Aus dem Department für Nutztiere und öffentliches Gesundheitswesen in der Veterinärmedizin

der Veterinärmedizinischen Universität Wien

Universitätsklinik für Wiederkäuer

(Leiter: Univ.-Prof. Dr. Thomas Wittek, Diplomate ECBHM)

Composition of Alpaca Colostrum

INAUGURAL-DISSERTATION

zur Erlangung der Würde eines

DOCTOR MEDICINAE VETERINARIAE

der Veterinärmedizinischen Universität Wien

vorgelegt von

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Wien, im Dezember 2022

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INHALTSVERZEICHNIS

1. Einleitung

1.1. Zoologie

Neuweltkamele (NWK) gehören gemeinsam mit Altweltkamelen zur Ordnung Paarhufer (*Artiodactyla)*, Unterordnung Schwielensohler (*Tylopoda)* und Familie Kamelartige (*Camelidae).* Bei den Altweltkamelen ist die Gattung *Camelus* anerkannt, die zwei Arten umfasst (*Camelus dromedarius* und *Camelus bactrianus*).
Die Neuweltkamele umfassen zwei Gattungen. Die Gattung *Lama* unterteilt sich in Guanaco (*Lama guanacoe*) und die durch Domestikation etablierte Art Lama (*Lama glama*), die Gattung *Vicugna* in Vicuña (*Vicugna vicugna*) und die domestizierte Art Alpaka (*Vicugna pacos*) (Kadwell et al. 2001, Wheeler 2012, Zarrin et al. 2020).

Kamelartige zeichnen sich durch ihre hohe Anpassungsfähigkeit aus. Altweltkamele leben in der afrikanischen, asiatischen oder australischen Wüste, sowie auf zentralasiatischen Ebenen. Neuweltkamele sind an die rauen Bedingungen der Gebirge der Anden und der Hochebenen des Altiplano angepasst. Durch die vielfältigen Nutzungsmöglichkeiten sichern sie durch Milch- und Fleischproduktion einerseits die Ernährung der lokalen Bevölkerung, andererseits haben sie durch die Wollproduktion Einfluss auf die Wirtschaft (Wheeler 2012, Zarrin et al. 2020).

Seit Ende des 20. Jahrhunderts steigt die Anzahl von Haltern und Züchtern von NWK in Europa stark an. Die genauen Bestandszahlen an gehaltenen NWK in Österreich können nur geschätzt werden, da es keine Kennzeichnungspflicht und kein zentrales Melderegister gibt. NWK sind gemäß Paragraph 36 der Tierkennzeichnungs- und Registrierungsverordnung 2009 nur vor Ausstellung amtlicher Zertifizierungen, bei Impfung gegen anzeigepflichtige Tierseuchen oder einer anderen veterinärrechtlich geregelten Tierkrankheit und auf behördliche Anordnung mit injizierbaren Transponder zu kennzeichnen (Bundesministerium für Gesundheit 2009). Durch Online-Befragungen von NWK Haltern in Deutschland, Österreich und Schweiz wurde ermittelt, dass die heimischen NWK vorrangig als Hobbytiere, für die Zucht, die Wollproduktion oder als Trekkingtiere gehalten werden (Bauerstatter et al. 2018, Jost et al. 2020, Wolfthaler et al. 2020, Neubert et al. 2021). Für die Zucht gibt es in Deutschland und Österreich noch keine einheitlichen Zuchtrichtlinien, die einzelnen Züchter gehören unterschiedlichen Zuchtorganisationen an. Bei der Wollproduktion haben besonders Alpakas eine große Vielfalt an Fellfarben, was sie für die Faserproduktion wertvoll macht. Vor allem die weiße Fellfarbe ist durch die vielfältigen Weiterverarbeitungsmöglichkeiten die begehrteste in der Textilindustrie (Jost et al. 2020, Zarrin et al. 2020).

1.1.1. Lama (*Lama glama*)

Mit einem Stockmaß von 110-125 cm und einem Gewicht von 100-250 kg ist das Lama das größere der zwei domestizierten Neuweltkamele. Man unterscheidet drei Typen, die sich vor allem in der Fasercharakteristik unterscheiden: Classic, Wooly und Suri (Gauly et al. 2018).

1.1.2. Alpaka (*Vicugna pacos*)

Das Alpaka ist mit einem Stockmaß von 76-104 cm und einem Gewicht von 50-90 kg deutlich kleiner als ein Lama. Es werden die zwei Rassen Huacaya und Suri unterschieden. Die beiden Rassen unterscheiden sich vor allem im Aufbau und der Struktur des Vlieses. Huacayavlies zeichnet eine starke Kräuselung aus, die beim Surivlies kaum zu finden ist. Das Vlies der Suri ist zudem glänzend und lockig (Gauly et al. 2018).

1.2. Geburt und Kolostralphase

Alpakas und Lamas werden in Österreich vor allem zur Zucht, zur Wollproduktion und zur Landschaftspflege gehalten (Bauerstatter et al. 2018, Wolfthaler et al. 2020). Um eine erfolgreiche Zucht zu ermöglichen, ist fundiertes Wissen über ein richtiges Geburtsmanagement besonders wichtig (Tibary et al. 2014, Whitehead und Cebra 2014, Franz et al. 2021). In Mitteleuropa können NWK ganzjährig trächtig werden, in Südamerika zeigen die Tiere ein wahrscheinlich futterbedingtes, saisonales Fortpflanzungsverhalten (Gauly et al. 2018). Menschliche Eingriffe während der Geburt und direkt danach sollen so gering wie möglich gehalten werden, um den Aufbau der Verbindung zwischen Mutter und Jungtier (Cria) durch Summen und Nase-an-Nase-Berühren nicht zu stören (Tibary et al. 2014). Neugeborene werden von dem Muttertier zumeist nicht besonders umsorgt und auch nicht wie bei anderen Tierarten beleckt. Die Mutterstute bleibt allerdings in der Nähe des Jungtieres (Wittek et al. 2021). Nach spätestens ein bis zwei Stunden soll das Jungtier stehen und mit dem Suchen nach dem Euter der Stute beginnen, um eine erfolgreiche Kolostrumaufnahme zu ermöglichen (Gauly et al. 2018).

Eine adäquate Versorgung mit Kolostrum ist ein entscheidender Bestandteil in der Aufzucht von Jungtieren, da es alle für die Entwicklung der Jungtiere benötigten Inhaltsstoffe liefert. Der Gehalt an Makro- und Mikronährstoffen im Alpakakolostrum ist im Vergleich zur Alpakamilch signifikant verändert, so wie es auch bei anderen Tierarten beschrieben wurde (Daley-Bauer et al. 2010, Mößler et al. 2021, Playford und Weiser 2021). Die epitheliochoriale Plazenta (*Placenta diffusa* und *epitheliochorialis*) der NWK verhindert, dass die Jungtiere pränatal mit Immunglobulinen versorgt werden (Weaver et al. 2000, Genst et al. 2006, Gauly et al. 2018).

Deshalb benötigen Crias eine optimale Kolostrumversorgung mit hohem Immunglobulingehalt, um einen passiven Immunschutz durch die Aufnahme von Immunglobulinen aus dem Darm zu erlangen (Garmendia und McGuire 1987, Wernery 2001, Mößler et al. 2022). Dabei spielt die Zeit der Kolostrumaufnahme eine wichtige Rolle. Mit jeder Stunde nach der Geburt verringert sich die Immunglobulinaufnahme über den Darm, da diese die Darmschranke nicht mehr überwinden können (Gauly et al. 2018).

Bei einer Befragung von 92 Züchtern von NWK aus Österreich, Deutschland und der Schweiz gaben 3,8 % der Befragten an, dass ihre Stuten nach der Geburt Milchmangel aufweisen (Wolfthaler et al. 2020). Eine ähnliche Befragung von 255 NWK Züchtern in Deutschland ergab, dass 12,2 % der Befragten öfter als einmal pro Jahr und 3,1 % der Befragten ein- bis zweimal pro Jahr Probleme mit Milchmangel der Stuten haben (Neubert et al. 2021). Um in solchen Fällen das Cria ideal zu füttern, ist es notwendig die Zusammensetzung des Kolostrums genau zu kennen, um optimal ergänzen zu können. Aktuell werden bei Milchmangel der Alpakastute entweder kommerziell hergestellte Ersatzprodukte oder Kolostrum von anderen Tierarten (Rind, Schaf, Ziege) verwendet. Die bisher veröffentlichten Studien über die Zusammensetzung von Kolostrum von NWK (Bravo et al. 1997, Daley-Bauer et al. 2010, Flodr et al. 2012) und der Milch von NWK (Morin et al. 1995, Riek und Gerken 2006, Schoos et al. 2008, Chad et al. 2014, Martini et al. 2015, Larico et al. 2018, Medina et al. 2019, Ormachea et al. 2021) liefern bereits erste Anhaltspunkte für einen Ersatz. Insgesamt basieren diese Untersuchungen auf wenigen Tieren, zudem wurde nach meiner Kenntnis bei keiner Studie die Zusammensetzung des Kolostrums im zeitlichen Verlauf der ersten Laktationstage untersucht.

2. Ziele und Hypothesen

Das Ziel dieser Dissertation war es den Gehalt von Fett, Protein, Laktose, Immunglobulin G und Mineralstoffen im Alpakakolostrum an den ersten vier Tagen nach der Geburt zu erheben. Begonnen wurde am Tag der Geburt (Tag 1). Außerdem wurde die Zusammensetzung des Alpakakolostrums mit Angaben in der Literatur für NWK und andere Tierarten verglichen, um einen geeigneten Ersatz für Alpakakolostrum zu finden. Zusätzlich wurden die Korrelationen der einzelnen Inhaltstoffe zueinander berechnet, um signifikante Zusammenhänge zu finden.

Es wurden folgende Hypothesen aufgestellt:

1. Der Gehalt der untersuchten Inhaltsstoffe Fett, Protein, Laktose, Immunglobulin G und Mineralstoffe im Alpakakolostrum verändert sich innerhalb der ersten vier Tage nach der Geburt signifikant.
2. Zwischen dem Gehalt an Immunglobulinen und dem der anderen Inhaltsstoffen des Alpakakolostrums gibt es signifikante Korrelationen.
3. Der Gehalt von Fett, Protein, Laktose, Immunglobulin G und Mineralstoffe im Alpakakolostrum unterscheiden sich von dem im Kolostrum anderer Tierarten.

3. Publikationen

3.1. Publikation 1

Mößler M, Aichner J, Müller A, Albert T, Wittek T. 2021. Concentrations of fat, protein, lactose, macro and trace minerals in alpaca colostrum and milk at different lactation stages. Animals, 11 (7). DOI: 10.3390/ani11071955.

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Concentrations of Fat, Protein, Lactose, Macro and Trace Minerals in Alpaca Colostrum and Milk at Different Lactation Stages

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Simple Summary: Alpacas and llamas are domesticated species of New World camels. If the mare dies or produces insufficient colostrum or milk, information about the composition of colostrum and milk is needed to formulate suitable substitutes to adequately supply the crias. Milk composition in alpacas has been sparsely studied. In this study colostrum samples were taken daily during the first four days after parturition and milk samples were obtained monthly during the first four months of lactation. The samples were analyzed for their composition. The fat and lactose content are lowest on the day of birth and then increase, the protein content decreases during the first four days. Over the next four months, these contents do not change significantly. The results can be used for the development of colostrum and milk replacers.

