CHARACTERIZATION OF MILK PRODUCTION SYSTEMS IN THE COUNTY OF ALEGRETE, RS, BRAZIL, BASED ON PRODUCTIVE INDEXES

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Abstract

This study aimed to characterize dairy production systems in Alegrete, RS, Brazil, based on productive indices, management practices, and technification. The present study was conducted on 43 farms distributed in 22 localities of the county. The collection of data on milk production systems was carried out through visits to the properties, using a semi-structured guide questionnaire. The data obtained with the questionnaires were tabulated in Excel and with the aid of the IBM SPSS Statistics 20.0 software, through multivariate statistics, data were submitted to main component analysis (MCA) and hierarchical clusters analysis (HCA), allowing the division of 43 production units into homogeneous groups. The studied variables were summarized through the MCA in two main components (1 and 2), which clarified 71.53% of the explained variance. The alpha-Cronbach values observed for the two main components totaled 0.977, a result that confirms the reliability of the questionnaire used and reveals the high correlation between the answers obtained. From the hierarchical classification analysis, the dataset of the 43-farm studied was reduced to six groups (G1, G2, G3, G4, G5, and G6). The quadrants obtained from the insertion of the axes of the main components 1 and 2 allowed the interpretation of the groups of systems, according to the characteristics related to milk production. G2 presented the highest number of farms of the six systems formed, representing 41.86% of the establishments studied. These are characterized by being a more productive farm, an average 881-1 L day, with greater technological adoption of production and greater area destined to milk production, corresponding to the average of 78 hectares. The productive aspects that define the characteristics of milk production systems in the county were related to the structure of the herd, pasture area, daily production, disposal criteria, and milking management. The main differences found in the different groups are related to the productive indexes, suggesting that the technical assistance and rural extension actions in the dairy production systems in the county of Alegrete should be directed according to the individual need of each group formed.

Keywords: Cluster Analysis. Dairy Properties. Production Systems. Technology.

1. Introduction

Milk production is one of the most explored activities in Brazilian agribusiness, where Brazil ranks fifth in the world ranking of milk production (Maia and Rodrigues 2012; Willers et al. 2014; Strassburger et al. 2019). In 2019, Brazil industrialized approximately 25 million liters of milk, with the state of Rio Grande do Sul (RS) responsible for 13% of this volume (IBGE 2019). So, milk production plays an important role in providing food and creating jobs, contributing to the movement of the economy in the regions where they are inserted (Maia and Rodrigues 2012; IBGE 2019). In recent years, this activity has undergone structural changes according to the technological level adopted in the dairy farms related to zootechnical, nutritional, sanitary, and reproductive aspects (Lange et al. 2016).

The dynamic and inherent character of the production environment, socioeconomic diversity, and soil and weather conditions are factors that characterize milk production systems (MPS). In Brazil, there is big heterogeneity of MPS, because the existing systems come from the interaction between two subsystems, the biotechnological subsystem, associated with biological responses related to factors of production, and the decision subsystem, where producer decisions are translated into the actions of farm management practices (Gabbi et al 2016; Strassburger et al. 2019). The technical characterization of an MPS is extremely important because it allows the identification of the main organizational processes associated with livestock activities developed in each production unit and through this diagnosis, it is possible to develop strategic planning for decision-making through technical guidance and research bodies in the study regions (Moura et al. 2013; Gabbi et al. 2016; Bankuti and Caldas 2018).

The state of Rio Grande do Sul shows big heterogeneity in milk production among its seven mesoregions where the state is divided, this factor is mainly due to the technological and zootechnical aspects used in the MPS and the volume of milk produced in each region (Gabbi et al. 2016; Silva et al. 2019). The county of Alegrete located in the western region of the state of Rio Grande do Sul, obtained a 44% increase in the volume of milk produced between the years 2006 to 2015 (IBGE 2015), which contributed to the growth of the western region of the state in the scenario of dairy production. However, there are no studies that identify which factors are associated with milk production in the municipality of Alegrete, RS. Thus, the objective of the present study was to characterize the production systems in dairy farms in the municipality of Alegrete, RS, Brazil, based on production indexes, milking practices, and herd management, as well as the technological level employed.

