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Prospection of sustainable agrifood systems based on discourse analysis of Curraleiro Pé-Duro cattle breeders in Brazil

[*Prospecção de sistemas agroalimentares sustentáveis baseados na análise do discurso dos criadores de gado Curraleiro Pé-Duro no Brasil*]

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ABSTRACT

Developing countries face great challenges to couple agricultural intensification and sustainable supply chain development. This paper explores the opportunities for innovation in the conservation of the locally adapted Curraleiro Pé-Duro (CPD) cattle. The CPD is a historical Brazilian breed, related to regional culture, which exhibits remarkable adaptability in tropical biomes. The research method consisted of interviewing and analyzing the discourse of CPD breeders in Tocantins, Brazil. The systematization of the data resulted in four categories and eleven subcategories, which were defined a posteriori. Our findings reveal motivational aspects, potentialities, and prospects for valuation, besides the needs and perceived challenges faced by CPD farmers. A better understanding of the current situation may guide public policies, encourage stakeholders, benefit farmers, and lead to sustainable agri-food initiatives. The empirical contributions of our diagnosis are discussed, and we show how they bring forward and provide valuable lessons to prospect innovations in the conservation of CPD cattle. These findings may support scholars and people who are also interested in accessing and supporting the conservation of indigenous livestock. In general, the study supports the definition of strategies, planning, and investments for the value chain, including the participation of upstream and downstream segments of the farms.

Keywords: Cerrado, entrepreneurship, locally adapted, Bos taurus, supply chain

RESUMO

Os países em desenvolvimento enfrentam grandes desafios para combinar a intensificação da agricultura com o desenvolvimento sustentável das cadeias de abastecimento. Este documento explora as oportunidades de inovação na conservação do gado Curraleiro Pé-Duro (CPD). O CPD é uma raça brasileira histórica, relacionada à cultura regional, que apresenta notável adaptabilidade em biomas tropicais. O método de pesquisa consistiu em entrevistar e analisar o discurso dos criadores de CPD no Tocantins, Brasil. A sistematização dos dados resultou em quatro categorias e onze subcategorias, que foram definidas a posteriori. Nossas descobertas revelam aspectos motivacionais, potencialidades e perspectivas de valorização, além das necessidades e desafios percebidos pelos produtores de CPD. Uma melhor compreensão da situação atual pode orientar as políticas públicas, incentivar os interessados, beneficiar os agricultores e levar a iniciativas agroalimentares sustentáveis. As contribuições empíricas de nosso diagnóstico são discutidas e mostramos como elas trazem e fornecem lições valiosas para prospectar inovações na conservação do gado de CPD. Estas descobertas podem apoiar acadêmicos e

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pessoas que também estão interessadas em acessar e apoiar a conservação e produção animal com uso de raças crioulas. Em geral, o estudo apoia a definição de estratégias, planejamento e investimentos relacionados com cadeia de valor, incluindo a participação de segmentos a montante e a jusante das fazendas.

Palavras-chave: Cerrado, empreendedorismo, adaptado localmente, Bos taurus, cadeia de suprimentos

INTRODUCTION

The concept of sustainability has permeated various sectors and structures of society, including the agri-food systems. Discussions on social, cultural, economic, and environmental aspects have been the core of debates on sustainable development (Sustainable…, 2021). This involves increasing sustainable initiatives in food supply chains and being more efficient and effective. The sustainability of food production and supply chain development are discussed alongside processes of inclusion, technology adoption, and forms of communication and participation (Camargo and Soares, 2021; Commission on Sustainable Agricultural Intensification, 2021).

The increasing demand for food imposes changes in the primary sector, which have potential repercussions on rural development. Therefore, innovations in food supply chains are drivers for the sustainability of agri-food systems (Camargo and Soares, 2021). Findings show that innovations have increased agricultural productivity, besides the health, education, and well-being of families in the rural space (Gaffney *et al*., 2019). However, innovation requires that people and communities be able to generate changes for their own, with improvements in processing, distribution, and consumption practices, besides organizational arrangements, and production (Guide…, 2013; Klerkx and Begemann, 2020).

Currently, the lack of managerial indicators for decision making and of qualification and quantification methods are factors that limit sustainable innovations in agri-food systems. The establishment of international agreements and the consolidation of political agendas that define sustainable development goals and objectives tend to guide actions when prospecting sustainable food systems. Typically, this requires bringing together supply chain actors and encouraging collective actions (Neilson and Mckenzie, 2016; Gaffney *et al.*, 2019).