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Citation: Mößler, M.; Aichner, J.; Müller, A.; Albert, T.; Wittek, T. Concentrations of Fat, Protein, Lactose, Macro and Trace Minerals in Alpaca Colostrum and Milk at Different Lactation Stages. *Animals* **2021**, *11*, 1955. https://doi.org/10.3390/ani11071955

Received: 8 June 2021
Accepted: 28 June 2021
Published: 30 June 2021

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Abstract: Although alpacas are not used for milk production a detailed knowledge on the composition of the colostrum and milk is needed for development of colostrum and milk replacers. The aim of the present study was to measure the concentration of fat, protein, lactose, and minerals in alpaca colostrum and milk. Colostrum samples were taken daily over four days after parturition from 20 multiparous alpaca mares. Milk samples were obtained monthly, during the first four months of lactation from 17 alpacas. Composition of colostrum and milk differed in numerous indicators. The concentrations of fat and lactose increased from day 1 (0.5%, 4.0%) to day 4 (5.3%, 5.0%), protein decreased from 20.4% on day 1 to 8.3% on day 4. In milk these three indicators did not change during the lactation. Minerals have been little studied in alpaca colostrum and milk in the past, many of which had the highest concentrations in colostrum immediately after birth. The results of the present study do not support that goat's milk is the preferred substitute for feeding crias. This study contributes to the knowledge of the composition of alpaca colostrum and milk which can be of particular use in developing replacers.

Keywords: alpaca; colostrum; composition; fat; lactose; milk; minerals; protein

1. Introduction

Alpacas, along with llamas, are one of the domesticated species of New World camelids [1,2]. Although alpacas and llamas are not used for milk production knowledge on the composition of the colostrum and milk is needed for development of colostrum and milk replacers. Such replacers are required for crias which have to be hand reared if their mothers have died or are not producing sufficient quantity of milk. Currently milk from other species, mostly cattle or goat or milk replacers designed for calves, lambs, and kids are used [3].

In contrast to numerous studies in several dairy species only a small number of studies have been reported on the composition of milk from South American camelids (SAC) [4–9]. The studies on colostrum composition in alpacas have mainly reported on immunoglobulin concentration [10–12]. Additionally, studies on alpaca which is a dominant SAC breed in many countries are mostly based on a small number of animals [13–15].

One study measured colostrum constituents taking samples 48 h after parturition, comparing alpacas kept in different altitudes (18 animals at sea level and 24 animals at 4400 m above sea level). Later in the same study milk samples were obtained monthly from the first into the fifth month of lactation. However, to obtain sufficient volume for analyses (60 mL) the researchers had to pool the samples of three animals, reducing the effective number of samples by a third. Colostrum fat, protein, and lactose concentrations did not differ between the habitats, but milk constituents were influenced by lactation status [16]. The content of fat, protein, casein, and minerals (calcium, phosphorus, magnesium, potassium, sodium, and zinc) were measured in the milk of eight alpaca mares taken on the 30th and 60th lactation day in Italy [17]. Chad [18] studied the composition of alpaca milk (calcium, phosphorus, potassium, magnesium, sodium, sulfur, lactose, fat, protein, and urea) using milk samples of 11 alpaca mares taken on two Californian farms. The samples were taken every week during the first 25 weeks of lactation. To our best knowledge studies on trace elements in colostrum or milk from SAC have not been published so far.

The aims of the present study were to measure the concentration of fat, protein, lactose, macro and trace minerals in alpaca colostrum and milk at different stages of lactation. Further the composition of colostrum and milk should be compared to information given in the literature for SAC and other species.

It was hypothesized that:

1. The composition of colostrum from alpacas changes within the four day colostral period after parturition.
2. The composition of milk changes according to the lactation status in alpaca mares.
3. The composition of alpaca colostrum and milk differs in certain indicators from ruminant milk which supports the development of species specific colostrum and milk replacers.

2. Materials and Methods

2.1. Animals and Sampling Procedures

The project was discussed and approved by the institutional ethics and animal welfare committee in accordance with GSP guidelines and national legislation (Ethic Code ETK-21/11/2016).

2.1.1. Alpacas for Colostrum Sampling

The colostrum samples were taken from 20 alpaca mares kept in three smaller alpaca farms in the district Bruck-Mürzzuschlag in Styria (Austria). The farms were in close proximity having almost identical weather, husbandry, and feeding conditions. All available pregnant multiparous alpaca mares of the foaling season (June–September) were included in the study. The animals belonged to the Huacaya breed and were between four and nine years old. They were pastured in the Austrian Alps at an altitude between 700 and 1100 m above sea level on a calcareous source rock. The animals were additionally offered hay ad libitum. Colostrum samples were taken on four consecutive days after foaling, the first samples (day 1) were taken on the day of birth between two and four hours after parturition. Crias were not separated from their mothers, but the teats were closed with a tape at least two hours before sampling. After that, the entire amount of colostrum was milked by hand.

2.1.2. Alpacas for Milk Sampling

The milk samples were obtained from lactating alpacas four times at monthly intervals from all 17 alpaca mares on a farm in the Alps in South Tyrol (Northern Italy). Mothers and crias were not separated the whole time, but only for two hours before sampling. These animals (15 Huacaya and two Suri) were comprised of ages between three and 10 years. Thirteen of the mares were multiparous and four had given birth to their first cria. The alpacas grazed on alpine meadows between 1320 and 1550 m above sea level on a calcareous source rock.

2.1.3. Sample Preparation

For sampling the mares were restrained by their owners using a halter and were milked by hand. The udders were examined for conspicuous redness, swelling, and induration to exclude animals with clinical mastitis. Colostrum or milk from all four udder quarters was obtained in similar volume. Samples obtained were examined for visible milk changes that would indicate mastitis. After milking the sample container was immediately transferred to a cooled polystyrene box (4 °C) (Henry Schein Medical Austria GmbH, Vienna, Austria). Within one hour the samples were divided into sub samples in Eppendorf® Safe-Lock microcentrifuge tubes (volume 2.0 mL, Eppendorf Austria GmbH, Vienna, Austria) and in one Greiner tube (15.0 mL volume, Greiner Bio-One GmbH, Kremsmünster, Austria) and stored at −18 °C and shipped to the laboratories.

2.2. Laboratory Analyses

2.2.1. Analyses of Milk Fat, Protein, and Lactose Concentration

Analyses of milk and colostrum fat, lactose, and protein concentrations were performed at the laboratory of the Institute of Food Hygiene, Veterinary Faculty at Leipzig University applying standardized laboratory methods as described by the German Industry Standard (Deutsche Industry Norm, DIN). The fat content was determined using the Weibull–Berntrop gravimetric method [19]. Due to the limited volume of colostrum or milk the analysis of fat concentration could only be performed as a single measurement. The content of lactose was analyzed by the UV lactose/D-galactose method (Roche Diagnostics®, Mannheim, Germany) and the protein content by the Kjehldahl method [20].

2.2.2. Analyses of Macro and Trace Minerals

The milk and colostrum samples were analyzed at the Vet Med Labor GmbH, IDEXX Ludwigsburg (Germany). The elements sulfur (S), phosphorus (P), sodium (Na), and potassium (K) were analyzed by inductive coupled plasma optical emission spectrometry (ICP-OES) using Vista-Pro device (Varian Inc., Palo Alto, CA, USA) and the elements lithium (Li), boron (B), magnesium (Mg), aluminum (Al), calcium (Ca), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), strontium (Sr), molybdenum (Mo), cadmium (Cd), tin (Sn), barium (Ba), thallium (Tl), lead (Pb), and uranium (U) by the inductive coupled plasma mass spectrometry (ICP-MS) device Aurora M90 (Bruker Daltonics, Bremen, Germany). The coefficients of variation of the analyses are shown in Table 1 for each measured parameter.

Table 1. Coefficients of variation (CV) for the analysis of macro and micro minerals.

Mineral	**P** [%]	**Ca** [%]	**Mg** [%]	**Na** [%]	**K** [%]	**S** [%]		**Fe** [%]	**Cu** [%]	**Zn** [%]	**Se** [%]	**Sr** [%]	**Mo** [%]
CV	4.7	4.7	3.9	12.0	1.0	11.0		3.4	8.0	6.2	11.0	4.2	5.2
Mineral	**Ba** [%]	**Al** [%]	**Co** [%]	**Ni** [%]	**Tl** [%]	**Pb** [%]	**U** [%]	**Cd** [%]	**Sn** [%]	**As** [%]	**Mn** [%]	**B** [%]	**Li** [%]
CV	3.6	8.5	2.6	3.6	2.8	3.2	11.7	5.9	12.4	5.2	3.0	3.9	9.9

2.3. Statistical Analyses

Since not all data were normally distributed (Kolmogorov–Smirnov Test), all the indicators are presented as median and first/third quartile. Composition of milk and colostrum was compared using the nonparametric Mann–Whitey U Test. Further analyses were performed using log transformed data. The fat, protein, lactose, and mineral element concentrations were compared over time separately for colostrum and milk using a mixed

Since not all data were normally distributed (Kolmogorov–Smirnov Test), all the indicators are presented as median and first/third quartile. Composition of milk and colostrum was compared using the nonparametric Mann–Whitey U Test. Further analyses were performed using log transformed data. The fat, protein, lactose, and mineral element concentrations were compared over time separately for colostrum and milk using a mixed linear model (measurement repetition). The individual alpaca mare was considered as a random effect, while the age of the animal, the day in milk and the lactation number were fixed effects. The Bonferroni test was applied as a post-hoc test. Microsoft Excel 2010 and the SPSS Statistics Version 24 (IBM Corp., Armonk, NY, USA) were used for statistical analysis. The significance level was set at 5%.

3. Results

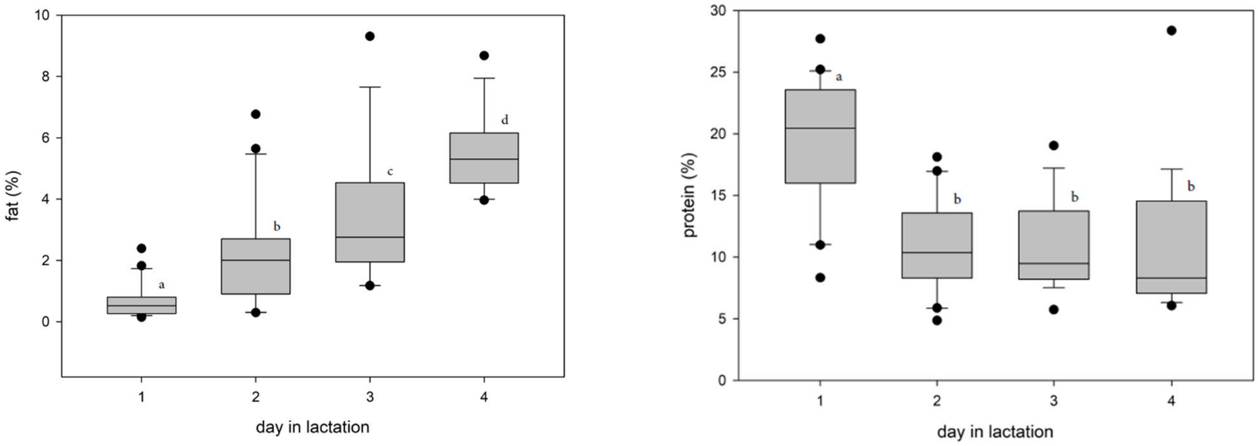
3.1. Colostrum and Milk Volume

A total of 77 colostrum samples were obtained from the 20 mares during four days postpartum. The three missing samples were due to one animal dying on day 3 and one animal developed a clinical mastitis on day 4. The volumes which could be obtained varied between 12 and 28 mL with a median of 20.8 mL. There was no difference between the days in the obtainable colostrum volume.