2. Material and Methods

The present study was conducted at dairy farms of the county of Alegrete, RS, Brazil, located at latitude 29º 46 '59 "S and longitude: 55º 47' 31" W, at an altitude of 102 m, comprising 43 distributed farm in 22 localities of the county. The farms of each locality were represented by daily volume of milk, where production systems were ordered according to productivity. The access to the properties and their respective productions was carried out in partnership with Emater/Ascar-RS of the county. The daily sold volume of milk was used as a criterion for the representativeness of dairy producers in each city, who were ordered according to production. From this ordered database, it was possible to randomly select the producers, where three producers were excluded, and the following was selected. This step was repeated from the producers with the highest to the lowest daily volume of milk, characterizing a proportional and representative sampling.

The data collection for the MPS was carried out through visits to the properties, using a semi-structured guide questionnaire. This questionnaire obtained 84 observations, approaching information about the cadastral data, characterization of the owner, rural property, dairy production, herd, nutritional management, milking management, reproductive management, sanitary control, and finalizing the milk marketing strategies.

At the end of the interview, each producer response was considered a variable. Subsequently, the method of selection of the variables was performed, through the Main Components Analysis (MCA), the methodology used for the exploration of categorical data, analogous to Factor Analysis, used mainly to graphically verify relationships between categories of variables. The variables that obtained the highest contribution scores described in terms of explained variance were maintained (Kubrusly 2001).

The data obtained with the questionnaires were tabulated in Excel and with the aid of the SPSS Statistics 20.0 software, through multivariate statistics were submitted to the Main Component Analysis (MCA) and Hierarchical Clusters Analysis (CHA) to divide the 43 units of production into homogeneous groups.

The data obtained from the questionnaires were tabulated in Excel and subjected to multivariate analysis (factorial and cluster analysis), using the statistical software IBM SPSS Statistics 20.0. for divide the 43 milk-producing units into homogeneous groups. In factor analysis, the Bartlett Test was used to evaluate the statistical criteria to reduce the number of variables, with a Measure of Sampling Adequacy (MSA) greater than or equal to 0.6. The clusters were analyzed by analysis of variance and the means were compared by the Tukey test considering a 5% significance level, as described by Hair et al. (2009) e Lopes Junior et al. (2012).

3. Results and Discussion

The variables studied were summarized by MCA in two main components (1 and 2), which explained 49.96% and 21.57% of the dataset variance, respectively, totaling 71.53% of the variance explained in the study (Table 1). The total of the explained variance is above the 70% recommended by Fávero et al. (2009) for greater reliability of the study. We can say that the higher the percentage of accumulated variations, the greater the number of variables were used to explain the work. The Cronbach's alpha values observed for the two main components (Table 1) are above the value of 0.70 quoted by Hora et al. (2010) as the minimum for the validation of the questionnaire used. The results found in this study are similar to those obtained by Lange et al. (2016), Lopes Junior et al. (2012), and Bodenmüller Filho et al. (2010) when studying the typification of milk production systems of the State of Paraná. Therefore, our results confirm the reliability of the questionnaire used and reveal the high correlation between the answers obtained.

Table 1. Main components (MCs) eigenvalues (λi) and percentage of variance explained and accumulated (%) by the components.

Main components	α Cronbach*	Eigenvalues (λi)	Variance explained (%)	Variance accumulated (%)
1	0.941	8.992	49.957	49.957
2	0.786	3.883	21.574	71.531
Total	0.977	12.876	71.531	-

*Based on the totals of the eigenvalue.

Integrating the two components formed, also called explanatory variables (Lopes Junior et al. 2012) are 18 variables (Table 2), which translate the association between the original qualitative variables and that were used to measure the productive aspects contemplated in the study and the main components formed. These variables are mainly related to herd structure and milking management (Table 2). At MC 1, the variables: total number of animals (TotAnim), number of lactating cows (LactCows) daily production of liters of milk (ProdDaily), type of milking machine (TypeMilk), cleaning of the milking machine (CleanMilking), and type of cooler (TypeCooler) were the ones that had greater weight in the composition of this component. At MC 2, the variables of the greatest weight were the pasture area of each property (AreFod) and again the type of milking machine (TypeMilk), the cleaning of the milking machine (CleanMilking), and the type of cooler (TypeCooler).

