parity. Aydogdu and Guzelbektes (2018) indicated that cow parity didn't impact blood glucose level; however, the calves born from primiparous cows had the highest level of blood glucose. Additionally, the level of triglycerides was significantly increased with advanced parity. Also, El-Malky *et al*. (2023) found that dam parity had no significant changes in TAC. Other results were obtained by Wafa (2017), who mentioned in his study of Holstein cows that cow parity positively influences the concentration of total lipids and cholesterol.

Our results showed differences through parities ($P<0.05$) for serum albumin, where primiparous had the lowest value of albumin. Additionally, the levels of total protein and globulin IgG were higher in calves from multiparous cows compared to calves from primiparous. The same opinion was mentioned by Lora *et al*. (2019), and Brereton *et al*. (2024), who demonstrated that the colostrum quality of primiparous cows is lower than that of multiparous cows. Moreover, Abd El-Hady *et al*. (2006) recorded insignificant changes in the overall mean levels of

calf serum IgG, where levels of serum IgG for calves from first parity cows recorded 1.79 g/dl and then increased to 2.32 g/dl by the fourth parity. Furthermore, (Wafa 2017) found that the insignificant effect of cow parity on calves' serum concentration of immunoglobulins (IgG, IgM, and IgA), protein profile, and glucose.

Consistent with our results, Hassan *et al*. (2019), and Cavirani *et al*. (2024) reported that calf sex and cow parity didn't affect serum IgG concentration. On the other hand, Souza *et al*. (2019), Marcato *et al*. (2022), and El-Malky *et al*. (2023) found that cow parity had a significant effect on protein profile and IgG concentrations, where the levels of protein profile and IgG increased with advanced parity.

According to the current findings, plasma total lipids, TAC, protein profile, and IgG levels are significantly impacted by the quality of colostrum. Furthermore, in comparison to the second group, calves fed low-quality colostrum had the highest value of glucose and albumin levels. Additionally, the highest concentration of serum (total lipids, triglycerides, TAC, TP, globulin, and IgG) was observed in the high-quality group. This may be referred to as the elevation of the bioactive component in high-quality colostrum, which raises the quantity of antioxidants in calves' blood, which will promote calves' performance.

Our data findings are compatible with those obtained by Aydogdu and Guzelbektes (2018), and An *et al*. (2022), who found that plasma glucose decreased in calves fed good-quality colostrum. Also, Souza *et al*. (2020) found a high correlation between both colostrum IgG and TP at the first milking. Furthermore, Brereton *et al*. (2024) indicated that multiparous cows produce higher quality colostrum ($P < 0.05$) than primiparous, and their calves had greater ($P = 0.05$) serum IgG and TP concentrations than calves from primiparous cows. Additionally, our result is matched with a previous study reported by Mortazavi *et al*. (2024), who found in their study of newborn calves that the level of albumin significantly decreased after ingestion of high-quality colostrum. Contrary to our result, Abdullah and Ahmed (2023) reported that calves have approximately the same amounts of serum IgG regardless of whether they were subjected to low or high colostrum during different times.

Total protein is a reliable indirect parameter used to evaluate passive immune transfer because TP concentrations have high sensitivity and specificity for the detection of FPIT. Due to the small variation in serum albumin concentrations in new-born's, the increase in TP concentrations is exclusively due to the absorption of Ig's present in colostrum.

The results of the current study agree with a previous report by Enculescu *et al*. (2024) confirming our findings that age influenced HGB, RBC, HTC, and RDW from the first month of life to five years old. Furthermore, Jaramillo *et al*. (2022) observed that hemoglobin levels increased significantly with older animals, and male buffalo calves showed higher values for red blood cell count, white blood cell count, and thrombocyte count compared to females.

Moreover, Jacob *et al*. (2019) mentioned that age exerted a significant effect on Hb and PCV levels in Jaffarabadi males but had no significant influence on Jaffarabadi females. Marcato *et al*. (2022) found that female calves had higher haemoglobin, hematocrit, and RBC than males. Also, Mortazavi *et al*. (2024) found that the haematocrit parameter was significantly different depending on the calf's gender. Females had higher haematocrit concentrations than males, depending on how long after colostrum intake they had been fed.

