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ATITUDES DO PÚBLICO EM RELAÇÃO AOS SISTEMAS DE PRODUÇÃO E AO COMPORTAMENTO DE CONSUMO DE CARNE BOVINA

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[2021]

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Dissertação submetida como requisito final para a obtenção do grau de mestre em Agroecossistemas pela Universidade Federal de Santa Catarina e mestre em Sistemas de produção animal pela Pontifícia Universidad Católica de Chile em regime de cotutela.
Orientadores:
Profa. María José Hötzel Dra. UFSC.
Prof. Daniel Enriquez-Hidalgo Dr.. Pontificia Universidad Católica de Chile

Florianópolis/Santiago de Chile
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ACTITUDES DEL PÚBLICO HACIA LOS SISTEMAS DE PRODUCCIÓN DE CARNE DE VACUNO Y COMPORTAMIENTO DE CONSUMO DE CARNE DE VACUNO

Tesis presentada como requisito final para la obtención del título de Magíster en Agroecosistemas de la Universidad Federal de Santa Catarina y Magíster en Sistemas de Producción Animal de la Pontificia Universidad Católica de Chile en régimen de cotutela.

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O presente trabalho em nível de mestrado foi avaliado e aprovado por banca examinadora composta pelos seguintes membros:

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Certificamos que esta é a **versão original e final** do trabalho de conclusão que foi julgado adequado para obtenção do título de mestre em Agroecossistemas.

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pandemia, pero espero que tal como mostraron los participantes de esta investigación desarrollemos la empatía y trabajemos juntos día a día para crear un mundo mejor.

Resumo

Muito se discute sobre as diferentes características, eficiência e externalidades dos diferentes sistemas de produção de carne bovina, mas pouco se sabe sobre como essas características influenciam as atitudes dos cidadãos em relação à indústria da produção de carne bovina. Essas atitudes podem influenciar as decisões quanto aos hábitos de consumo da carne bovina e aumentar o número de pessoas que decidem reduzir ou parar de comê-las. Em primeiro lugar, este estudo teve como objetivo explorar as atitudes dos cidadãos em relação aos sistemas de produção e consumo de carne bovina e a influência da informação sobre os sistemas; em segundo lugar, averiguar o consumo atual de carne bovina, a sua projeção e as razões subjacentes. Cidadãos chilenos foram recrutados pessoalmente ou online. Os participantes foram convidados a responder um questionário que incluiu informações sobre um dos sistemas produtivos (confinamento, pastoreio extensivo, pastoreio regenerativo) ou nenhuma informação, e cada um deles foi randomizado para um desses questionários. Os participantes (n = 1509) tiveram atitudes mais favoráveis em relação aos sistemas a base de pasto do que em relação ao confinamento, principalmente devido a preocupações com o bem-estar animal e impactos ambientais. O fornecimento de informações não teve efeito nas respostas dos participantes sobre os sistemas de produção de carne bovina, nem sobre seu consumo atual ou futuro de carne bovina. Metade dos participantes disse ter reduzido o consumo de carne no último ano por motivos de bem-estar animal ou ambientais e 42% espera reduzir o consumo no futuro. Além disso, 80% esperavam que os chilenos reduzissem o consumo de carne bovina no futuro, mas a maioria não confiava que isso aconteceria. Os participantes acreditam que é necessário reduzir o consumo de carne bovina, tanto próprio quanto da sociedade como um todo. Tanto o apoio à produção quanto ao consumo de carne bovina podem se beneficiar se os sistemas de produção adotarem características percebidas pelo público como positivas para o meio ambiente e o bem-estar animal.

Palavras chave: atitudes, carne bovina, confinamento, pastoreio, gases de efeito estufa.