From these variables, it is possible to understand that at the study site, the number of animals, daily production, and characteristics of the milking system are the determining factors in milk production systems. These factors are related, because as the number of animals increases, the number of cows in production increases, and consequently the milk production, necessitating a larger pasture area. Accompanying this evolution, there is a need for the adequacy of the milking system of the properties to attend to the largest number of animals in milking and the highest milk volume daily.

The values of each variable in the components (Table 2), the relationship between the variables identified in the MCA, and the two dimensions formed with the two main components identified from the eigenvalues of the variables explain the variation and enable the characterization of the properties milk producers in the county of Alegrete, RS, Brazil. The technical assistance (TechAss) and the variables that characterize the management of milking (TypeCooler, TypeMilk, CleanMilking, CleanMilkParl, Dipping, MilkColl, and CleanFeedUten) are correlated because they form acute angles among themselves (Fraga et al. 2016). In the same way, herd structure variables (TotAnim, LactCows, Heifers), production (ProdDaily), area and pastures (TotArea, AreFod), infrastructure (CowRest), and sanity (DryCowTreat) (Figure 1). However, although the resting place of cows (CowRest) has a relation with the technical assistance (TechAss), it is not related to the other variables of the study, since it presents an angle greater than 90 degrees (Hora et al. 2010).

Table 2. Values of each variable in each of the major components used for the characterization of dairy properties in the county of Alegrete, RS, Brazil.

Variable	Description of the variable	Main component	
		1	2
TotAnim	Total cattle size in the farm	0.818*	-0.490
LactCows	Lactating cows in the farm	0.834	-0.457
Heifers	Total heifers on the farm	0.707	-0.419
TotArea	Total farm area	0.723	-0.539
AreFod	Area for fodder production	0.573	-0.648
ForTypes	Forage types and systems used	0.702	-0.154
ProdDaily	Daily milk production in the farm	0.834	-0.423
HousHeifers	Place of the housing of heifers	0.557	-0.062
TypeMilk	Milking type in the farm	0.807	0.550
Dipping	Dipping use	0.710	0.390
CowRest	Cow resting place	-0.608	0.457
CleanMilking	Cleaning the milking machine	0.808	0.545
TechAss	Technical assistance	-0.031	0.532
MilkColl	Milk collection period	0.726	0.484
CleanMilkParl	Cleaning the milking parlor	0.768	0.507
CleanFeedUten	Cleaning of feeding utensils	0.679	0.520
TypeCooler	Type of milk cooler	0.796	0.566
DryCowTreat	Dry cow treatment	0.620	-0.125

*Weight of each variable studied in each component.

In the study of the direct correlations between studied variables, it was verified that in the set of variables: total animals (TotAnim), number of lactating cows (LactCows), number of heifers, total area of the property (TotArea), pasture area (AreFod), forage system used (ForTypes) and daily production (ProdDaily), all have a positive correlation with each other. However, all the variables mentioned above have a negative correlation with the resting place of cows (DiscCow) (Table 3).