Governments of food-exporting countries are heavily pushed towards sustainability, as the primary sector is a source of carbon emissions and home to a considerable portion of the world's population. In this sense, the Brazilian Ministry of Agriculture, Livestock, and Supply (MAPA) has pointed out strategic axes, encouraging sustainability, bioeconomy, open innovation, food tech, and digital agriculture (Camargo and Soares, 2021).

There seems to be, however, a mismatch between what is intended or proposed and the conditions that exist to induce a faster transition towards building more sustainable societies and more sustainable agri-food systems. For instance, public funding for extension and research has lagged in several regions of the world (Gaffney *et al*., 2019). In Brazil, public policies for rural development have been weakened and government institutions for agricultural extension and research have been dismantled (Diesel *et al*., 2021; Grisa and Niederle, 2021).

In this scenario, there is an increasing need for partnerships between public and private sectors, i.e., hybrid governance mechanisms oriented towards the sustainability of agri-food systems, involving the empowerment of farmers and the fulfilment of the objectives of sustainable development (Promoting…, 2020; Wang and Ma, 2020). Thereby, research is warranted to analyze real situations faced by farmers in developing countries. Information about local needs and expectations may lead to innovative systems that positively impact farmers and society.

A case study was developed focusing on the conservation and production of a particular indigenous cattle locally adapted to the semi-arid, Cerrado, and Amazon biomes, in the central-west and north regions of Brazil. The indigenous Curraleiro Pé-Duro (CPD) cattle are known to present unique features related to adaptability, the quality of meat and milk, and is considered a

genetic heritage that refers to the colonization of Brazil and the expansion of extensive farming systems in Brazilian biomes (Silva *et al*., 2012; Fioravanti *et al*., 2021). Currently, as in the case with several indigenous breeds in Brazil, CPD seem poorly consolidated in the formal meat and dairy sector.

The aim of this study was to contribute to the state of the art and enlighten actions in favour of the development of the CPD breed and its inclusion in sustainable agri-food systems. Without properly accounting for the values and current opportunities perceived by the CPD farmers the identification of assertive actions may be misleading. In this sense, the following research questions guided the present study: "how and under what perspective does the production of CPD take place in Tocantins and how does this practice relate to the local context and the lives of farmers?"; "what are the motivations, expectations, and potentialities?"; "do the CPD farmers perceive adherence to formal food supply chains, markets and agricultural entrepreneurship?"; and "what are the main obstacles faced by CPD farmers?".

The CPD farmers were configured as supply chain members referring to a systematized framework which broadly considers and defines a beef cattle supply chain, summarized in Casagranda *et al*. (2021). Thus, farmers and CPD farming systems refer to a segment of the supply chain, mainly the rural property, responsible for raising, breeding, fattening, animal health and pasture. When referring to other segments, this may include farmers' viewpoints regarding the agroindustry and market, responsible for distribution and trade.

MATERIALS AND METHODS

A questionnaire containing open questions was developed. Answers were recorded with a portable audio recording device to be later transcribed into a digital file. The questions were formulated to comprise different aspects, addressed to the farm level or not. These included the production system; needs, desires, expectations, and potentialities perceived by CPD farmers; income generation; and aspects pertaining to organization, production, and supply chain.

Seven CPD farmers in the state of Tocantins were interviewed individually, after a prior appointment. Sampling was defined according to the availability of farmers and determined based on contacts provided by the Brazilian Association of Curraleiro Pé-Duro Breeders (ABCCPD), based in Teresina - PI. The interviews were conducted in person in a room on the campus of the Federal University of Tocantins, in Palmas - TO, during the month of May 2021. Clarification procedures and signing of the free consent test preceded the interviews and audio recording.

For discourse analysis, we adopted the manual method of content analysis proposed by Bardin (2004), which was divided into pre-analysis, analysis, and inferential stage. The sentences cut in the corpus were called Elementary Context Units (ECUs), i.e., smaller text segments that have their own meaning. Each ECU in the corpus was encoded with a slash "/", with two slashes delimiting an ECU. The ECUs were grouped by similarity and later divided into categories, from which subcategories emerged. The ECUs (f and %) were quantified within the categories and subcategories. Sentences that did not fit into any group, or seemed out of context, were disregarded. The name given to the categories and subcategories originated was the result of an a posteriori criterion, that is, how the ECUs were grouped, and the categories and subcategories originated, and named, did not follow ideas of topic hierarchy before the stages of the content analysis performed.

The analyses involved the presence of and interaction with two judges involved with the line of research and the research project in question, which allowed a more participatory approach of interpretation and inference. Some details regarding the methodology used, including data treatment, are illustrated in Gordo *et al*. (2013), Silva *et al*. (2013), Solano *et al*. (2013), and Silva *et al*. (2019).