In parallel with these findings, Wafa (2017) revealed that dam parity had no significant impact on the count of WBCs, Hb, and PCV, while the count of RBCs was lower in calves of heifers than in those of cows. The same observation was recorded by Mortazavi *et al*. (2024), who confirmed that there was no effect of parity on the entire hematological profile. While hematocrit % was positively affected by the ingestion of high-quality colostrum.

A further finding by Abdullah and Ahmed (2023) was that total white blood cells, lymphocytes, neutrophils, eosinophils, and basophils counts were not affected by colostrum quality. However, the monocytes count is higher in calves fed low-quality colostrum compared to those fed high-quality colostrum.

Figure (1) shows the correlation between gender of calves, parity, colostrum quality, growth parameters, and blood parameters. There was a strong positive correlation between parity and colostrum quality and blood IgG. While the colostrum quality showed a moderate positive correlation with TP, globulin, and IgG, supporting passive immunity transfer. On the other hand, blood glucose exhibited a negative correlation with growth parameters.

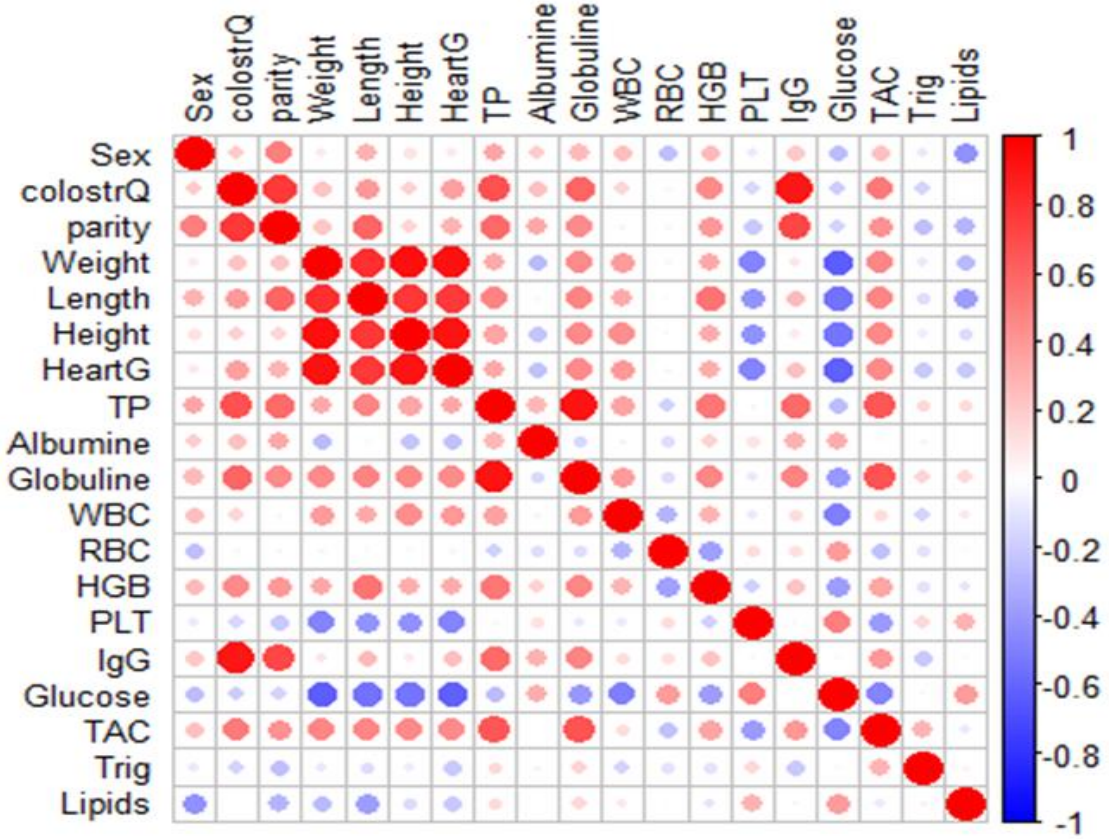

Fig. 1. Correlation heatmap between gender of calves, parity, colostrum quality, growth parameters, and blood parameters.
ColostrQ: colostrum quality; HeartG: Heart girth; TP: Total protein; HGB: Hemoglobin; RBC: Red blood cell; WBC: White blood cell; PLT: Platelet count; TAC: Total antioxidant capacity; IgG: immunoglobulin G.; Triglycerides.