Overall, 61 milk samples were obtained (17 in the first month, 16 in the second month, 16 in the third month, 12 in the fourth month). The hand milking of the alpaca mares became generally more difficult with increasing duration of lactation and in some animals in advanced lactation only very small volumes or no milk at all could be obtained. One animal had to be excluded since it developed a clinical mastitis in lactation month 2, while in four animals no milk could be obtained in month 4. The volumes which could be obtained varied between 0 and 25 mL with a significant difference between the milk volumes of the months 1 and 2 (median 14.0 mL and 12.5 mL) and the volumes of month 3 and 4 (median 8.0 mL and 5.5 mL).

3.2. Fat, Protein, and Lactose Concentrations in Colostrum and Milk

The colostrum concentrations of fat, protein, and lactose are shown in Figure 1 and Table 2. The concentration of fat in colostrum increased significantly from day 1 to day 4; at day 4 the fat concentration was already similar to the fat concentration in milk during later lactation (Figure 2, Table 3). The lactose concentration on the day of parturition (day 1) was lower in comparison to days 2, 3, and 4. In contrast the colostrum protein concentration decreased substantially over the colostral period; however, the protein concentration on day 4 was significantly higher in comparison to the concentrations in milk later during lactation (Figure 2, Table 3).



(a) (b)

Figure 1. *Cont.*

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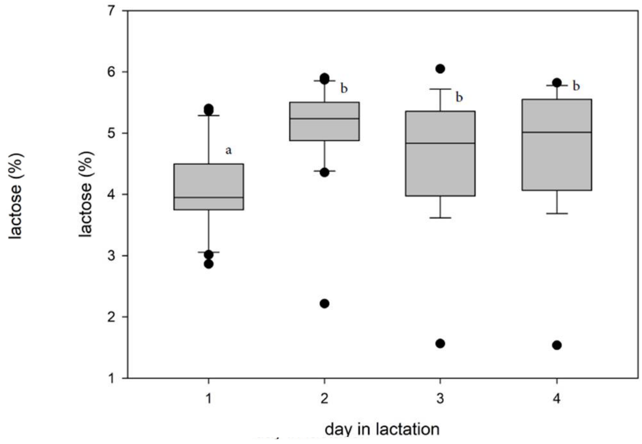
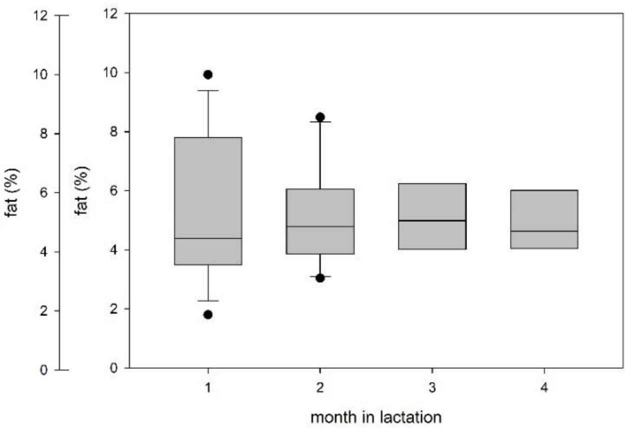


(c)

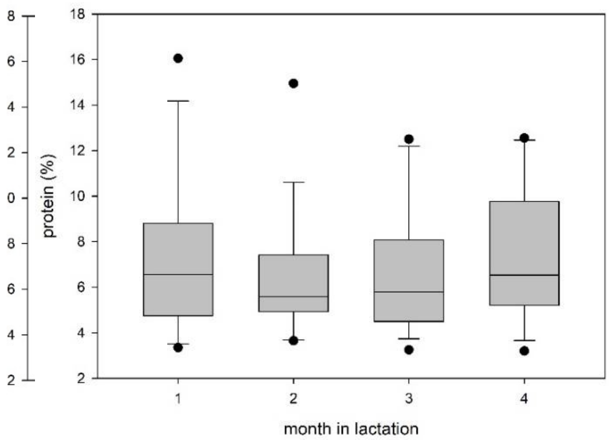
Figure 1. (**a**) Boxplot of fat concentration in alpaca colostrum during four days postpartum, significant differences between the days are marked with different indices. (**b**) Boxplot of protein concentration in alpaca colostrum during four days postpartum, significant differences between the days are marked with different indices. (**c**) Boxplot of lactose concentration in alpaca colostrum during four days postpartum, significant differences between the days are marked with different indices.

Table 2. Percentages of fat, protein, and lactose in alpaca colostrum during the four days postpartum, data are provided as median (1st quartile/3rd quartile), significant differences between the days are marked with different indices.

Colostrum	Day 1 (n = 20)	Day 2 (n = 20)	Day 3 (n = 19)	Day 4 (n = 18)
Fat [%]	0.51 (0.29/0.77)^{a}	2.01 (0.95/2.53)^{b}	2.78 (2.03/4.52)^{c}	5.31 (4.57/5.95)^{d}
Protein [%]	20.4 (16.6/23.3)^{a}	10.4 (8.50/13.4)^{b}	9.48 (8.24/13.6)^{b}	8.30 (4.13/13.5)^{b}
Lactose [%]	3.95 (3.78/4.49)^{a}	5.23 (4.92/5.46)^{b}	4.84 (4.17/5.31)^{b}	5.01 (4.13/5.51)^{b}

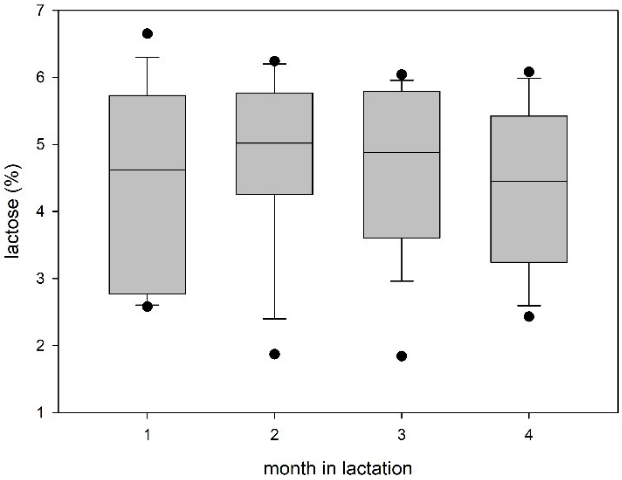


(a)



(b)

Figure 2. *Cont.*



(c)

Figure 2. (a) Boxplot of fat concentration in alpaca milk during four months postpartum, there were no significant differences between the months. (b) Boxplot of protein concentration in alpaca milk during four months postpartum, there were no significant differences between the months. (c) Boxplot of lactose concentration in alpaca milk during four months postpartum, there were no significant differences between the months.

Table 3. Percentages of fat, protein and lactose in alpaca milk during four months postpartum, data are provided as median (1st quartile/3rd quartile); there were no significant differences between the months.

Milk	Day 6–30 (n = 17)	Day 31–60 (n = 16)	Day 61–90 (n = 16)	Day 91–120 (n = 12)
Fat [%]	4.39 (3.57/7.33)	4.78 (3.92/5.76)	4.98 (4.25/5.89)	4.64 (4.08/6.05)
Protein [%]	6.55 (4.86/8.36)	5.59 (4.94/7.21)	5.79 (4.75/7.38)	6.53 (5.34/9.68)
Lactose [%]	4.62 (3.32/5.47)	5.02 (4.31/5.73)	4.88 (3.74/5.78)	4.45 (3.45/5.39)

The concentrations of milk fat, protein and lactose during four months into lactation are shown in Figure 2 and Table 3. None of the three indicators differed over the sampling period.

3.3. Mineral Concentrations in Colostrum and Milk

The concentrations of macro and trace elements are presented in Table 4 (colostrum) and Table 5 (milk). The concentration of Ca, P, and Mg decreased during the colostral period, having the highest concentration at the day of parturition (day 1). The same condition was present in a number of trace elements (Fe, Cu, Zn, Sr, Ba, Co, Ni, S) showing the highest concentrations immediately after parturition (Table 4).

Table 4. Concentrations of macro and trace elements in alpaca colostrum during the four days postpartum, data are provided as median (1st quartile/3rd quartile), significant differences between the days are marked with different indices.

Colostrum	Day 1 (n = 20)	Day 2 (n = 20)	Day 3 (n = 19)	Day 4 (n = 18)
P [g/L]	2.51 (2.01/2.96)^{a}	1.94 (1.77/2.01)^{b}	1.80 (1.63/1.91)^{b,c}	1.64 (1.55/1.75)^{c}
Ca [g/L]	1.96 (1.74/2.34)^{a}	1.55 (1.35/1.76)^{b}	1.60 (1.43/1.86)^{b}	1.48 (1.29/1.89)^{b}
Mg [g/L]	0.60 (0.47/0.66)^{a}	0.19 (0.17/0.32)^{b}	0.21 (0.15/0.27)^{b}	0.36 (0.29/0.39)^{b}
Na [g/L]	0.36 (0.29/0.39)	0.37 (0.32/0.43)	0.43 (0.36/0.64)	0.40 (0.32/0.55)
K [g/L]	1.28 (1.19/1.45)	1.26 (1.10/1.52)	1.34 (0.86/1.46)	1.20 (0.93/1.32)
S [g/L]	2.10 (1.86/2.34)^{a}	1.10 (0.92/1.45)^{b}	1.04 (0.92/1.54)^{b}	0.87 (0.74/1.45)^{b}
Fe [mg/L]	0.88 (0.74/1.03)^{a}	0.68 (0.58/0.81)^{b}	0.72 (0.59/0.90)^{a,b}	0.79 (0.64/0.95)^{a,b}
Cu [mg/L]	0.48 (0.43/0.62)^{a}	0.49 (0.41/0.73)^{a}	0.64 (0.49/0.73)^{a,b}	0.78 (0.51/1.15)^{b}

Table 4. *Cont.*

Colostrum	Day 1 (*n* = 20)	Day 2 (*n* = 20)	Day 3 (*n* = 19)	Day 4 (*n* = 18)
Zn [mg/L]	7.20 (5.76/9.43)^{a}	5.62 (4.90/6.20)^{b}	3.83 (3.12/5.32)^{b}	3.41 (2.70/3.86)^{c}
Se [µg/L]	189 (125/304)^{a}	104 (80.8/129)^{b}	113 (78.6/158)^{b}	87.1 (69.1/127)^{b}
Sr [mg/L]	1.78 (1.14/1.97)^{a}	1.12 (1.02/1.42)^{a,b}	1.14 (1.01/1.48)^{a,b}	1.07 (0.81/1.45)^{b}
Mo [µg/L]	9.35 (6.55/13.4)	7.40 (5.00/12.2)	8.70 (6.8/18.4)	7.50 (3.50/14.8)
Ba [µg/L]	1006 (594/1255)^{a}	658 (417/788)^{a,b}	661 (434/885)^{a,b}	431 (349/985)^{b}
Al [µg/L]	29.0 (23.1/60.6)	44.2 (34.5/75.7)	52.8 (33.9/69.3)	38.6 (24.4/57.4)
Co [µg/L]	6.76 (4.08/9.66)^{a}	1.92 (1.61/3.30)^{b}	2.12 (0.93/3.12)^{b}	0.85 (0.66/2.88)^{b}
Ni [µg/L]	8.42 (7.51/9.74)^{a}	6.53 (5.60/7.58)^{b}	6.86 (6.60/8.31)^{a,b}	6.12 (5.59/8.14)^{b}
Tl [µg/L]	0.14 (0.13/0.21)	0.12 (0.09/0.19)	0.09 (0.06/0.14)	0.08 (0.05/0.11)
Pb [µg/L]	0.97 (0.48/2.01)	1.23 (0.82/1.56)	0.98 (0.74/1.43)	1.00 (0.78/1.60)
U [µg/L]	0.01 (0.01/ 0.04)	0.08 (0.04/0.13)	0.06 (0.01/0.23)	0.04 (0.02/0.10)
Cd [µg/L]	0.10 (0.00/0.16)	0.07 (0.00/0.17)	0.06 (0.01/0.23)	0.05 (0.00/0.15)
Sn [µg/L]	0.80 (0.40/1.39)	0.60 (0.42/1.11)	0.83 (0.51/1.93)	0.82 (0.49/1.54)
As [µg/L]	0.65 (0.48/0.81)	0.60 (0.48/0.75)	0.70 (0.55/0.95)	0.55 (0.45/0.85)
Mn [µg/L]	15.2 (8.93/22.1)	19.3 (12.5/27.7)	17.7 (11.6/24.2)	17.3 (10.8/28.3)
B [µg/L]	171 (139/213)	147 (105/194)	143 (116/187)	164 (128/197)
Li [µg/L]	1.64 (0.82/3.24)	1.48 (0.78/2.87)	1.33 (0.71/1.96)	1.35 (0.49/2.56)

Table 5. Concentrations of macro and trace elements in alpaca milk during four months postpartum, data are provided as median (1st quartile/3rd quartile), significant differences between the months are marked with different indices.