RESUMO EXPANDIDO

Introdução

O crescimento da população mundial e o aumento da renda associada estão impulsionando uma crescente demanda por produtos alimentícios de origem animal, incluindo carne bovina (FAO, 2018; Masters et al., 2016). Em paralelo, um número crescente de pessoas está escolhendo evitar ou reduzir a carne bovina em suas dietas, particularmente em países desenvolvidos (Soler & Thomas, 2020; De Gavelle et al., 2019; Vranken et al., 2014). Uma recente revisão feita por Sanchez-Sabate & Sabate (2019) mostrou que as pessoas estão dispostas a reduzir o consumo de carne bovina devido a preocupações com a saúde e o bem-estar animal. O apoio público, as atitudes e a disposição de pagar pela carne bovina produzida em diferentes sistemas de produção de carne bovina também podem ser afetados pelas características e externalidades associadas a esses sistemas (Stampa et al., 2020). Os compradores e consumidores de carne em muitos países preferem produtos de pastagem aos produzidos em sistemas confinados (Xue et al., 2010; Boogard et al., 2010; Yunes et al., 2017). Além disso, alguns consumidores estão dispostos a pagar mais e têm atitudes mais favoráveis em relação à carne bovina baseada em pastagens em comparação com a carne produzida em sistemas fechados (Conner et al., 2008; Morales et al., 2013; Garcia-Torres et al., 2016). Entretanto, as pessoas demonstram pouco interesse em reduzir o consumo de carne bovina por razões ambientais (Fox & Ward, 2008; Ruby, 2012). Como a carne bovina é produzida em diferentes sistemas, com diferentes externalidades para as quais as pessoas podem ter atitudes diferentes.

Objetivos

Este estudo teve como objetivo explorar as atitudes dos cidadãos chilenos em relação aos sistemas de produção de carne bovina e as razões subjacentes, e avaliar sua atitude e comportamento em relação ao consumo de carne bovina.

Materiais e métodos

Para alcançar os objetivos do estudo, foi aplicada uma pesquisa a 1591 participantes chilenos, que foi realizada em duas partes diferentes enquanto ao tipo de recrutamento de participantes. A primeira parte do recrutamento foi feita pessoalmente em fevereiro de 2020 em Santiago do Chile; a segunda parte foi feita on-line em abril e maio de 2020, devido ao surto de Covid-19. Em ambos, a coleta de dados foi realizada utilizando um questionário auto-administrado, sem interação entre o recrutador e o respondente após a aceitação para participar. Hoube 4 formulários diferentes do questionário que correspondiam às informações recebidas pelos participantes, portanto os participantes foram randomizados para um desses 4 formulários que poderiam ser questionários com informações sobre confinamento (CONF), pastagem extensiva (EXTgra), pastagem regenerativa (REGgra) ou para um sem nenhuma informação (NOInf). as primeiras perguntas foram sobre a atitude dos participantes em relação aos sistemas sobre os quais receberam informações, então cada um foi perguntado especificamente sobre o sistema que recebeu e os da NOInf não tinham essas perguntas. Depois houve as questões gerais sobre o consumo atual e futuro de carne, além das questões sócio-demográficas. O questionário final incluía 15 perguntas fechadas e 2 perguntas abertas. Os análisisis estadísticos gerais das respuestas se hicieron em Microsoft Excel e os outros em SAS. Para a constituição dos participantes e para os sistemas se hizo Spearman Coeficientes de correlação, como as perguntas foram altamente correlacionadas as respostas foram calculadas como média para criar uma construção de "atitude". Para as outras preguntas sobre o consumo de carne acutal e futuro tanto a nível individual como coletivo, foram utilizados modelos de regressão logística multinomial para analisar associações entre o tipo de recrutamento e os dados sociodemográficos e as respostas dos participantes. E as respostas abertas foram submetidas a uma análise temática.

Resultados e discussão

Um total de 1509 pessoas participaram, das quais 367 foram do recrutamento presencial e 1142 do recrutamento on-line. Os participantes expressaram as atitudes mais negativas em relação ao CONF e depois ao EXTgra, que foram inferiores às do REGgra (1,94, 2,83 e 2,94 SEM 0,078; $P < 0,001$). Além disso, as mulheres e os