CONCLUSION

The current study demonstrated that dam parity has a substantial effect on buffalo colostrum quality. The effects of calf age, cow parity, and colostrum quality on all growth parameters were highly significant ($P > 0.0001$). No significant differences were found between male and female calves except for body height, serum glucose, total lipids, haemoglobin, RBC, and PLT count. These findings highlight the significance of providing high-quality colostrum to neonatal calves. Furthermore, most blood variables were significantly improved with the ingestion of high colostrum quality.

AUTHOR CONTRIBUTIONS

Ayat Kassem Fayed designed, planned and conducted the animal trial, processed, and took the lead role in the writing. Mohamed A. Radwan, writing, review, editing and approve the manuscript in the final form. Ahmed Ali Abd El-Maksoud contributed to analysis of colostrum sample, review and editing. Masouda A. Allak analysed the data contributed to the designing planning, data visualization and analysis. All authors have approved the manuscript for publication.

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ANIMAL WELFARE STATEMENT

The experimental procedures for this research project have been approved (CU-IIF-3224) by Cairo University's Institutional Animal Care and Use Committee (CU-IACUC).

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تأثير جودة السرسوب المنتج من أمهات ذات مواسم ولادة مختلفة على أداء النمو والإستجابة المناعية وحالة مضادات الأكسدة وهيماتولوجيا الدم في عجول الجاموس المصري

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أُجري هذا البحث بهدف ١) تقييم تأثير عدد المواسم على جودة السرسوب.٢) دراسة تأثير عمر العجل وجنس العجل وجودة السرسوب على أداء النمو والإستجابة المناعية وحالة مضادات الأكسدة وهيماتولوجيا الدم في عجول الجاموس المصري. تم إستخدام عدد ثلاثون من الجاموس مصري الحلاب من مواسم مختلفة وخلفتهم، تم تقسيم العجول لمجموعتين حسب جودة السرسوب. المجموعة الأولى أعطيت (عدد ١٦ حيوان) سرسوباً منخفض الجودة، بينما أعطيت المجموعة الثانية (عدد ١٤ حيوان) سرسوباً عالي الجودة. وقد أظهرت النتائج أن عدد مواسم الولادة (الولادة الأولى مقابل الرابعة) أثرت بشكل كبير على جودة السرسوب ومكوناته وكذلك اداء النمو والوظائف المناعية. كانت نسبة البروتين الكلي في السرسوب المنتج من جاموس متعدد مواسم الولادة أعلى (٧,٣ جم / ١٠٠ مل) مقارنة بسرسوب الأمهات الموسم الأول (٤,٩ جم / ١٠٠ مل). اما على مستوي العجول الرضيعة، أظهرت الذكور قيماً أعلى في جميع مقاييس النمو مقارنةً بالإناث. كما أظهرت النتائج فروق معنوية في معدلات النمو لصالح العجول التي تغذت على السرسوب عالي الجودة. ومن ناحية اخري، كان لجودة السرسوب (منخفضة مقابل عالية) تأثير واضح على العديد من مقاييس الدم، لا سيما مستويات مضادات الأكسدة الكلية (٠,٥ مقابل ٠,٧ نانومول/لتر) والجلوبيولينات المناعية (٢,٥ مقابل ٣,٩ جم/ديسيلتر)، على التوالي. في الوقت نفسه، لم تتأثر مستويات الجلوكوز والدهون الثلاثية في الدم بجودة السرسوب. بالإضافة إلى ذلك، أظهرت النتائج وجود فروق معنوية بين العجول الذكور والإناث في كل من: إرتفاع الجسم، ومستوى الجلوكوز، والدهون الكلية، والهيموجلوبين، وعدد كريات الدم الحمراء، والصفائح الدموية. تُبرز نتائج هذه الدراسة أهمية توفير السرسوب عالي الجودة للعجول حديثي الولادة، لما له من أثر إيجابي لتحسين النمو والمناعة والحالة الصحية العامة.