Milk	Day 6–30 (*n* = 17)	Day 31–60 (*n* = 16)	Day 61–90 (*n* = 16)	Day 91–120 (*n* = 12)
P [g/L]	1.21 (1.00/1.42)	1.15 (0.86/1.34)	1.15 (0.98/1.45)	1.11 (0.73/1.41)
Ca [g/L]	1.40 (1.23/1.55)^{a}	1.33 (1.18/1.49)^{a}	1.24 (1.02/1.55)^{a,b}	1.11 (0.90/1.35)^{b}
Mg [g/L]	0.16 (0.14/0.22)	0.15 (0.14/1.17)	0.15 (0.14/0.16)	0.13 (0.11/0.17)
Na [g/L]	0.50 (0.27/1.29)	0.42 (0.28/0.85)	0.46 (0.31/1.00)	0.52 (0.33/1.36)
K [g/L]	0.84 (0.78/1.11)^{a}	0.96 (0.88/1.13)^{a,b}	1.16 (1.13/1.28)^{b}	0.98 (0.79/1.34)^{a,b}
S [g/L]	0.60 (0.47/0.93)	0.50 (0.41/0.67)	0.49 (0.45/0.65)	0.54 (0.50/0.70)
Fe [mg/L]	1.16 (0.88/1.69)	1.59 (0.76/3.25)	1.33 (0.81/2.01)	1.08 (0.67/2.65)
Cu [mg/L]	0.25 (0.15/0.56)^{a}	0.15 (0.13/0.17)^{b}	0.13 (0.14/0.16)^{b}	0.11 (0.08/0.14)^{b}
Zn [mg/L]	3.16 (2.71/3.74)	3.07 (2.90/3.85)	2.94 (2.59/3.37)	3.19 (2.81/3.57)
Se [µg/L]	31.0 (19.9/43.6)^{a}	20.2 (14.8/26.7)^{b}	14.5 (8.68/26.3) ^{b}	18.0 (11.9/33.4)^{b}
Sr [mg/L]	0.77 (0.61/0.88)^{a}	0.70 (0.66/0.84)^{a}	0.61 (0.58/0.75)^{a,b}	0.56 (0.41/0.63)^{b}
Mo [µg/L]	6.50 (4.55/9.00)^{a}	4.50 (3.50/7.65)^{b}	2.80 (1.92/3.50)^{c}	4.60 (2.80/5.98)^{b}
Ba [µg/L]	514 (399/611)	753 (493/923)	641 (439/905)	449 (349/602)
Al [µg/L]	750 (204/950)	918 (698/1947)	1114 (560/1635)	607 (468/707)
Co [µg/L]	0.75 (0.40/1.15)	0.50 (0.30/1.10)	0.65 (0.40/1.10)	0.50 (0.30/0.70)
Ni [µg/L]	4.65 (3.58/5.92)	5.40 (4.50/8.70)	5.85 (4.65/8.00)	4.55 (3.65/6.05)
Tl [µg/L]	0.13 (0.11/0.17)	0.11 (0.08/0.17)	0.10 (0.08/0.16)	0.11 (0.08/0.14)
Pb [µg/L]	5.40 (2.02/7.85)^{a}	9.80 (4.82/19.3)^{b}	4.98 (3.24/10.1)^{a}	3.00 (2.58/4.13)^{c}
U [µg/L]	0.12 (0.09/0.14)	0.17 (0.14/0.19)	0.15 (0.13/0.19)	0.14 (0.12/0.20)
Cd [µg/L]	0.25 (0.08/0.40)	0.31 (0.12/0.44)	0.25 (0.13/0.39)	0.24 (0.18/0.32)
Sn [µg/L]	1.45 (0.78/3.45)^{a}	3.10 (1.80/5.44)^{b}	3.10 (1.88/3.70)^{b}	3.40 (2.78/4.78)^{b}
As [µg/L]	1.65 (0.98/1.90)^{a}	1.80 (1.10/3.20)^{a}	0.85 (0.70/2.05)^{b}	0.60 (0.50/0.88)^{b}
Mn [µg/L]	82.1 (46.2/118)^{a}	131 (73.8/305)^{b}	129 (77.6/257)^{b}	76.5 (59.8/104)^{a}
B [µg/L]	168 (147/200)	144 (129/180)	155 (122/185)	142 (135/167)
Li [µg/L]	12.8 (7.05/36.2)	15.6 (6.15/27.9)	11.9 (6.60/12.95)	12.60 (9.70/13.2)

During later lactation, milk calcium was the only macro element for which concentrations decreased during the four months of lactation. A comparison of mineral concentration between colostrum and milk is shown in Table 6. The concentration of numerous macro and trace elements differ significantly. Additionally, for comparison upper concentration limits for drinking water (Austria) and concentration for llama and alpaca milk reported in the literature are provided.

Table 6. Comparison of concentrations of macro and trace elements in alpaca colostrum (samples from day 1 to day 4 postpartum) and milk (samples from day 11 to day 120 in lactation), data provided as median (1st quartile/3rd quartile), significant differences between the days are marked with different indices. For comparison upper concentration limits for drinking water (Austria) and concentration for llama and alpaca milk reported in the literature are provided.

Mineral	Colostrum (n = 77)	Milk (n = 61)	Water [1]	Milk Llama (L) and Alpaca (A)
P [g/L]	1.85 (1.64/2.15)[a]	1.16 (0.92/1.38)[b]		A: 1.13 ± 0.16 [2], 0.98 ± 0.15 [3] L: 1.13 ± 0.16 [4]
Ca [g/L]	1.71 (1.36/2.00)[a]	1.23 (1.07/1.35)[b]		A: 1.20 ± 0.16 [2], 1.38 ± 0.22 [3] L: 1.70 ± 0.18 [4]
Mg [g/L]	0.29 (0.17/0.33)[a]	0.15 (0.14/0.17)[b]	0.05	A: 0.10 ± 0.02 [2], 0.13 ± 0.02 [3]
Na [g/L]	0.37 (0.31/0.47)	0.42 (0.30/0.93)	0.20	A: 0.58 ± 0.28 [2], 0.20 ± 0.10 [3] L: 0.27 ± 0.18 [4]
K [g/L]	1.26 (1.08/1452)[a]	0.98 (0.81/1.12)[b]		A: 1.61 ± 0.28 [2], 1.30 ± 0.19 [3] L: 1.20 ± 0.20 [4]
S [g/L]	1.31 (0.92/1.83)[a]	5.40 (0.46/0.70)[b]	250 [1]	A: 476 ± 112 [3], L: 425 ± 48.0 [4]
Fe [mg/L]	0.79 (0,61/0.92)[a]	1.28 (0.77/2.01)[b]	0.20	L: 0.65 [4]
Cu [mg/L]	0.48 (0.43/0.62)[a]	0.14 (0.11/0.19)[b]	2.00	L: 0.11 [4]
Zn [mg/L]	5.12 (3.44/6.37)[a]	3.07 (2.80/3.57)[b]		L: 4.19 ± 0.95 [4]
Se [µg/L]	117 (81.1/173)[a]	21.4 (13,3/33.5)[b]	10.0	
Sr [mg/L]	1.15 (0.94/1.62)[a]	0.66 (0.58/0.80)[b]		
Mo [µg/L]	8.60 (5.30/14.8)[a]	4.50 (2.90/6.86)[b]		
Ba [µg/L]	656 (410/969)	582 (418/783)		L: 278 [4]
Al [µg/L]	42.0 (26.1/62.8)[a]	762 (598/1362)[b]	200	L: 416 [4]
Co [µg/L]	2.59 (0.99/4.34)[a]	0.50 (0.33/1.10)[b]		
Ni [µg/L]	7.30 (5.94/8.47)[a]	5.25 (4.35/6.84)	20.0	
Tl [µg/L]	0.11 (0.07/0.16)	0.12 (0.10/0.19)		
Pb [µg/L]	1.00 (0.69/1.62)[a]	4.81 (3.00/9.77)[b]	40.0	
U [µg/L]	0.04 (0.01/ 0.10)[a]	0.17 (0.10/0.50)[b]	15.0 [1]	
Cd [µg/L]	0.06 (0.00/0.16)[a]	0.30 (0.10/0.35)[b]	5.00 [1]	
Sn [µg/L]	0.80 (0.40/1.39)[a]	2.93 (1.49/4.33)[b]		
As [µg/L]	0.60 (0.49/0.82)[a]	1.11 (0.75/1.88)[b]		
Mn [µg/L]	17.2 (11.6/24.4)[a]	93.7 (69.2/209)[b]	50.0 [1]	L: 71.0 [4]
B [µg/L]	159 (126/186)	150 (132/180)	1000 [1]	
Li [µg/L]	1.31 (0.78/1.86)[a]	12.5 (6.85/20.0)[b]		

[1] Ordinance of the Austrian Federal Minister for Social Security and Generations on the Quality of Water for Human Consumption (Drinking Water Ordinance-TWV) StF: BGBl. II Nr. 304/2001 [CELEX-Nr.: 398L0083] of 10.01.2018. [2] Martini [17]. [3] Chad [18]. [4] Morin [7].

4. Discussion

As hypothesized, the composition of fat, protein, and lactose concentration in colostrum changed substantially during the colostral period. The decreasing concentration of protein and the increase of fat concentration mirrored that of other animal species [21–23]. The substantial decrease in colostral protein concentration can be attributed to the decrease in immunoglobulin concentration as described by Mößler [24] in alpacas and occurs in most other mammals [25–30]. For comparison Parraguez [16] took colostrum samples 48 h after parturition from alpaca mares in two regions of Chile. Six pooled alpaca colostrum samples taken in a herd kept at sea level in Patagonia had concentrations of 2.71 ± 0.6% fat, of 9.24 ± 0.5% protein, and of 5.33 ± 0.1% lactose whereas in eight pooled samples from the High Altiplano region (4400 m above sea level) concentrations of 4.80 ± 1.2% fat, of 9.84 ± 0.6% protein, and of 4.41 ± 0.1% lactose were measured. These measurements at 48 h after parturition are comparable and similar to the measurements at day 2 and 3 of the present study. The concentration of fat and lactose in colostrum at day 1 of the present study was also similar to the concentration measured in llama colostrum (fat 0.75 ± 0.25%, lactose 4.12 ± 0.46%) taken between four and 12 h after parturition [8]. However, the protein concentration in alpaca colostrum in the present study appeared to be higher in comparison to llamas at the same time (16.79 ± 1.64%) [8]; since the sample sizes are rather small in both studies (20 alpacas and nine llamas) it is impossible to draw conclusions on species differences. The composition of colostrum milked at day 4 after parturition is similar considering numerous indicators to milk later during lactation.