RESULTS

The systematization of the data gave rise to four categories, which were each divided into subcategories, totaling eleven subcategories (Table 1.). The recording time added up to 103 min, considering the seven interviews together.

Table 1. Frequency (f) and percentage of elementary context units (ECUs) in Categories 1, 2, 3, and 4, obtained by speech content analysis after interviewing Curraleiro Pé-Duro cattle farmers in Tocantins in 2021

Category 1: Motivations and CPD in the breeders' lives			
Subcategory	f	% Subtotal	% Total
Family and the past	54	56.84	25.96
The context of raising and finances	41	43.16	
Subtotal 1	95	100	
Category 2: Near future			
Intentions, objectives, and prospects	36	29.51	33.33
Prospects for the evolution of the breed	40	32.78	
Hardiness combined with investments, knowledge, and exchange of genetic material	46	37.71	
Subtotal 2	122	100	
Category 3: Peculiarities of the breed			
Valuation of interesting aspects	33	38.82	23.22
Breed dissemination initiatives	34	40.00	
Perception of sustainable livestock production with CPD	18	21.18	
Subtotal 3	85	100	
Category 4: Obstacles to farming and breeder organizations			
Difficulties at the national level	33	51.57	17.49
Difficulties in Tocantins	5	7.81	
National association and regional centers	26	40.62	
Subtotal 4	64	100	
Total	366	100	

Category 1 was divided into two subcategories, representing aspects related to the farmers' ancestors as well as the history and culture of the region that motivate the breeders, in addition to the context of CPD cattle raising in their life and finances. This category accounted for 25.96% of the total of ECUs.

The practice of agricultural activities, whether on a small scale or not, associated with CPD cattle raising is almost always motivated by inheritance and family custom. It alludes to the childhood or youth of the respondents and was or is still practiced by their ancestors in other regions or in the same place. It is usually of an amateur nature, small-scale, and practiced as a hobby or as a supplementary source of income, and there is usually a desire to expand and improve cattle production. The farming of CPD usually alludes to a lifestyle of living amid nature and consuming meat with special flavor and quality "/It is a place where I feel very good, close to nature, and I even feel, in some way, the presence God/"; "/They had CPD cattle for their own consumption because it was a better, nobler meat/"). The farming of CPD usually constitutes a branch of other businesses run by the families, which may begin or be continued by the influence of friendship circles. Friends encourage others by donating specimens, which seems to be an incentive to adhere to the lifestyle.

The motivation for raising CPD cattle is related to the influence of friends and family, childhood memories, and experiences. Farmers referred to times when the direct ancestors of CPD specimens were predominant in the region according to stories told during their youth, when common cattle predominated. This demonstrates an emotional involvement of the interviewees with these cattle and explains why some raise CPD for pet purposes, more than for profitability ("/It was the love for the breed and seeing my friend (...) speak with so much love made me also grow to love the breed/").

The context and reason for farming CPD cattle are given by the close relationship with the traditions of family and friends, experience, history, and differentiated milk and meat quality,

in addition to adaptability to the biomes of the region (“/The taste of the breed, both meat and milk, is differentiated/”; “/The viability of Curraleiro is notable, and I repeat: on top of all that, there is the quality of the meat/”). However, CPD cattle farming seems to be driven by a wish to overcome old prejudices surrounding this type of cattle, helped by the current pride in favor of its conservation and understanding that this breed yields satisfactorily (“/People are proud to have some Curraleiro Pé-Duro in the surroundings/”). Thus, the reason for and the context of CPD cattle farming are mixed between appreciation, own consumption, and an intention to increase production and make it profitable, aiming at milk and meat production (“/I’m very interested in this marbled-meat part because I want to narrow my herd to animals with a high degree of marbling/”; “/Since we’re going to consume, we might as well consume an animal with the quality we desire/”).

In terms of the financial aspect, overall, the group of interviewees was divided into those who earn income from CPD cattle farming and those who do not (“/I have not received income from the Curraleiro Pé-Duro cattle, but I can already supply my house with its meat/”). Some interviewees started raising CPD cattle recently, so they relate it to expenses or investments. Others, for raising CPD as a hobby, claim that the activity is not commercial, although they admit that the supplementary income is an intention for the near future (“/But it is a hobby, and of course it is not out of our interest to work with Curraleiro on a commercial basis/”).