participantes não consumidores de carne expressaram atitudes mais negativas do que os homens e os consumidores de carne em relação a todos os sistemas. As principais justificativas dadas pelos participantes para suas atitudes em relação aos sistemas foram o bem-estar animal e o meio ambiente. Em geral, os participantes expressaram atitudes negativas em relação ao consumo de carne e atitudes favoráveis à redução do consumo de carne pelas mesmas duas razões expressas acima, tanto individual quanto coletivamente, na verdade 80% dos participantes acreditavam que os chilenos deveriam reduzir seu consumo de carne, entretanto, apenas 47% acreditavam que isso realmente aconteceria. A amostra obtida, que consiste em uma porcentagem maior de fêmeas e jovens pessoas com educação superior, é semelhante às amostras obtidas em pesquisas anteriores realizadas online sobre o mesmo assunto (Clonan et al., 2015; Graça et al., 2015; Bollani et al,2019) permitiram identificar a influência de alguns dados demográficos sobre as variáveis de resultados. Educação, gênero, consumo de carne e relação com a produção animal foram as características sócio-demográficas que tiveram maior influência nas atitudes das pessoas, sendo as mulheres, as pessoas com formação universitária, as pessoas que não consomem carne e as pessoas sem relação com a produção animal as mais favoráveis à redução do consumo de carne tanto pessoalmente quanto em nível nacional. O tipo de recrutamento e as informações dadas aos participantes não influenciaram suas respostas. Os participantes tinham atitudes mais positivas em relação à carne bovina baseada em pastagem sistemas de produção em comparação com o sistema CONF, semelhante a outros estudos em desenvolvimento e países em desenvolvimento (Stampa et al., 2020; Yunes et al., 2017; Schnettler et al, 2009). O bem-estar animal e os impactos ambientais foram as principais razões subjacentes apoio e atitudes mais positivas em relação à EXTgra e REGra, respectivamente, assim como os principais motivos de oposição e atitudes negativas em relação ao CONF. Alguns participantes expressaram interesse em reduzir o consumo de carne bovina, com aqueles que já a tinha reduzido com a intenção de continuar com este comportamento e acreditando que os outros chilenos também devem reduzir o consumo de carne bovina. De acordo com as atitudes dos participantes em relação a os diferentes sistemas de produção de carne bovina, bem-

estar animal e questões ambientais foram as principais razões mencionadas para justificar a vontade de reduzir o consumo de carne bovina

Conclusões

Os participantes tinham atitudes mais positivas em relação aos sistemas baseados em pastagens do que aos sistemas em que o gado não tinha acesso a pastagens. As duas principais razões subjacentes às atitudes em relação aos sistemas eram o bem-estar animal e o impacto ambiental que eles geram. O fornecimento de informações sobre os diferentes sistemas de produção de carne bovina não teve efeito nas respostas dos participantes em relação à produção de carne bovina ou seus hábitos de consumo de carne e o consumo prospectivo de carne bovina. Os participantes acreditavam que existe uma necessidade de reduzir consumo de carne bovina, tanto pessoalmente quanto em nível social. Apoio à produção de carne bovina como bem como o consumo pode se beneficiar se os sistemas de produção adotarem características que são percebida pelo público como positiva para o meio ambiente e o bem-estar animal.

Palavras-chave: atitudes, carne bovina, confinamento, pastagem, gases de efeito estufa.