Chad [18] measured on average 3.68 ± 1.32% fat, 4.53 ± 0.78% protein and 6.00 ± 0.48% lactose in milk of 11 alpacas over 25 weeks into lactation. The minor differences to the present study might be due to the fact that they also included animals in the first week of lactation meaning they used some colostrum samples and they applied a different method (infrared spectrometry) for measurement which has been validated for cow milk. In a study covering five months of lactation performed in two regions of Chile Parraguez [16] found in six pooled alpaca milk samples in Patagonia (sea level) concentrations of 2.6 ± 0.5% fat, of 6.5 ± 0.3% protein and of 5.2 ± 0.5% lactose and in eight pooled samples from High Altiplano (4400 m above sea level) concentrations of 3.8 ± 0.6% fat, of 6.9 ± 0.3% protein and of 4.4 ± 0.5% lactose. The milk composition in Chile was also similar to the present study.

In contrast in comparison to llama milk in which Morin [7] in the USA found a fat concentration of 2.7 ± 1.0%; the fat concentration in alpaca milk in the present study was substantially higher. Additionally, the reported lactose (6.5 ± 0.5%) and protein (3.4 ± 0.4%) concentrations in lamas in the study by Morin [7] also differed substantially from the indicators in the present study in alpacas. Since the used laboratory methods were similar possible reasons for the differences are not obvious, however the diet might have had a substantial influence. The results for llama milk composition of a German study [8] (fat 4.70 ± 0.81%, protein 4.23 ± 0.23%, lactose 5.93 ± 0.27%) and an Argentinian study [9] (fat 4.55 ± 0.66%, protein 4.33 ± 0.17%, lactose 6.34 ± 0.34%) were much closer to the results of the present study in alpacas.

Comparing fat, lactose, and protein concentration of alpaca milk to goat milk (fat 3.9%, protein 3.3%, lactose 4.2%) and cow milk (fat 3.8%, protein 3.4%, lactose 4.7%) it seems that there is no firm rationale for the widely accepted opinion in the breeder community that goat's milk is the preferred option for feeding alpaca crias [31]. Our clinical experience also does not support this.

The mineral content of alpaca colostrum and milk found in the present study is difficult to compare to other studies in SAC. It seems that there are no studies available on the mineral content of SAC colostrum. Further, it was observed that minerals are obviously stored in the udder before parturition as the concentration of a number of elements was highest in the first colostrum and decreased within the colostral period (Table 4). Only sparse information is available especially for trace elements in milk (Table 5). In a study by Morin [7] in 1995 the concentrations of a number of trace elements (B, Co, Mo, Sn, As, Cr, Cd, Hg, Pb, Se, Tl) were below the detection limits of the methods used at that time. Over 25 years later these technical limitations no longer exist; however, comparisons between different measurement methods are always difficult to draw.

Additionally it has to be considered that the trace element concentrations found in colostrum and milk are influenced by the availability of those minerals in feed. The study found some substantial differences in a number of elements between colostrum and milk. However, since the alpacas herds in which colostrum and milk samples were obtained are kept in different areas of the Alps with similar but not identical conditions it remains unclear which part of the differences is caused by the lactation status or by the different feed supply.

A limitation of the present study was that the trace and macro minerals were studied only in two regions in the Alps which were geologically similar. Since the source rock has an influence on the mineral content of milk, the results may therefore differ in other regions with different geological conditions. Further studies in geologically different areas on larger sample sizes would provide more reliable data.

Summarizing the findings, the present study contributed to the establishment of reference ranges for these indicators, albeit there were some differences between fat, protein, lactose, and macro element concentrations between the present study and information from different literature sources. Taken together, they provide guidance for replacement colostrum and milk from other sources including milk replacers for motherless reared crias.

5. Conclusions

The components fat, protein, and lactose change significantly in the first four days of lactation and remain at a constant level during the further months of lactation. Concentrations of numerous macro and trace elements also differ significantly over lactation especially during the first four days after parturition. The composition of colostrum and milk is substantially different from cow or goat milk. It appears that there is no rationale for the widely accepted opinion that goat milk is the preferred option for feeding motherless alpaca crias.

Author Contributions: Conceptualization, M.M., J.A. and T.W.; methodology, M.M. and T.W.; software, M.M. and T.W.; validation, A.M., T.A. and T.W.; formal analysis, T.W.; investigation, M.M. and J.A.; resources, M.M., J.A., A.M., T.A. and T.W.; data curation, M.M. and T.W.; writing—original draft preparation, M.M.; writing—review and editing, T.W.; visualization, M.M. and T.W.; supervision, T.W.; project administration, M.M., J.A. and T.W.; funding acquisition, T.W. All authors have read and agreed to the published version of the manuscript.

Funding: Open Access Funding by the University of Veterinary Medicine Vienna.

Institutional Review Board Statement: Discussed and approved by the institutional ethics and animal welfare committee in accordance with GSP guidelines and national legislation (Ethic Code ETK-21/11/2016).

Data Availability Statement: Data available on request. The data presented in this study are available on request from the corresponding author.

Acknowledgments: We would like to thank the alpaca breeders for their allowance to use the animals in the study and for the support taking the samples. We would also like to thank Froeb-Borgwardt for her support of the laboratory work at Leipzig University. We are grateful to D. Logue (Glasgow University) for his help in writing the manuscript. The study was financially supported by the Austrian Buiatric Association (ÖBG) for which we are indebted.

Conflicts of Interest: The authors declare no conflict of interest.

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3.2. Publikation 2

Mößler M, Rychli K, Reichmann VM, Albert T, Wittek T. 2022. Immunoglobulin G concentrations in alpaca colostrum during the first four days after parturition. Animals, 12 (2). DOI: 10.3390/ani12020167.

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Article

Immunoglobulin G Concentrations in Alpaca Colostrum during the First Four Days after Parturition

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Simple Summary: During the first days after parturition, mammalian milk (colostrum) is specifically formulated to nourish newborns. Immunoglobulins are a particularly important component for newborn New World camelids, as their immune system is almost totally dependent on the intestinal transfer of colostral immunoglobulins to acquire passive immunity. In this study, colostrum samples were collected from 20 alpaca mares in the first four days after parturition and analyzed for their immunoglobulin concentration. Sampling started on the day of parturition. The associations of immunoglobulins with other components were determined. The immunoglobulin G (IgG) concentrations decreased significantly within the first four days after parturition. The correlation coefficients between IgG content and the content of various minerals were significant but variable. The correlation between IgG content and fat and lactose content was negative but between IgG content and protein content was highly positive. This strong association could be used for a brief estimation of the IgG content of the colostrum based on the measured protein concentration. The results of the present study can be used for the development of colostrum replacers where motherless rearing is required.

Abstract: Colostrum provides the newborn with nutrients and immunoglobulins. Immunoglobulins and their intestinal transfer play a major role in the immune system of neonates since they are born agammaglobulinemic. In this study immunoglobulin G (IgG) content was determined in alpaca colostrum and the correlations of the IgG concentration by fat, protein, lactose and minerals were calculated. Colostrum samples were collected daily from 20 multiparous alpaca mares during the first four days after parturition. The IgG concentrations were determined by radial immunodiffusion using a Camelid IgG Test Kit. The IgG concentration decreased significantly from 26,319 mg/dL on day 1 to 3848.8 mg/dL on day 4. There were significant correlations between IgG concentration and the other components of the colostrum. While the correlations between IgG and fat (r = −0.69, $p \leq 0.001$) and lactose (r = −0.64, $p \leq 0.001$) were negative, the correlations with protein (r = 0.91, $p \leq 0.001$), magnesium (r = 0.86, $p \leq 0.001$) and cobalt (r = 0.87, $p \leq 0.001$) were strongly positive. Due to the strong association, the colostrum protein concentration could be used for a brief estimation of the IgG content.

Keywords: alpaca; colostrum; immunoglobulin G

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Citation: Mößler, M.; Rychli, K.; Reichmann, V.M.; Albert, T.; Wittek, T. Immunoglobulin G Concentrations in Alpaca Colostrum during the First Four Days after Parturition. *Animals* **2022**, *12*, 167. https://doi.org/10.3390/ani12020167

Academic Editor: Umberto Bernabucci

Received: 9 December 2021
Accepted: 8 January 2022
Published: 11 January 2022

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1. Introduction

Colostrum is the milk of mammals during the first days after parturition, which differs in composition from milk during lactation and plays an important role in the acquisition of passive immunity, development and survival of the newborn [1,2]. The major quality determining components of colostrum are immunoglobulins [3,4]. Due to the epitheliochorial placenta of alpacas crias are born agammaglobulinemic. Therefore, they should consume high-quality colostrum to gain passive humoral protection from their dams via intestinal absorption to be protected against infectious diseases [5–10]. If the dams do not provide a sufficient amount and quality of colostrum or even die during parturition efficient colostrum replacers are necessary. The formulation of colostrum replacers requires detailed knowledge of the composition of the colostrum of alpacas. However, the composition of alpaca colostrum and that of South American Camels (SAC) in general has been sparsely investigated [11,12].

One study examined the IgG content of colostrum collected from 25 llamas kept in Argentina prior to crias suckling [13]. Additionally, in Argentina 15 llamas were milked within the first 24 h after parturition and the samples were analyzed for their IgG content [14]. Flodr et al. [15] analyzed 26 alpaca colostrum samples collected in Peru immediately after parturition before the first suckling of the crias. In another study, colostrum samples were analyzed from 14 alpacas kept in the USA sampled immediately after parturition and 24 h later [16]. Bravo et al. [17] collected samples from 15 llamas and 15 alpacas kept in Peru before, immediately at and after parturition. These studies measured the IgG concentrations only at one defined time point after parturition. To our best knowledge, the changes of IgG in colostrum over time have not been investigated yet.

The major objective of this study was to determine the concentrations of IgG in the colostrum of alpacas over the first days after parturition to obtain data for the development of suitable replacements for motherless reared crias or for crias of agalactic dams. We further investigated the relationship of IgG concentration with other colostral components in particular fat, protein, lactose, and minerals and compared with those of other animal species. In cattle, goats, sheep and other mammals, the term colostrum refers to the first five days after parturition before the milk changes into mature milk [1–4]. We have adopted this period for alpacas, and therefore, the first four days were chosen.

We hypothesized (i) that the concentrations of IgG in colostrum change significantly within the first days after parturition, (ii) that there are associations between IgG and other components of the colostrum.

2. Materials and Methods

2.1. Animals and Sampling Procedures

The project was approved by the institutional ethics and animal welfare committee in accordance with GSP guidelines and national legislation (Ethic Code ETK-21/11/2016).