In Category 2, termed “Near future” (33.33% of the total ECUs) the intentions, objectives, goals, and prospects were allocated in the first subcategory. This subcategory includes situations in which the production of CDP remains pleasurable and joyful, taking advantage of adaptability and hardiness, but developed in a more organized and profitable fashion. This includes improving the beef and/or dairy aptitude of the breed and accessing market niches that sell special cuts and value-added products (“/I intend to administer my farming in a way that it is profitable, economically viable (...); I want to dedicate myself to improving my herd to produce quality meat and serve the premium meat market/”). Farmers foresee better use of native pastures and feedlot in the finishing phase. In this regard, objectives and prospects included concerns about increasing the scale of production (“/But we obviously need to have products, right? (...) to be able to serve this audience/”). Some prospects and plans concern the desire to provide genetic material, facilitated by using reproductive biotechnologies and genetic improvement. Other objectives included the farming of CPD cattle for their own consumption, as a source of income for defraying expenses on the farm, and as an option for rural tourism and sustainable production. In this respect, there were ECUs revealing some criticisms about the fact that the production of other cattle breeds is often not aimed at consumption by the local population. There was some evidence that CPD farmers perceive that CPD is more closely associated with local supply and consumption (“/Now, to produce meat to sell it in Jalapão, which is a major tourist hub where meat consumption is high, and all meat comes from outside. In the past, there were a lot of Curraleiro; today, everything is “Nelloreiro”, and the “Nelloreiro” there do not end up in the pot/”). In addition, some farmers would like to achieve a more vertical production scenario, with greater organization on the part of producers.

As for the prospects of evolution of the breed—the second subcategory of Category 2—the perception of optimism about its potential prevails, although it is admitted that advances happen slowly. Part of this optimism is explained by the perceptions that the local and current contexts are favorable for the farming of CDP in the region (“/I see prospects (...) favorably. There is a trend of global warming, an increase in demand for protein, the population has only grown, better utilization of forage, a hardy animal (...) so, I don't see any obstacles concerning the characteristics of the breed (...) I only see qualities/”). Among the expectations, the breeders predict a greater use of technologies and the genetic improvement of animals for meat or milk production (“/With people being aware of the potential of the quality of Curraleiro, it will be one of the best options for crossbreeding” (...)/”). They also predict greater insertion in markets (“/You could add value to it, because you are working organic cattle/”; “/a very good relationship with the environment, right? As it feeds on natural pasture, I believe that we could (...) work with the organic part/”; “/(...) we should sell quality, marbling, and not quantity/”;

"/It is not about wanting to compete with zebu (...), but it is about also having your space in the market, your place in the sun (...)/").

Other factors linked to expectations of evolution include the need for a greater number of animals, genetic uniformity, and profitability ("/Because it's no use saying (...) I have a Curraleiro", and when you go check it out, it's a crossbred/"; "/Being careful with the evolution of the breed, keeping within the standards, avoiding inbreeding, always with a view to economic viability (...), this is the path that will keep the breed alive and growing more and more/"). Considering the large investment made in favor of the modernization of Brazilian agriculture in recent decades (development of improved cultivars and breeds), which leveraged the status of national agriculture in the global scenario, there seems to be a mismatch in relation to the CPD case. In this respect, the interviewees commented on the chances given to the CPD case ("/The CPD (...) needs a chance to present itself as a self-sustaining breed, which can produce quality derivatives and can climb and conquer space on the market shelves/"; "/As much as it is a specific market, for specific customers, the CPD can conquer space in national livestock, as long as it is given a chance/"; "/I believe that, with proper work, we can make a commercial animal with high potential; that's what I imagine/").

Therefore, there is an expectation and a call to government authorities and development agencies. As for the role of breeders, there is a prospect or intention for producers to collaborate to circumvent the limiting points found for the farming of this type of cattle ("/(...) this is all something that can be worked on, on an associative level (...) sometimes the producer has few animals, but by joining more than one (....), an interesting scale can be achieved (...), so, assembly is important (...); it must be nationwide/"). This refers to the expansion and consolidation of collaboration networks between breeders ("/If we stay only here, within the state, we won't be able to achieve great things/"). In general, it was observed that expectations in favor of the evolution of the breed are related to trends of change in perception and behavior and necessary adjustments to current conditions and reality ("/(...) for the future, I see people (...) having a different view, which used to be more towards beautifying the farm or own consumption, because it is a differentiated meat, (...) but we feel (...) that many people are interested (...) for sale, for slaughter, (...); soon we shall have a nice supply/").