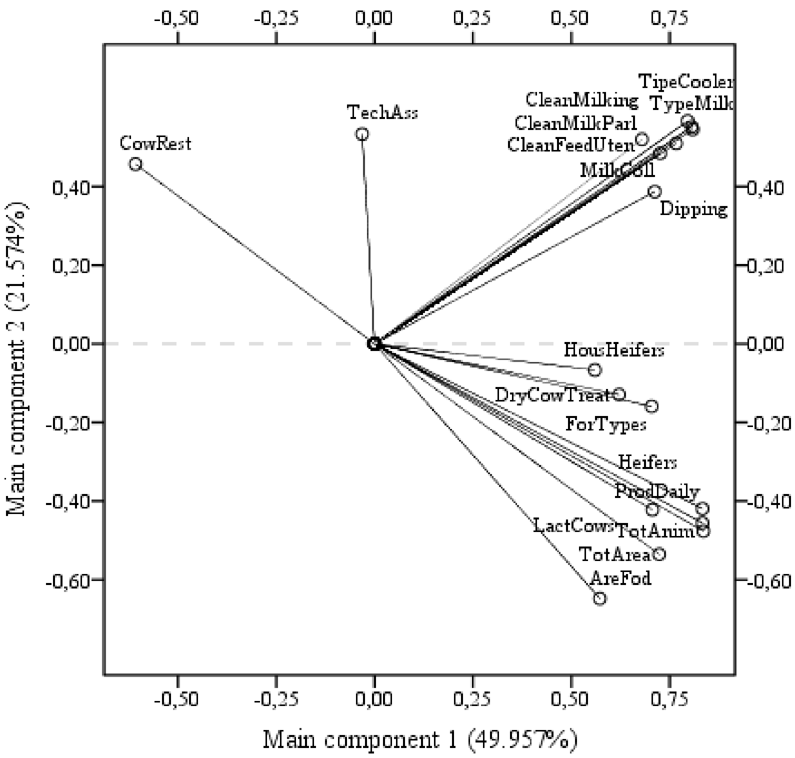

Figure 1. Projection and contributions of the variables for the formation of main components 1 and 2 that retains the existing variance in milk production units of the county of Alegrete, RS, Brazil. MC: main component; TotAnim: total cattle size in the farm; LactCows: lactating cows in the farm; Heifers: total heifers on the farm; TotArea: total farm area; AreFod: area for fodder production; ForTypes: forage types and systems used; ProdDaily: daily milk production in the farm; HousHeifers: a place for housing the heifers; TypeMilk: milking type in the farm; Dipping: dipping use; CowRest: cow resting place; CleanMilking: Cleaning the milking machine; TechAss: technical assistance; MilkColl: milk collection period; CleanMilkParl: cleaning the milking parlor; CleanFeedUten: cleaning of feeding utensils; TypeCooler: type of milk cooler; DryCowTreat: dry cow treatment.

In the first group of variables, the positive correlation is justified by the characteristics of the dairy activity, because the increase in one of the variables as a total herd, followed by the recommended structuring of the herds, consequently, also increase the number of animals in the other categories (lactating cows and heifers, for example). Also, the greater number of animals requires a larger area, especially for fodder production, and greater specialization in the forage base to ensure the feeding of all herd. However, due to the greater number of animals and greater forage need, the areas of pasture are no longer used for the rest of the cows, leading them to be housed in other places to rest, such as exclusive pickets for this purpose or feeding rooms. This adjustment in properties whose food base is a pasture with direct grazing causes food losses to the animals since especially in periods of high temperature cows adopt nocturnal grazing as a priority grazing or complementary to day grazing to meet your need for dry matter consumption.

Regarding the resting of the cows and the places destined for this purpose, when they are not kept in confinement, it is important to observe the minimum area for each animal and the type of floor of the environment. A minimum area of 40-50 m² per animal is required to reduce the risk of mud formation and to avoid competition between cows. Also, the areas destined to the rest of the cows can be their pastures or paddocks destined for this purpose, provided they have characteristics such as moderate slope and soil with good drainage, for flow and infiltration of rainwater, respectively (Araujo et al. 2016). The prevention of mud formation in environments frequented by dairy cows, especially resting areas, is essential to reduce the incidence of clinical and subclinical mastitis (Israel et al. 2018).

This prevention is essential because the infection of the mammary gland occurs with greater frequency and intensity when the animals are exposed to places with excess humidity, accumulation of organic matter, and dirt. This attention needs to be redoubled when it comes to the environments destined to the rest of the animals in the pre- and post-milking, aiming at reducing the presence of mud, soil, and manure (Costa et al. 2017). For critical areas such as troughs and drinking fountains, it is recommended to scrape and remove mud frequently. If the problem is recurrent it is recommended to concrete an area of 3 m around the troughs and drinking fountains, as these situations also predispose the animals to a higher incidence of hull problems and reduction of feed consumption (Araujo et al. 2016).