During the period from June to September 2017 samples were obtained at three alpaca farms with similar environmental, husbandry and feeding conditions located in close proximity in the Austrian federal state of Styria, district of Bruck-Mürzzuschlag. During this time, the animals grazed on a pasture at 700 to 1100 m above sea level and hay ad libitum was offered additionally. Colostrum samples were collected from 20 multiparous alpacas (Huacaya breed) over four days after parturition (farm A five mares, farm B seven mares, farm C eight mares). The teats were taped two hours before sampling to obtain enough colostrum while the crias were not separated and could always nurse between samplings. During sampling, the animals were fixed by the owner using a halter. The first sample was collected on the day of birth between two and four hours after parturition, which is referred to as "day 1". The samples of the following days were taken every 24 ± 4 h.

2.2. Sample Preparation

The udders were palpated and visually examined conspicuous redness, swelling and induration to exclude animals with clinical mastitis. The teats were cleaned before sampling using a swab dipped in alcohol. All available colostrum was milked from all four udder quarters into sterile 15 mL tubes (Greiner Bio-One GmbH, Kremsmünster, Austria). The samples were aliquoted in Eppendorf® Safe-Lock microcentrifuge tubes (volume 2.0 mL, Eppendorf Austria GmbH, Vienna, Austria) frozen without preservatives immediately afterward and stored at −18 °C until further examination.

2.3. Sample Analysis

IgG concentrations were determined by a radial immunodiffusion test (RID) using the Camelid IgG Test Kit (Triple J Farms, Bellingham, WA, USA) in duplicates. The analysis has been conducted according to the instructions provided by the manufacturers. Colostrum samples were thawed at room temperature and diluted in saline (1:10–1:40, depending on sample viscosity). Sample viscosity was visually estimated and the sample was diluted accordingly. Sample dilution was adjusted and IgG determination was repeated if necessary. Three standardized concentrations (203 mg/dL, 1452 mg/dL, 2851 mg/dL) were used on each 24-well plate. The remaining wells were filled with 5 µL of the diluted samples. The plates were incubated in plastic bags at 23 °C for 24 h. After 24 h the precipitin circle diameters (in mm) were measured. Using the reference values, a linear regression equation was created, which was used to determine the sample results.

The methods for determining fat, lactose, and protein content as well as mineral analysis are described in detail by Mößler et al. [12]. Briefly, fat content was analyzed with the gravimetric method according to Weibull-Berntrop [18], lactose content with the UV-lactose/D-galactose method (Roche Diagnostics®, Mannheim, Germany) and protein content with the Kjehldahl method [19]. Minerals were analyzed by inductive coupled plasma optical emission spectrometry (ICP-OES) using Vista-Pro device (Varian Inc., Palo Alto, CA, USA) and by inductive coupled plasma mass spectrometry (ICP-MS) device Aurora M90 (Bruker Daltonics, Bremen, Germany).

2.4. Statistical Analysis

The statistical evaluations and data presentations were performed with the statistics program R-Studio (product version: 1.1.463, RStudio Inc., Boston, MA, USA). Descriptive statistics (minimum, maximum, median, first/third quartile, arithmetic mean and standard deviation) were calculated. Further analyses were performed using log transformed data. The IgG content was compared over time separately using a mixed linear model (measurement repetition). The individual alpaca mare was considered as a random effect, while the day in milk, the farm and the lactation number were fixed effects. The Bonferroni test was applied as a posthoc test. The significance of the differences between the individual days was calculated with a significance level of $p < 0.05$. The correlations between the individual components were calculated using Pearson's Rank correlation coefficient.

3. Results

From each alpaca mare ($n = 20$) four samples were collected with two exceptions: one mare died on the third day, and one showed clinical mastitis on the fourth day. In total 77 samples were collected. The volumes which could be obtained varied between 12 and 28 mL with a median of 20.8 mL. There were no differences in the obtainable volume from day 1 to day 4.

Immunoglobulin G

The IgG content significantly decreased from day 1 (26,319 ± 8754.73 mg/dL) to day 2 (9234.4 ± 5778.96 mg/dL, Figure 1). Furthermore, there was a significant difference in the IgG concentration between day 3 (7280.1 ± 5014.32 mg/dL) and day 4 (3848.8 ± 3475.91 mg/dL).

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IgG concentration between day 3 (7280.1 ± 5014.32 mg/dL) and day 4 (3848.8 ± 34 mg/dL).

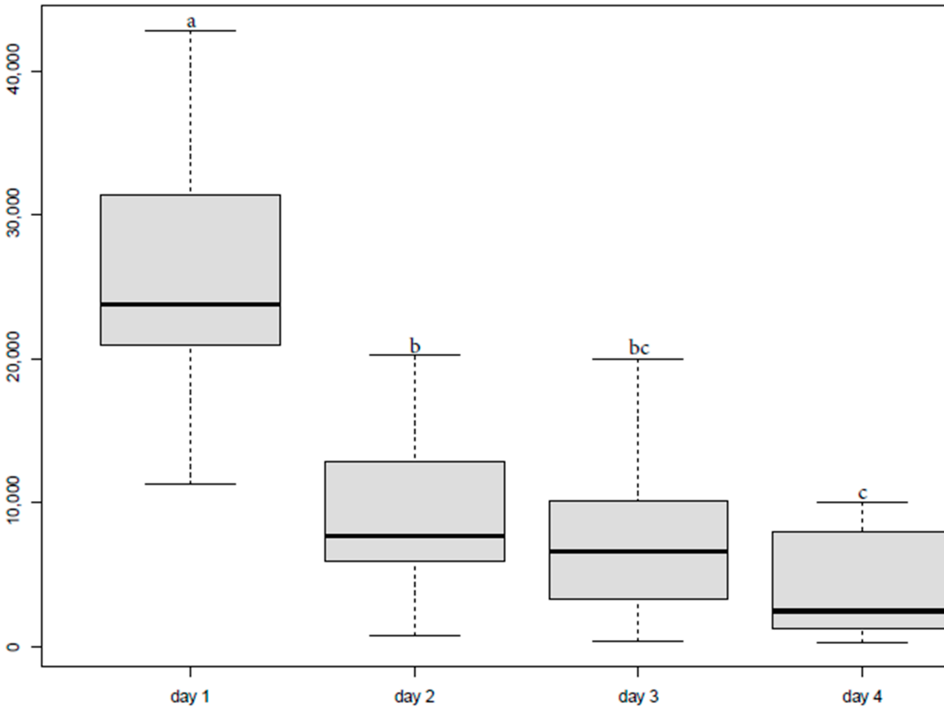

Figure 1. Boxplot of IgG concentrations in alpaca colostrum during four days after parturition, significant differences between the days are marked by different indices. Different letters indicate significant differences in values ($p < 0.05$).

We observed a negative association between IgG and fat (r = −0.69, $p \leq 0.001$, Figure 2A) and lactose (r = −0.64, $p \leq 0.001$, Figure 2B) content. IgG was positively correlated with protein content (r = 0.91, $p \leq 0.001$, Figure 2C). The IgG content was also correlated with magnesium (r = 0.86, $p \leq 0.001$, Figure 2D) and cobalt (r = 0.87, $p \leq 0.001$, Figure 2E). The correlation coefficients between IgG content and the content of other minerals were lower but significant (Table 1).

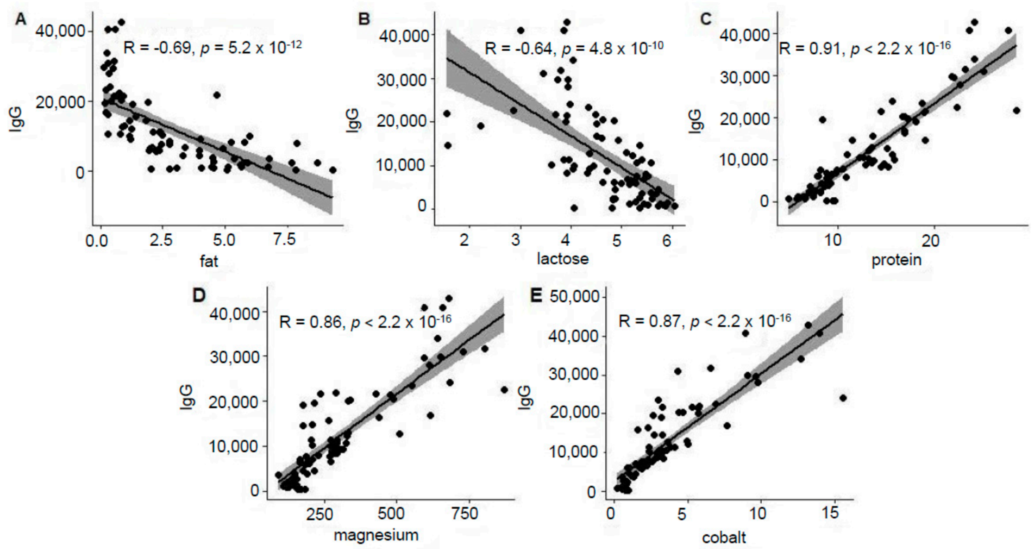

Figure 2. Associations between IgG and fat (**A**), lactose (**B**), protein (**C**), magnesium (**D**) and cobalt (**E**) concentrations in alpaca colostrum during four days after parturition.

Table 1. Correlation coefficients and significance levels between IgG content and other mineral content in alpaca colostrum from 20 alpaca mares during four days after parturition (*n* = 77).

Correlation Partners	Correlation Coefficient (r)	Significance Level (*p*)
IgG/S	0.62	<0.001
IgG/Zn	0.53	<0.001
IgG/Ca	0.52	<0.001
IgG/Se	0.52	<0.001
IgG/Sr	0.46	<0.001
IgG/Ba	0.45	<0.001
IgG/P	0.45	<0.001
IgG/Fe	0.39	<0.001
IgG/Cu	−0.36	<0.01
IgG/U	−0.31	<0.01
IgG/Tl	0.29	<0.01

S: Sulfur, Zn: Zinc, Ca: Calcium, Se: Selenium, Sr: Strontium, Ba: Barium, P: Phosphorus, Fe: Iron, Cu: Copper, U: Uranium, Tl: Thallium.

4. Discussion

As our hypothesis suggested, the concentrations of IgG in the colostrum of alpacas significantly decreased within the first four days of lactation. The significant change in the IgG content from the day of parturition to the following day has also been described in other animal species, such as camels, cattle, goats and sheep [9,20–22]. The IgG content continued to decrease after the first 24 h after parturition, following the same progression as in other animal species.

In the present study, the colostrum on day 1 showed an IgG content of 26,319 ± 8755 mg/dL. In previous studies of alpaca colostrum IgG concentrations were found with 28,337 ± 5593 mg/dL [15] and 21,792 ± 786 mg/dL [17], respectively. Analyses of colostrum from llamas at birth showed IgG concentrations of 23,254.9 ± 7068 mg/dL [13] and 22,313 ± 3806 mg/dL [17].

Studies in which the alpaca colostrum was examined with a different test method namely enzyme-linked Immunosorbent Assay ELISA, obtained IgG content with 19,620 ± 2590 mg/dL [16] and 4254 ± 2779 mg/dL [14]. It has already been reported that results from the two test methods, RID and ELISA, are not directly comparable and that generally lower concentrations are measured with ELISA compared to RID [23–27].

Compared to our study the colostrum IgG concentrations of ruminant species analyzed with RID on the first day after parturition are substantially lower. Colostrum from cattle contains between 6360–9960 mg/dL [21,28–33], from sheep contains between 4810–6090 mg/dL [34–36] and from goat contains between 2151–7201 mg/dL [22,37–39] IgG.