In the third subcategory of Category 2 (Hardiness combined with investments, knowledge, and exchange of genetic material), there are several testimonies regarding the good adaptability and hardiness of CPD cattle, even in challenging environments, which is opportune for the local reality and gives some prominence in terms of environmental sustainability. Although they do not understand it as a prerequisite, and even though most farmers interviewed offered good-quality pastures, farmers defend that the performance of CPD would be even better if the conditions of forage supply, infrastructure, and management were improved, aiming at low or high scale production. As for the aspects of hardiness and investment needs, most interviewees perceive that cattle farming requires hard work, regardless of the breed ("/The Curraleiro also needs to benefit from modern livestock production techniques, artificial security, and controls, of the most diverse type, for this breed to show its potential/"). While recognizing the aptitude and resistance of CPD cattle in the biome interviewees mentioned several concerns and investment needs ("/There is an entire work of selection, improvement, and dissemination, that these breeds considered modern undergo/"). Another aspect identified concerns better knowledge for the acquisition of animals with the desired characteristics of common cattle.

Trade of breeding stock between farmers, still in the third subcategory of Category 2, is facilitated by the existence of contact groups, social networks, and friendships. This is how the practices for acquisition and exchange of genetic material prevail, including the search for animals in Tocantins or elsewhere. Farmers perceive that there have been some advances on knowledge that encourages farmers to acquire and incorporate animals into their herds ("/Because a WhatsApp group was created (...) there's been a link of knowledge sharing (...) for three years now (...); we've already started to look for bulls (...); we've started to encourage this rotation in the trade of bulls within the herd (...)/"). Some breeders have already bought animals from other

breeders but have never made trades (swap) with each other. When it comes to the acquisition of genetic material, it appears that there have already been changes in the current scenario ("/And what I notice is that the first purchases were cheaper but have become increasingly expensive; there's an inflation in the price of animals/"; "/(...) those who have one are no longer willing to sell their animal/"). This probably refers to positive expectations regarding the (formal) insertion of CPD in the meat or milk sector. Some farmers revealed that they intend to improve cattle farming with adoption of reproductive biotechnologies ("/Today, we already have insemination, but the majority works with the bull chasing after the cow. So, the best way to improve this is by looking for herd bulls that are already under continuous improvement, to generate good quality animals/").

Category 3 comprised ECUs containing peculiarities of CPD cattle, concerning what breeders value the most and what most draws their attention to the breed. Several factors were mentioned, such as the docility and beauty of CPD cattle ("/I think the coat, the horn, are beautiful. As a whole, I think it's beautiful/"), in addition to the good adaptability, resistance, and more interesting stocking rates for the conditions of the region ("/They are animals that surprise us in terms of hardiness, adaptability, use of forage/";/(...) the cattle breed most able to graze broad leaves, with greater diversity than the other animals (...)/"; "/This cattle can be raised in the 'cerradão', which you cannot do with other animals/"; "/Hill areas, areas not suitable for agriculture – soybean growing, cultivation of crops, stony areas, areas considered inferior/"; "/The Curraleiro Pé-Duro makes great use of the pasture forest, the mallow, the 'pindoba', a number of plants from our native vegetation/"). Also, the breeders mentioned aspects such as earliness, fertility, and prolificacy ("/(...) they conceive very, very early (...)/"), and the high quality, tenderness, and flavor of the meat ("/What makes it viable, in my experience and to my understanding, is the quality of its meat, coupled with the hardiness and the lower cost of producing it/").

The second subcategory of Category 3 comprised the ECUs related to initiatives for the dissemination of the breed. In most cases, dissemination occurs on digital social networks, a behavior marked by its ludic nature and the sense of satisfaction, pride, and pleasures in posting photographs and content about CPD cattle. The contribution of social networks to the process of bringing together farmers and enthusiasts is notorious ("/(...) after I created this page, I made many contacts, many friends (...) we thought there were almost no breeders here in the state (...). I created a WhatsApp group (...); today we are more than 30 breeders here in the state/"). Publicity is not strictly for commercial interest, but for the pleasure of satisfying people's curiosity, reviving a tradition and genetic heritage linked to the history and culture of the region. Regarding dissemination, there were statements linked to the fact that it is a breed considered beautiful, yet small ("/Other producers typically have that first reaction: 'Do you breed this? It's small'; it's a remnant of that ancient culture, which almost caused the extinction of the breed/"). The interests in stimulating breeding through the dissemination of the breed is remarkable ("/You try to gradually show the advantages of the cattle so that these people also become interested and also start to breed it/"); however, speech content of farmers never resembled a persuasive, insistent or propagandist approach toward breed dissemination ("/So, when the person resists, I don't force it, I show the result, the numbers, what has happened in my experience as a breeder/"). Even if the interest in publicity actions is not predominantly of a commercial nature, commercial dissemination strategies and market niches for the breed are discussed among farmers ("/So, I think maybe it would be a form of dissemination, to work as if it were an organic animal/"; a geographical indication would be interesting, right? (...) for the meat to be advertised (...) in large networks/").