Table 3. Correlations between the main herd structure variables (LactCows and Heifers), pasture area (TotArea, AreFod, and ForTypes), (ProdDaily) and discard criteria (DiscCow) used for the characterization of the milk production systems Alegrete, RS, Brazil.

	LactCows	Heifers	TotArea	AreFod	ForTypes	ProdDaily	DiscCow
TotAnim	0.953**	0.815**	0.856**	0.793**	0.565**	0.921**	-0.665**
LactCows		0.755**	0.845**	0.811**	0.595**	0.916**	-0.675**
Heifers			0.594**	0.566**	0.607**	0.782**	-0.626**
TotArea				0.871**	0.493*	0.816**	-0.588**
AreFod					0.445*	0.714**	-0.525**
ForTypes						0.612**	-0.557**
ProdDaily							-0.656**

**: significant at 1% probability; *: significant at 5% probability.

Regarding the characteristics of milking management, a positive correlation was found between all variables studied (Table 4). This shows, for example, that the greater the investment made by the producer in terms of equipment (milking machines and cooler), the greater is also your awareness of using the products and perform the proper hygiene of milking. The positive correlation of the milking characteristics with the frequency of milk pick-up demonstrates a return from the industry to the producers who make the investments and adopt appropriate milking practices. This aspect is relevant since the properties that correctly adopt and follow the recommended technologies for the management of milking produce an improvement in the quality of milk produced (Nero et al. 2009). Still, concerning producers, the degree of education is decisive in the acceptance of new technologies (Winck and Thaler Neto 2012). Thus, for the management of milking, the adoption of technologies through equipment suggests that the producer can adopt for his property materials that contribute to the improvement of milk quality produced.

Table 4. Correlations between the main milking management variables used for the characterization of the milk production systems in the county of Alegrete, RS, Brazil.

	Dipping	CleanMilking	MilkColl	CleanMilkParl	CleanFeedUt	TypeCooler
TypeMilk	0.730**	0.997**	0.856**	0.927**	0.788**	1.000**
Dipping		0.742**	0.619**	0.662**	0.735**	0.725**
CleanMilking			0.853**	0.923**	0.783**	0.996**
MilkColl				0.755**	0.673**	0.856**
CleanMilkParl					0.732**	0.928**
CleanFeedUt						0.792**

**: significant probability 1.

From the knowledge of the incidence of each variable within each case, that is, of their weight measured by inertia, they were submitted to Hierarchical Classification of Clusters aiming at the formation and explanation of groups of production systems. The purpose of Hierarchical Classification analysis is to group similar to maintain maximum variance between groups and low intra-group variance (Lopes Junior et al. 2012). From this analysis, the data set of the 43 properties studied were reduced in six groups (G1, G2, G3, G4, G5, and G6) (Table 5 and Figure 2). The quadrants obtained from the intersection of the axes of the main components 1 and 2 allow the interpretation of the groups of systems, according to the characteristics related to milk production (Figure 1).

The G1 is the second with the largest number of producers, representing 32.55% of the total studied. This group has as characteristic the low level of technification, which corresponds to the observed data, regarding the productivity and number of animals of the properties, having as a premise the coverage technique, where the predominance is the system natural breeding (57.14%). When referring to the management of milking, the type of equipment adopted by the G1 was the bucket milking system, which corresponded to 71.43% of the properties, this data about the low number of animals in the group (average of 27 lactating cows). According to Silveira et al. (2008), the bucket system at the foot is considered the cheapest, being used mainly in properties with up to 50 animals. Regarding the quality of milk, this system requires greater hygiene care, since the milk stays for a short time in direct contact with the environment, allowing contamination and microbial proliferation in the milk when no precautionary measures are taken.

Table 5. The number of cases and key features of the clusters formed from principal component analysis for characterization of dairy properties from Alegrete, RS, Brazil.