Al-Busadah [40] tested the absorption abilities of newborn camels of IgG from colostrum from other species. The crias received either colostrum from their own dam or pooled colostrum with similar IgG content from cattle or goats. The study showed a similar absorption of IgG with goat and cattle colostrum feeding. Whether this also provides protection against animal-specific diseases remains to be researched. However, if no species-specific colostrum is available, then goat or bovine colostrum could be an option.

In this study, a significant correlation (r = 0.91, $p \leq 0.001$) between the IgG and protein concentration was demonstrated. In bovine colostrum correlations of r = 0.86 [41] and r = 0.82 [42] between IgG content and protein content were found. Additionally, in goat colostrum the IgG concentration associated with the protein content (r = 0.9 [39], r = 0.7 [43]). In a different study using ELISA for the IgG determination, there was a weaker correlation between the IgG and the protein content in bovine colostrum (r = 0.66 [44]).

On the other hand, a negative correlation between IgG and fat content (r = −0.69, $p \leq 0.001$) was observed, while studies in goats reported a moderate or weak positive correlation between IgG content and fat content (r = 0.44 [39], r = 0.31 [43]). In cattle, only weak negative correlations between the IgG and fat content were demonstrated (r = −0.36 [41]). The negative correlation between the IgG and lactose content in this study (r = −0.64, $p \leq 0.001$) has also been found in goat colostrum (r = −0.6 [43]). To our knowledge, correlations between IgG content and other components of the colostrum have not been reported in SAC. In our study, we found significant correlations between IgG content and two minerals (magnesium, cobalt). We are not aware that these associations have been described elsewhere for colostrum of other animal species and we are also not aware of their biological relevance.

Correlations studies of colostrum components were mostly conducted to test the use of rapid on-farm tools like colostrometer or refractometer for colostrum quality determination. RID is the reference method for IgG determination in colostrum, but it takes at least 24 h to obtain a result. Furthermore, it is an expensive method [45]. The colostrometer measures the specific gravity, which is influenced by the temperature and dry matter content of the colostrum. Higher solids and/or fat content result in a higher specific gravity value [46,47]. Digital or optical refractometers measure the refractive index of liquids on a Brix scale with acceptable sensitivity and specificity compared with RID and it is not sensible to temperature [30,45,48,49]. Flodr et al. [15] determined the IgG content of alpaca colostrum by refractometer and RID analysis and detected a strong correlation between the two methods. For the use of these on-farm tools in SAC, however, cut-off values for the evaluation of the result are not yet available and must first be determined. It would then be possible to check the quality of the colostrum quickly and inexpensively and, if necessary, promptly intervene and supplement adequately.

5. Conclusions

In conclusion, the concentrations of IgG in the colostrum of alpacas decrease significantly within the first four days after parturition. Compared to other animal species, the IgG concentration in alpaca colostrum is similar to those of other SACs, while substantially lower contents have been reported for bovine, caprine and ovine colostrum. The IgG content correlated negatively with the fat and lactose content, and positively with the protein content. Due to the strong correlation, a high colostrum protein concentration could be used as a predictor for a sufficient IgG content in the colostrum of alpaca.

Author Contributions: Conceptualization, M.M., V.M.R. and T.W.; methodology, M.M. and T.W.; software, M.M. and T.W.; validation, M.M., K.R., T.A. and T.W.; formal analysis, T.W.; investigation, M.M. and V.M.R.; resources, M.M., K.R., V.M.R., T.A. and T.W.; data curation, M.M. and T.W.; writing—original draft preparation, M.M.; writing—review and editing, K.R. and T.W.; visualization, M.M., K.R. and T.W.; supervision, T.W.; project administration, M.M., K.R., V.M.R. and T.W.; funding acquisition, T.W. All authors have read and agreed to the published version of the manuscript.

Funding: Open Access Funding by the University of Veterinary Medicine Vienna.

Institutional Review Board Statement: Discussed and approved by the institutional ethics and animal welfare committee in accordance with GSP guidelines and national legislation (Ethic Code ETK-21/11/2016).

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available on request. The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors would like to thank the alpaca breeders for their permission to use the animals in the study. For his assistance in laboratory work we would like to thank Andreas Zaiser. This study was financially sponsored by the Austrian Buiatrics Association (ÖBG), for which we are grateful.

Conflicts of Interest: The authors declare no conflict of interest.

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4. Erweiterte Diskussion

Um ein geeignetes Ersatzprodukt für Alpakakolostrum zu finden, wird der Gehalt der Inhaltstoffe von Alpakakolostrum analysiert und mit der Zusammensetzung des Kolostrums anderer Tierarten, die häufig bei uns gehalten werden, verglichen.

Muss ein Cria zugefüttert oder komplett mit einem Ersatzprodukt gefüttert werden, so ist es wichtig in den ersten Tagen ausreichend Kolostrum zu tränken. Wenn es zwei Stunden nach der Geburt noch nicht selbstständig gesaugt hat, muss mit dem Füttern von Kolostrum begonnen werden (Tibary et al. 2014). Als Faustregel gilt, dass das Neugeborene in den ersten zwölf Stunden nach der Geburt 10 % des eigenen Körpergewichts getrunken haben soll, mindestens die Hälfte dieser Menge in den ersten sechs Stunden nach der Geburt (Tibary et al. 2014, Wittek et al. 2021). In der Literatur findet man verschiedene Fütterungsempfehlungen. Entweder füttert man alle zwei Stunden unter Tags und in der Nacht alle vier Stunden. Oder man füttert 5 % des Körpergewichts in einer Fütterung und die gleiche Menge 6 bis 8 Stunden später (Tibary et al. 2014). In einer anderen Publikation wird empfohlen, anfangs ca. 3,5 % des Körpergewichts pro Mahlzeit zu füttern (Whitehead und Cebra 2014). Am besten eignet sich eine Flaschenfütterung. Wenn allerdings kein Saugreflex vorhanden ist, kann notfalls auch über eine Sonde gefüttert werden (Tibary et al. 2014). Müssen Crias bei der Aufzucht unterstützt werden, so ist der Kontakt mit dem Jungtier trotzdem auf einem Mindestmaß zu halten, da es sonst zu Fehlprägungen und Verhaltensstörungen kommen kann (Gauly et al. 2018, Wittek et al. 2021).

Die erste Hypothese, dass sich der Gehalt der untersuchten Inhaltstoffe Fett, Protein, Laktose, Immunglobulin G und Mineralstoffe im Alpakakolostrum innerhalb der ersten vier Tage nach der Geburt signifikant verändert, konnte bestätigt werden:
Der Fettgehalt steigt in den ersten vier Tagen nach der Geburt täglich signifikant an, der Laktosegehalt zeigt einen signifikanten Anstieg von Tag 1 zu Tag 2. Der Proteingehalt sinkt signifikant von Tag 1 zu Tag 2 (Mößler et al. 2021). Der Immunglobulin G Gehalt sinkt signifikant von Tag 1 zu Tag 2 und von Tag 3 zu Tag 4 (Mößler et al. 2022). Bei den Mineralstoffen Barium, Eisen, Kalzium, Kobalt, Kupfer, Magnesium, Nickel, Phosphor, Schwefel, Selen, Strontium und Zink wurden signifikante Veränderungen im Gehalt nachgewiesen (Mößler et al. 2021). Wie in den Publikationen diskutiert, treten diese Veränderungen auch bei anderen Tierarten auf.

Die zweite Hypothese, dass es zwischen dem Gehalt an Immunglobulinen und den anderen Inhaltsstoffen des Alpakakolostrums signifikante Korrelationen gibt, konnte bestätigt werden: Der Gehalt an Immunglobulin G korreliert negativ mit dem Gehalt an Fett und Laktose und positiv mit dem Gehalt an Protein, Magnesium und Kobalt (Mößler et al. 2022).

Die dritte Hypothese, dass die untersuchten Inhaltsstoffe Fett, Protein, Laktose, Immunglobulin G und Mineralstoffe im Alpakakolostrum sich von anderen Tierarten unterscheiden, wird in der erweiterten Diskussion ausgeführt.
Für den Vergleich mit den Tierarten Rind, Schaf und Ziege werden Veröffentlichungen verwendet, in denen die gleichen oder sehr ähnliche Untersuchungsmethoden angewendet wurden, um eine direkte Vergleichbarkeit zu gewährleisten. Bei dem Vergleich des Laktosegehalts war dies nicht möglich, da es nur wenige Veröffentlichungen mit der gleichen Untersuchungsmethode gibt.

Alpakakolostrum enthält am Tag der Geburt 0,64 ± 0,56 % Fett. Im Vergleich dazu enthält das Kolostrum von Schaf und Ziege mit 7,43 ± 0,44-8,25 ± 0,51 % (Yang et al. 2009, Alves et al. 2015, Mohamed 2015) und Rinderkolostrum mit 5,44 ± 0,65-6,79 ± 0,16 % (Patoo et al. 2014, Mohamed 2015, Aydogdu und Guzelbektes 2018, Erdem und Okuyucu 2020) mehr Fett am Tag der Geburt. Der Laktosegehalt im Alpakakolostrum am Tag der Geburt beträgt 4,07 ± 0,64 %. Schaf- und Ziegenkolostrum enthalten am Tag der Geburt 1,99 ± 0,75-3,70 ± 0,94 % (Romero et al. 2013, Hodulová et al. 2014, Kessler et al. 2019) und Rinderkolostrum 1,96 ± 0,49-2.82 ± 0.08 % (Zarei et al. 2017, Wąsowska und Puppel 2018, Wojtas et al. 2019) Laktose. Am Tag der Geburt weist Alpakakolostrum einen Proteingehalt von 19,46 ± 5,24 % auf. Der Proteingehalt in Schaf- und Ziegenkolostrum beträgt am Tag der Geburt 10,24 ± 2,15-15,26 ± 0,47 % (Caja et al. 2006, Yang et al. 2009, Mohamed 2015) und in Rinderkolostrum 14,92 ± 3,32-18,12 ± 0,92 % (Kehoe et al. 2007, Aydogdu und Guzelbektes 2018). Am ersten Tag beträgt der Immunglobulin G Gehalt von Alpakakolostrum 263,31 ± 87,5 g/l. Der IgG-Gehalt von Schaf- und Ziegenkolostrum beträgt 48,1 ± 5,0-89,4 ± 34,8 g/l (Amalric 2011, Higaki et al. 2013, Moretti et al. 2010) und von Rinderkolostrum 63,6 ± 17,7-96,1 ± 38,4 g/l (Kehoe et al. 2007, Silva-Del-Río et al. 2017, Lago et al. 2018). Am zweiten Tag beträgt der IgG Gehalt im Alpakakolostrum 92,34 ± 57,79 g/l, am dritten Tag 72,80 ± 50,14 g/l und am vierten Tag 38,49 ± 34,76 g/l. Das Kolostrum von den anderen Tierarten ist signifikant fetthaltiger, laktose- und proteinärmer als Alpakakolostrum. Durch den Vergleich der Zusammensetzungen gibt es keine Erklärung, warum in der Literatur zumeist Schaf- oder Ziegenkolostrum als Ersatzprodukt empfohlen wird, da bei diesen

Untersuchungen keine Tierart eine ähnliche Zusammensetzung der Hauptinhaltsstoffe am Tag der Geburt aufweist. Bei keiner anderen Tierart kann ein vergleichbar hoher Immunglobulingehalt wie im Alpakakolostrum gefunden werden. Es zeigt sich, dass das Kolostrum von Alpakastuten vom zweiten bzw. dritten Tag nach der Geburt zumeist noch ähnlich hohe Gehalte aufweist, wie das Kolostrum anderer Tierarten am Tag der Geburt. Trotz intensiver Literaturrecherche konnte keine Untersuchung gefunden werden, ob Alpakacrias Immunglobuline anderer Tierarten im Verdauungstrakt aufnehmen können und diese dann einen Immunschutz bieten. Es gibt jedoch eine Veröffentlichung, in der die Aufnahmefähigkeit von Immunglobulinen aus Rinder- und Ziegenkolostrum bei neugeborenen Kamelen untersucht wurde. Die Fohlen erhielten entweder Kolostrum von der eigenen Mutter oder gepooltes Kolostrum mit ähnlichem Immunglobulin G Gehalt von Rindern oder Ziegen. Die Studie zeigte eine ähnliche Aufnahmefähigkeit von IgG bei der Fütterung mit Ziegen- und Rinderkolostrum (Al-Busadah 2007).