Resumen

Mucho se discute sobre las diferentes características, eficiencia y externalidades de los diferentes sistemas de producción de carne de vacuno, pero se sabe poco sobre cómo estas características influyen en las actitudes de los ciudadanos hacia la industria de producción de carne. Estas actitudes pueden influir en las decisiones sobre los hábitos de consumo de carne de vacuno y aumentar el número de personas que deciden reducirla o dejar de comerla. En primer lugar, este estudio tuvo como objetivo explorar las actitudes de los ciudadanos hacia los sistemas de producción y consumo de carne vacuna y la influencia de la información en los sistemas e investigar el consumo actual de carne de vacuno, su proyección y las razones subyacentes. Para esta investigación, los ciudadanos chilenos fueron reclutados en persona o en línea. Se pidió a los participantes que respondieran un cuestionario que incluía información sobre uno de los sistemas productivos (confinamiento, pastoreo extensivo, pastoreo regenerativo) o ninguna información, y cada uno fue aleatorizado a uno de estos cuestionarios. Los participantes (n = 1509) tuvieron actitudes más favorables hacia los sistemas basados en pasto que hacia el confinamiento, principalmente debido a preocupaciones sobre el bienestar animal y los impactos ambientales. El suministro de información no tuvo ningún efecto en las respuestas de los participantes respecto a los sistemas de producción de carne vacuna, ni en su consumo actual o futuro de carne. La mitad de los participantes dijeron que habían reducido el consumo de carne en el último año por razones ambientales o de bienestar animal y el 42% esperaba reducir el consumo en el futuro. Además, el 80% esperaba que los chilenos redujeran el consumo de carne de res en el futuro, pero la mayoría no confiaba en que esto suceda. Los participantes creen que es necesario reducir el consumo de carne de vacuno, tanto para ellos mismos como para la sociedad en su conjunto. Tanto el apoyo a la producción como el consumo de carne pueden beneficiarse si los sistemas de producción adoptan características que el público percibe como positivas para el medio ambiente y el bienestar animal.

Palabras clave: actitudes, carne de vacuno, confinamiento, pastoreo, gases de efecto invernadero.

Abstract

Much is discussed about the different characteristics, efficiency and externalities of different beef production systems, but little is known about how these features influence public attitudes towards beef production. These attitudes may influence decisions regarding beef consumption habits and add to the growing number of people that decide to reduce or stop eating beef. This study aimed, firstly, to explore citizens' attitudes towards beef production systems and beef consumption and the potential influence of provision of information about the systems; secondly, to investigate current and prospected beef consumption and underlying reasons. Chilean citizens were recruited in person or online to participate in a survey, which included information about one productive system (confinement, extensive grazing, regenerative grazing, or no information), and each of them was randomized to one of these questionnaires. Participants (n=1509) had more favourable attitudes towards pasture-based systems than towards confinement, mainly due to concerns with animal welfare and environmental impacts. Provision of information had no effect on participants' responses towards the systems or their current or prospective beef consumption. Half of the participants said they had reduced their meat consumption in the last year for animal welfare or environmental reasons and 42% expected to reduce their consumption in the future. Moreover, 80% expected Chileans to reduce their beef consumption in the future, but most did not trust that this would happen. Additionally, participants believed that there is a need to reduce beef consumption, both personally and at society level. Support for beef production as well as consumption may benefit if production systems adopt characteristics that are perceived by the public as positive for the environment and animal welfare.

Key words: attitudes, beef, confinement, grazing, greenhouse gases, pasture-based.

SUMÁRIO

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1 INTRODUCTION

The world's population growth and associated increased income are pushing an increasing demand for animal food products, including beef (FAO, 2018; Masters *et al.,* 2016). Concomitantly, a growing number of people are choosing to avoid or to reduce beef in their diets, particularly in developed countries (Soler & Thomas, 2020; De Gavelle *et al.,* 2019; Vranken *et al.,* 2014). A recent review by Sanchez-Sabate & Sabate (2019) showed that some people are willing to reduce beef consumption due to health and animal welfare concerns. Public support, attitudes, and willingness to pay for beef produced in different beef production systems may also be affected by the characteristics and externalities associated to these systems (Stampa *et al.,* 2020). Buyers and meat consumers in many countries prefer pastured-based products to those produced in confined systems (Xue *et al.,* 2010; Boogard *et al.,* 2010; Yunes *et al.,* 2017). In addition, some consumers are willing to pay more and have more favourable attitudes towards pasture-based beef compared to beef produced in indoor housing systems (Conner *et al.,* 2008; Morales *et al.,* 2013; Garcia-Torres *et al.,* 2016). However, people show little interest in reducing beef consumption for environmental reasons (Fox & Ward, 2008; Ruby, 2012), which may be associated with the low awareness towards environmental consequences that meat production may trigger (i.e. De Boer *et al.,* 2013; Pohjolainen *et al.,* 2016) or they may simply not find a link between beef consumption and climate change (Macdiarmid *et al.,* 2015).