Cluster	n	TotAnim	LactCows	Heifers	ProdDaily	ProdHecYear	TotArea	AreFod
1	14	27	11	6	103	1720	25	15
2	18	138	53	30	881	2821	161	78
3	6	53	21	17	331	3660	38	29
4	1	205	82	60	500	1055	173	60
5	3	20	3	3	13	161	39	36
6	1	6	2	1	15	608	9	7

n: number of farms; TotAnim: Total cattle size in the farm; LactCows: Lactating cows in the farm; Heifers: Total heifers on the farm; ProdDaily: Daily milk production in the farm; ProdHecYear: Production of milk hectare year^{-1}; TotArea: Total farm area; AreFod: Area for fodder production.

The experience time, over 10 years with the activity, by the G1 producers coincided with more than 50%, when compared to G2, which obtained higher productive performance, this result corroborates that although the time of experience is higher, this data does not correspond to the index of high productivity and performance of the activity. This justification was also found by Dantas et al. (2016) and explained by Solano et al. (2000), which states that other characteristics must be considered simultaneously, including the ability of producers to collect and process information, as well as the ability to use technologies and their predisposition to new challenges, which states that the medium and high level of schooling and instruction, interfere with the performance of the production.

The G2 has the highest number of properties of the six systems formed, representing 41.86% of the establishments studied. These are characterized by being properties with higher productivity, average 881 L day 1, with the greater technological adoption of production and greater area destined to milk production, corresponding to the average of 78 hectares. G2 is the production system that most presents owners with a high level of education and schooling, which justifies the performance of properties, characterizing them as properties with higher productive indices of the studied groups. Also observed in the study presented by Dantas et al. (2016), where it was verified that producers with the highest levels of education composed the group with the highest productive index. One notable observation is that 50% of these G2 producers had little experience in the activity, i.e., less than 5 years. However, in spite of the short time developing the milking activity, they spread the use of specific technologies, including the adequate use of feed to the herd, methods of milk quality control, such as the temperature of the cooling tank, correct hygiene of the milking, besides presenting a higher average of technical assistance, which indicates that the trainings and accompaniments provided are important and contribute to the success of milk production.

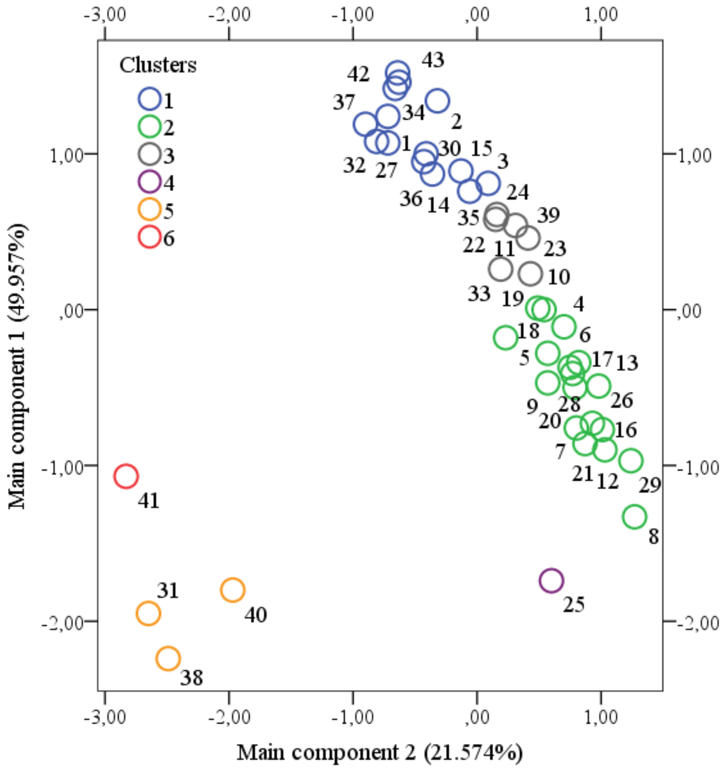

Figure 2. Representation of the clusters formed from principal component analysis for characterization of dairy properties from the county of Alegrete, RS, Brazil.