Bei den Mineralstoffen zeigen die Mengenelemente Kalzium, Magnesium, Phosphor und Schwefel, sowie viele Spurenelemente ihren höchsten Gehalt am Tag der Geburt. Beim Vergleich mit der Zusammensetzung von Kolostrum anderer Tierarten unterscheidet sich der Gehalt je nach untersuchtem Element. Während der Selengehalt von Alpakakolostrum reifer Ziegenmilch (Licata et al. 2012) ähnelt, so ist es bei Kupfer das Yakkolostrum (Mi et al. 2016) und bei Eisen die reife Alpakamilch (Mößler et al. 2021), die als Ersatz am ähnlichsten sind. Somit kann auch hier keine andere Tierart als idealer Ersatz festgelegt werden, da dies sehr stark vom jeweilig untersuchten Mineralstoff abhängt. Jedoch zeigt sich wieder, dass sich das Kolostrum vom Tag der Geburt von der Zusammensetzung während der restlichen Laktation bei vielen Mineralstoffen abhebt. Dies bestätigt wieder die Wichtigkeit einer guten Versorgung mit Kolostrum am ersten Lebenstag.

Grundsätzlich lässt sich sagen, dass bei Milchmangel oder Verlust der Mutterstute frisches oder eingefrorenes Alpakakolostrum die beste Alternative für das Cria ist. Da bei einem solchen Notfall sehr selten frisches Alpakakolostrum vorhanden ist, empfiehlt es sich vorbereitet zu sein und Kolostrum vorrätig einzufrieren, um schnell reagieren zu können. Dafür am besten geeignet ist Kolostrum, welches von gesunden Muttertieren am Tag der Geburt gewonnen wurde. Allerdings ist das nur bei sehr milchreichen Stuten möglich, das eigene Cria muss ausreichend Kolostrum aufnehmen können. Das Euter jeder Stute muss kurz nach der Geburt auf Veränderungen und Verhärtungen untersucht werden, bei Veränderungen soll eine tierärztliche Beratung hinzugezogen werden. Bei Verunreinigungen der Zitzen müssen diese mit einem warmen, feuchten Handtuch gereinigt und eventuell vorhandene Harzzapfen auf den Zitzenspitzen entfernt werden (Tibary et al. 2014). Im Rahmen dieser Tätigkeiten kann Kolostrum zum Einfrieren gemolken werden. Wenn man das Cria neben die Stute stellt oder es währenddessen trinkt, duldet die Stute die Untersuchungen zumeist besser (Wittek et al. 2021). Wichtig ist, dass das Kolostrum hygienisch entnommen wird, um eine bakterielle Verunreinigung zu verhindern. Die Zitzen müssen gereinigt und desinfiziert und das Kolostrum mit der behandschuhten Hand in ein steriles Gefäß gemolken werden (Wittek et al. 2021). Das Kolostrum muss gleich anschließend bei -20 °C in Gefrierbeuteln eingefroren werden, idealerweise in Portionsgrößen von 50-90 ml. Jeder Beutel sollte mit dem Datum der Entnahme und einer Zuordnung zu der Mutterstute beschriftet sein (Tibary et al. 2014, Wittek et al. 2021). Bei Lagerung im Kühlschrank kann es schnell zu bakteriellen Wachstum und somit zum Verderb kommen, weshalb eine Konservierung mittels Tieffrieren vorzuziehen ist (Kryzer et al. 2015). Richtig eingefrorenes Kolostrum kann bis zu einem Jahr ohne deutliche Qualitätsverluste gelagert werden. Beim Auftauen wird ein körperwarmes Wasserbad empfohlen, in dem die Kolostrumportion schonend und langsam aufgetaut und für die Fütterung auf Körpertemperatur gewärmt wird (Tibary et al. 2014).

Alternativ dazu werden kommerziell hergestellte Kolostrumersatzprodukte angeboten und zum Teil für den Einsatz bei Crias beworben. Meist wird bei der Herstellung gefriergetrocknetes Rinderkolostrum verwendet und somit enthalten diese Ersatzprodukte vergleichsweise weniger Immunglobulin und mehr Fett als das Alpakakolostrum. Jedoch sind solche Produkte einfach zu lagern und weisen ungeöffnet eine lange Haltbarkeit auf. Bei Verwendung wird eine angegebene Menge an Kolostrumpulver mit einer angegebenen Menge warmen Wassers verrührt und verfüttert.

Wenn kein Kolostrum oder Kolostrumersatzprodukt zur Verfügung steht, müssen Crias im Notfall mit Alpakamilch, Milch anderer Tierarten oder Milchersatz wie Milchaustauscher gefüttert werden, damit den Tieren Flüssigkeit und Nährstoffe zugeführt und die Darmaktivität angeregt wird. Jedoch müssen diese Crias intensiv beobachtet und betreut werden, da sie wegen der niedrigen Immunglobulingehalte keinen passiven Immunschutz über den Darm erhalten haben. Dieser Mangel kann mithilfe einer Plasmaübertragung abgefedert werden (Wernery 2001, Whitehead und Cebra 2014).

Die Alpakamilch unterscheidet sich nicht nur im Immunglobulingehalt, sondern auch der Proteingehalt der Milch ist deutlich geringer als im Kolostrum. Der Fett- und Laktosegehalt verändert sich nach den ersten drei Lebenstagen nicht mehr deutlich, sondern der Gehalt am

Tag 4 ist ähnlich dem Gehalt der restlichen Laktation (Mößler et al. 2021). Die Zusammensetzung von Rinder-, Schaf- und Ziegenmilch zeigt einen höheren Fettgehalt und einen deutlich geringeren Proteingehalt als das Alpakakolostrum, die Alpakamilch unterscheidet sich von Rinder-, Schaf- und Ziegenmilch durch einen geringerer Proteingehalt (Krömker et al. 2006, Märtlbauer und Becker 2016).

5. Fazit

Die Zusammensetzung des Alpakakolostrums verändert sich innerhalb der ersten vier Tage nach der Geburt signifikant. Im weiteren Laktationsverlauf zeigen sich keine signifikanten Änderungen der Hauptinhaltsstoffe. Durch die Vergleiche mit anderen Tierarten lässt sich zusammenfassend sagen, dass kein anderes Kolostrum den Anforderungen eines Crias optimal entspricht. Somit kann jedem Züchter nur geraten werden, Alpakakolostrum auf Vorrat einzufrieren, um es im Notfall zur Hand zu haben. Wenn dies nicht möglich ist, soll entweder auf frisches Rinderkolostrum vom Tag der Geburt oder auf ein Kolostrumersatzprodukt zurückgegriffen werden. Rinderkolostrum ist zumeist leichter verfügbar und in der Zusammensetzung dem Alpakakolostrum ähnlicher als Schaf- und Ziegenkolostrum.

6. Zusammenfassung

Neuweltkamele werden in Österreich immer häufiger zur Zucht eingesetzt. Um bei Tod der Mutterstute oder bei Milchmangel das Neugeborene (Cria) optimal zu versorgen, benötigt man detailliertes Wissen über die Zusammensetzung des Kolostrums. Dafür wurden im Rahmen dieser Arbeit von 20 Alpakastuten an den ersten vier Tagen der Laktation 77 Proben an Kolostrum gewonnen. Die erste Probennahme war am Tag der Geburt. Alle Proben wurden auf den Gehalt der Inhaltstoffe Fett, Laktose, Protein, Immunglobulin G und verschiedener Mineralstoffe untersucht. Am Tag der Geburt enthält Alpakakolostrum 0,64 ± 0,56 % Fett, 4,07 ± 0,64 % Laktose, 19,46 ± 5,24 % Protein und 263,31 ± 87,5 g/l Immunglobulin G. Der Fettgehalt steigt alle vier Tage *post partum* signifikant an, der Laktosegehalt zeigt einen signifikanten Anstieg vom Tag der Geburt zum Folgetag und verändert sich dann nicht mehr signifikant. Der Proteingehalt sinkt signifikant vom Geburtstag zum Folgetag und nimmt weiter ab, aber nicht mehr signifikant. Der Vergleich mit Kolostrum der anderen Tierarten Rind, Schaf und Ziege zeigt einen deutlichen Unterschied in der Zusammensetzung. Züchtern wird empfohlen, frisches Alpakakolostrum von gesunden Mutterstuten am Tag der Geburt abzumelken und dieses in Portionsgröße für einen solchen Notfall einzufrieren, da Crias damit optimal versorgt werden können. Wenn dies nicht möglich ist, kann auf frisches Rinderkolostrum oder auf ein kommerziell hergestelltes Kolostrumersatzprodukt zurückgegriffen werden.

7. Summary

New World camels are more frequently used for breeding in Austria. To provide optimal care for the newborn (cria) in case of death of the mother mare or milk shortage, detailed knowledge about the composition of the colostrum is needed. For this purpose, 77 samples of colostrum were obtained from 20 alpaca mares during the first four days of lactation, starting on the day of parturition. The fat, lactose, protein, immunoglobulin G and mineral content was determined in the samples. On the day of birth, alpaca colostrum contained 0.64 ± 0.56% fat, 4.07 ± 0.64% lactose, 19.46 ± 5.24% protein, and 263.31 ± 87.5 g/l immunoglobulin G. The fat content significantly increased every four days *post partum*, and the lactose content showed a significant increase from the day of birth to the following day. No significant change was observed the following days. Protein content significantly decreased from the day of birth to the second. The comparison with colostrum of the other animal species like cattle, sheep and goat showed significant difference in composition. Breeders are advised to milk fresh alpaca colostrum from healthy dams on the day of parturition and freeze it in portion size for such an emergency, as this will provide optimal nutrition for crias. If this is not possible, fresh bovine colostrum or a commercially produced colostrum substitute can be used.

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Danksagung

Ich möchte mich an dieser Stelle bei Herrn Univ.-Prof. Dr. Thomas Wittek für die hervorragende Betreuung und Unterstützung bedanken. Ebenso gilt mein Dank Dr. Kathrin Kober-Rychli für die gute Zusammenarbeit und Unterstützung.

Ein besonderes Danke geht an Dr. Michael Reichmann, der mich einerseits bei der Projektentwicklung und andererseits auch während der Zeit der Probennahme immens unterstützt hat. Ohne dich wäre dieses Projekt nicht zustande gekommen!

Auch ohne die Zustimmung, Mitarbeit und Bereitstellung der Alpakastuten der drei Alpakabetriebe Fam. Mickiewicz, Fam. Sonnbichler und Fam. Unterberger wäre das Projekt nicht möglich gewesen. Vielen herzlichen Dank dafür.

Weiterhin möchte ich mich bei der Österreichischen Buiatrischen Gesellschaft für die finanzielle Unterstützung der Laboranalytik bedanken.