Still in Category 3, a third subcategory concerned the perception of sustainable livestock production with CPD. In this subcategory, several arguments were identified regarding the good adaptability to native pastures, the biome, and the rough conditions of the region. Farming CPD was linked to sustainability of animal husbandry ("/It would be a cattle breed that would not require you to degrade (the environment)/"). This includes perceptions that CPD cattle could populate the legal reserves and conservation areas of farms and ecological parks.

Farmers argued that CPD cattle thrive on native pastures, thus dispensing with heavy reliance on pasture varieties that have been linked to fires, deforestation and land-use change ("/I think one of the great potentials of Curraleiro will be (...) to reduce (...) the incidence of deforestation, of anthropization (...); this is the biggest problem, the very high incidence of human-caused fires related to the establishment of exotic pastures (...)/"). This is linked to the feeding behavior of CPD cattle, as perceived by the interviewees ("/(...) some weeds, (...) mallows, broomweed, (...); you see that some weeds enter the pasture and sometimes you have to fight it with herbicides (...), and I have, several times (...), with this little Curraleiro Pé-Duro cattle eating it, even though other grasses are available (...)/"). Noteworthy, farmers perceive that sustainability depends on the economic viability of production allied with environmental and social aspects ("/Sustainable livestock husbandry is when (...) it is the farm that will (...) support you, pay your expenses, pay for the cowboy, pay for its own maintenance/").

The fourth and last category accounted for 17.49% of the ECUs and was named "Obstacles for raising and breeders' organizations". This category was divided into three subcategories, mainly related to breeders' association and regional centers in different regions or levels of organization.

As for the difficulties and obstacles for raising CPD cattle at a national level, the lack of information about and dissemination of the breed stood out. Respondents claim that this would be important to reveal the qualities of CPD and that the lack of knowledge at the population and market levels restricts this breed from being better exploited and used in the formal meat and dairy sector ("/I think the great majority of the Brazilian population doesn't even know what Curraleiro cattle is/"; "/Goiás recently slaughtered feedlot animals and displayed the products, and it was something that surprised (...) those who tried those food products/"). Another difficulty is to increase the herd on farms in a more efficient manner and consequently increase the proportion of the national CPD herd, including small, medium, and large producers ("/Let's put it this way: making commercial scale is difficult; you have no animals to offer/"; "/The problem today is the supply of the product, which is very timid—one herd is small, so marketing and advertising for this product can't even be worked on so much if I won't be able to meet an increase in demand/"; "/Few people know the quality of CPD, and those who do and who want to increase the herd soon don't own a lot of breeding stock/"). For several interviewees, the small herd limits the organization and advancement of cattle husbandry with the CPD breed ("/The difficulty many producers encounter growing lies precisely in this commercial part; you don't easily find a buyer when you want to sell/"). As a solution, respondents mentioned greater organization of production ("/The main obstacle is to break the barrier that they managed to break there in Goiás, for producers to be aware that they have to help each other and someone must take on the most difficult part, which is to finish the animal with quality to be able to deliver the desired subcutaneous fat (...)/"). Another admitted difficulty is overcoming prejudices about the size of the animal, since CPD is considered small cattle, a feature that could potentially relate to some advantages or disadvantages at the farm level or supply chain. Also concerning difficulties encountered at the national level, some interviewees argued that the breeders' association should give greater emphasis to specific goals and objectives, beyond preservation of the breed alone.

Regarding the main difficulties and obstacles for raising CPD cattle in the state of Tocantins (second subcategory of Category 4), the interviewees also point out that the number of breeders is small and that the scale of production is small ("/If, for instance, I were to make a deal with a restaurant and supply them with fifty, one hundred meals a day for tourists, I would not have this amount of meat available/"; "/(...) we are at a starting point so those who already had it, somehow, didn't have animals available for sale/"). For some, farming and establishing the CPD breed is a lonely task, with little unity between existing participants. Another relevant point is that cattle farmers that raise other breeds tend to be irreducible, maintaining preconceived preferences. As a solution to some obstacles faced in the state of Tocantins, the interviewees propose the organization of field trips, in which farmers and professionals can collectively share knowledge.