The G3 is composed of 13.95% of the establishments studied, characterized by the productive efficiency, is that it presents the highest hectare year $^{-1}$ yield correlated to the other groups. In this cluster are producers who unanimously receive technical assistance and participate effectively in courses and meetings promoted by the Association of Milk Breeders and Producers of Alegrete (ACRIPLEITE). In addition, the group has an average of 15 years of experience in the activity, including producers with education from incomplete primary education and full tertiary education. This demonstrates the importance of technical assistance and considerable levels of instruction for the growth and permanence of the producer in the activity.

The G4 is represented by 2.32% of the producers studied, distant from the other production systems in relation to the area destined to milk production and the number of animals of the property, which represents 3.41 animal units hectare^{-1}. Another factor observed and extremely relevant, which justifies the concern of the animal unit and pasture area, is the cow day $^{-1}$ production, which presents values of 6 L cow day $^{-1}$. According to Ferreira and Miranda (2007), the pasture stocking rate depends on the management system, soil fertility, fertilization, terrain topography, climate, pasture formation, among other factors, being that the Brazilian average is less than 1 animal unit hectare $^{-1}$. Using brachiaria pasture, for example, the animal load should be higher than 1.5 hectare $^{-1}$ cows, and in the case of rotational grazing in brachiaria, it should be above 3 hectare $^{-1}$ cows in the summer. Indices that are not applicable to the G4 due to the total area destined to the dairy production present plots of native field, winter, and summer pasture, without rotary management. However, the production area is lower than the number of animals and management adopted in the production system of the group, compromising productivity in L cow day $^{-1}$. The experience of the G4 producer in the dairy activity is 22 years and its educational level corresponds to the incomplete technical level, the property has technical assistance and technification in the management of milking, with the type of mechanized milking system and the destination of the animals after milking, being that the property owns room of feeding for animals. However, when referring to the type of coverage system, the property does not present technological advances, adopting the natural breeding system. G4 is the group that has the highest total number of animals in the herd, compared to the other groups of production systems, but it is not classified with high productivity, compromising the performance of the production system.

The G5 and G6 groups represent the lowest production strata, with average areas varying from 9 to 39 hectares, daily production of 13 and 15 L day $^{-1}$ and average productivity of 161 to 608 L production hectare year $^{-1}$, respectively. These results are explained because dairy farming is not the predominant activity in the group properties, intercalating with the production of beef cattle, fruit production, and horticultural products. The milking of the afternoon was intended for calves, and the first milking was intended for the production of derivatives, like dulce de leche, which were later marketed at the family farming fair every week in the main town square.

In order to obtain positive results in milk production, a set of practices such as nutritional management, sanitary management, and reproductive management, as well as practices that guarantee milk quality after milking, should be adopted by the production systems, ensuring the efficiency and permanence of the producer in the activity. Thus, Lange et al. (2016) and Dantas et al. (2016) point out that these methods, which include management in the property and the quality of the milk, are of paramount importance for the success of milk production and an increase of production rates.

4. Conclusions

The productive aspects that define the characteristics of milk production systems in the city of Alegrete, RS, Brazil were those related mainly to the herd structure, pasture area, daily production, disposal criteria, and milking management. From these, six distinct groups were identified whose main differences are related to the productive indexes, suggesting that the technical assistance and rural extension actions in the dairy production systems in the city of Alegrete, RS, Brazil should be directed according to the needs of each system. As well as further studies are needed to assess and correlate the economic and social level of milk producers in these regions, to increase the profitability of the production process.

Authors' Contributions: SILVA, C.A.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article; TADIELO, L.E.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article, critical review of important intellectual content; KASPER, N.F.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article, critical review of important intellectual content; ALTERMANN, O.D.C.: acquisition of data; GAYER, T.O.: acquisition of data; KROLOW, R.H.: acquisition of data; OAIGEN, R.P.: acquisition of data; CASTAGNARA, D.D.: conception and design, acquisition of data, analysis and interpretation of data, critical review of important intellectual content. All authors have read and approved the final version of the manuscript.

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