Regarding the last subcategory of Category 4 (26 ECUs) interviewees opined about the importance of forming regional centers as a complement to the National Association, which is currently based in Teresina-PI ("/Defense of the breed and the assembly of breeders in the region/"). Some interviewees manifested resistances to the creation of another association in addition to the National Association, probably because they thought it would be redundant ("/(...) because a fragmentation might lead to weakening, and we need a single association for the defense of the breed/"). For other interviewees, it is opportune to create an association in the state of Tocantins ("/In relation to Tocantins, I think it would be important, since we already have some networking among groups of farmers. It is important to bring the group closer to the association, to stimulate more producers to join the association/"). Notwithstanding this, some farmers reiterated the importance of creating regional centers, over the creation of an association in the state ("/No, not another association. I'm against the existence of another association. What we might eventually consider would be just a core of the association/"). The understanding of the need for farmers to collaborate was evident ("/(...) it's easier for us to partner and work together (...); if we partner with the people of Goiás (...), it'll be much faster (...)/"). Regarding the creation of centers or an association of breeders in the state of Tocantins, the interviewees highlighted some specific advantages. In addition to increasing contact between CPD farmers, this would allow for greater ease in exchanging genetic material, a greater possibility of benefiting from contributions from university research, and greater monitoring of the work developed, with greater success in choosing specimens based on the genetic information ("/(...) with training, by the veterinarians themselves, who should be accredited by the association, accredited technicians could carry out the assessment and registration of the herd, because we really need this here/").

DISCUSSION

Silva *et al*. (2013) reported the notable expression of affective feelings towards CPD cattle, the importance of historical aspects and environmental adaptability perceived in the tropical region. These authors analyzed the discourse of academics, breeders, and board members of the Breeders' Association of Goiás and Piauí at a meeting held by the Ministry of Agriculture, and Livestock in 2011, which contributed to the recognition of the CPD breed. At that time, breed recognition was one of the main obstacles as well as one of the most debated topics due to the problem of the duplicity of names with the legislation (the breed was called "Curraleiro" in the state of Goiás and "Pé-Duro" in Piauí), in addition to the existence of two distinct breeders' associations (one in Goiás and the other in Piauí). The problem of the duplicity of names was overcome upon an agreement; hence why the cattle is currently called Curraleiro Pé-Duro. The diversifying objectives among CPD farmers was also reported by Silva *et al*. (2013). However, this didn't seem to be an issue among farmers, even if it poses as a source of nebulosity for decision making. When it comes to topics such as technology and the market, it was clear that there is still much to be done to consolidate CPD in the meat and dairy sector. It is a challenging situation that may require the association of research with sustainable innovation strategies applied to multistakeholder supply chain management and development (Klerkx and Begemann, 2020).

The use of a mobile application for breed dissemination, interaction between farmers, and exchange of genetic material is a confirmation of socio-technical and digital transition. Additionally, it is an indication of greater rural connectivity, which is convenient for farmers and timely for supply chain shareholders and industries. Supply chain actors could benefit from the pre-existing means of communication and organization (Fielke *et al*., 2019; Yaacoub and Alouini, 2020). Nonetheless, advances typically depend on expanding connectivity, including actors present in other segments of the production chain (Tomich *et al*., 2019). Speech content regarding the connection between supply chain members from different segments of the value chain were too discreet or even absent in the analyzed discourse. This contrasted with the established (digital) interaction identified among CPD farmers. Agricultural entrepreneurship extends beyond the farm gate, including product distribution corridors, traceability systems, security, among other segments and actors that make up the business space, and require

connectivity (Milanez *et al*., 2020; Silva *et al*., 2021a).

Partnerships between the public and private sectors, oriented towards sustainability in agricultural production and the empowerment of rural producers, have been considered instruments for innovation in agriculture and for the fulfillment of sustainable development objectives (Promoting…, 2020; Wang and Ma, 2020). This type of partnership (public-private) is considered a hybrid governance mechanism that can increase the impacts of sustainable initiatives on food supply chains, such as mitigating greenhouse gas emissions (Furumo and Lambin, 2020). Public-private partnerships potentially contribute to the functioning dynamics of innovation systems in agriculture and stimulate other innovation policy instruments to address problems in agriculture and food supply chains (Hermans *et al*., 2019). Thus, connecting people and businesses is currently seen as a pathway towards greater development and prosperity (Brasil, 2021). Additionally, the creation of policy ecosystems aimed at low environmental impact is a trend and should be considered (Furumo and Lambin, 2020).

Another possibility, besides public-private partnerships, is integrating agricultural research and rural extension (Álvarez de Fernández *et al*., 2006; Mussoi, 1998; Doorman, 1991; Santos, 2001). In Brazil, this has been discussed within public institutions of agricultural research and rural extension (Presidente…, 2007; Epamig…, 2013; Reunião…, 2007; MDA…, 2013; Novas…, 2014). However, this opportunity seems to bump against budget cuts and the adoption of neoliberal policies, which roughly describes some political features in the last three decades. In Brazilian public institutions, the integration of agricultural research and extension has been associated with mergers or institutional incorporation strategies (Silva *et al*., 2021b), which seem disassociated from the integration of research and extension, in practice.

Faced with the current precariousness of the public research and extension sector and the dismantling of public policies for rural development (Diesel *et al*., 2021; Grisa and Nierdele, 2021), public-private partnerships appear to be a promising and increasingly necessary path. The scientific literature describes several cases of positive repercussions of such partnerships, more than with public subsidies alone (Buso and Stenger, 2018). In broad terms, the situation refers to neo-institutionalism, with a focus on the greater contribution of informal, formal, public, and private institutions to determine results and the behavior of food supply chain actors, which leads to the prospecting of more promising institutional arrangements. In this regard, public-private partnerships can contribute to the dynamics of the functioning of innovation systems in agriculture as well as stimulate direct investments and other innovation policy instruments to address problems in agriculture and food supply chains (Hermans *et al*., 2019; Furumo and Lambin, 2020). In terms of development policy, this should encompass environmental and social and governance and strategies that add value to food production and likely prompt agri-food systems (Camargo and Soares, 2021).

Culture, tradition, and high adaptability of CPD to the local biome are competitive advantages to access niche markets.

In terms of environmental sustainability, speech content reveals potentialities on connecting CPD cattle to efforts on contributing to the decarbonization of livestock activity. This can potentially generate wealth and benefits for farmers and society. Solutions of this kind constitute a convergence towards the sustainable development goals (Camargo and Soares, 2021). Likely, an innovative supply chain ecosystem will rely on multistakeholder collaboration, mark*et al*liances and efforts toward product certification and geographical indication seals (Verrier *et al*., 2005; Felix *et al*., 2013; Fielke *et al*., 2013, 2019).

A noteworthy fact was that CPD breeders claim that the meat of other bovine breeds (more consolidated in the formal meat and dairy sector) does not have the same perceived sensory or organoleptic traits and is often not intended for local consumption. Furquim & Cyrillo (2013) analyzed the discourse of actors in the Brazilian cattle/beef sector and found differences in the quality of beef that is consumed locally versus that which is exported.

CONCLUSION

This study provided an overview of features related to the current conservation and production of CPD cattle. The findings stem from speech content analysis of CPD farmers in Tocantins. Potentially, the results facilitate the identification of opportunities and pathways in favor of farmers and sustainable actions toward innovations in the agri-food system.

First, local history, tradition and breed adaptability in the biome are topics to embrace when prospecting an inclusive and sustainable food supply chain. This includes properly embracing rare livestock and addressing the social, economic, and environmental performance of agri-food systems in tropical regions and developing countries.

Efforts should be made to defray expenses at the farm level by increasing income from the commercialization of milk and/or meat. Endeavors should exploit local food preferences and highlight the cultural aspects and food security.

Clearly, the preservation and conservation of CPD cattle are initiatives linked with farmers´ intentions of undertaking agricultural entrepreneurship.

The organization among farmers, the improvement of infrastructure, management strategies and technology adoption at the farm are roads to travel. Likewise, marketing, genetic improvement programs and the increase of the effective herd size and number of breeders are required. Support to the farmers that are willing to be providers of genetic material is important because several challenges relate to small-scale production and limited supply chain capacity.

The expansion and consolidation of collaboration networks and knowledge sharing between CPD farmers and supply chain partners seems critical. This calls for innovative and transformative spaces for multistakeholder dialogue and action.

The content of speech evaluated leads to the conclusion that food from CPD cattle is still poorly consolidated and rather disconnected to the formal meat and dairy sector. Access to market niches that rely on the distinctiveness and high quality of food is likely the way to exploit, include and add-value to food coming from CPD cattle production.

One limitation of this study is failing to embrace a more representative sample of CPD farmers, from other regions of Brazil. Still, some findings overlap with results of previous papers. This reinforces the aspects that should be considered when prospecting sustainable and innovative agri-food systems in the scope of indigenous livestock.

Finally, we encourage scholars to continue the progress made in this study and we supplicate that decisionmakers and development agents should consider our findings while attempting to development and include indigenous cattle farming in sustainable agri-food systems. In face of the current precariousness of public extension and research structures, public-private partnerships seem to be a promising alternative.

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