In the last decades, beef production has increased in hand with the growth of intensive and confined cattle production systems (Thornton, 2010). This means that beef production outcomes regarding sustainability of the environment, animal welfare, social and economic aspects have also changed. The modern beef production systems have been effective regarding productivity, and with the looming environmental crisis and increasingly prominent concerns towards sustainability, there is a debate whether productivity is the pillar on which the systems must continue to be developed, given that increased productivity may increase other externalities (Vinnari & Vinnari, 2014). To ensure access for all to eat meat and sustainable production over time, it is necessary to modify beef production and consumption (Schramski *et al.,* 2020; Clark *et al.,* 2020).

The environmental impact of the different beef production systems is an emerging topic, recently highlighted by the last IPCC reports (IPCC, 2019; IPCC, 2014). Beef production systems differ in characteristics like land management, animal management practices and housing, and overall system productivity, which overall entails different animal welfare and environmental impact (Broom, 2019; Rowntree *et al.,* 2019). Due to these differences, their production efficiency, understood as animal production under the same amount of input resources, may also differ (Van der Werf, 2000). Additionally, differences in efficiency of resources' used may also influence productivity and environmental impact per unit of product provided (Crosson *et al*., 2011; Godfray & Garnett, 2014).

Public attitudes towards the different dimensions of sustainability need to be better understood and, to the best of our knowledge, citizens' attitudes towards the different beef production systems are still an understudied topic (Sanchez-Sabate & Sabate, 2019). Therefore, this study aimed to explore Chilean citizens' attitudes towards beef production systems and underlying reasons, and to evaluate their attitude and behaviour towards beef consumption.

2 LITERATURE REVIEW

2.1 Beef production and consumption

Agriculture and livestock food production have been accompanying human development for millennia by providing the sources of energy and nutrients. The transition from a society that gathered and hunted for food, to a society of voluntary production of certain species of plants and animals allowed us to become the 7,700 million people inhabiting Earth today. The increase in meat consumption and production has been proportional to the increase in human population, however meat production and consumption has increased considerably since the 1960s, with the rising incomes and middle-income countries development, which have been the meat demand drivers in the last decades (FAO, 2018; Masters *et al.,* 2016). Production increased from 70 million tons per year in 1960 to more than 330 million tons per year in 2018, which is equivalent to a 4-fold increase in 50 years which has allowed to reach a consumption of 43 kg of meat per capita on average in the world (FAOSTAT, 2020). The increase in demand represents a great challenge for both the sustainability and productivity of the meat production sector (Conan *et al.,* 2001) considering that the world will have to increase food production up to 60% by 2050 to feed its increasing population (Alexandratos & Bruinsma, 2012).

Cattle are an important component and source of meat for human diets worldwide, except in the Antarctica (Herring, 2014). In terms of worldwide meat production, beef is the third, after poultry and pigmeat (FAOSTAT, 2020). Currently there are over 1.4 billion cattle heads in the world, which means about one bovine for every five people on the planet. Considering the 65 million tons of beef consumed annually, the vast majority of them end as meals (FAOSTAT, 2020) which means that their rearing and subsequent slaughter are the product of human needs.

In Chile, 3 million cattle heads were destined for milk production, meat or fieldwork in 2018, of which 25% were slaughtered for meat consumption. Average per capita meat consumption in Chile is currently around 79 kg per year, of which 30% corresponds to beef (22 kg of beef/per person) (FAOSTAT, 2020, Ortega *et al.,* 2020).

This rate exceeds the world average of 9 or 10 kg per capita (Masters *et al.,* 2016). It is important to outline that there are high discrepancies in per capita beef consumption, being that some countries exceed the consumption of 100 kg of beef per year, such as Argentina, Uruguay, the United States, New Zealand and Australia, whereas, on the other hand, some countries, like Gambia, Ethiopia and Rwanda barely reach 9kg of beef consumption per person per year (FAOSTAT, 2020).

In contrast to this considerable increase in beef consumption in the last 50 years, an incipient observation on consumers' habit, has shown changes in diets and reduction or elimination of beef from meals, mainly among high-income consumers and in developed countries, motivated mainly by ethical and health concerns (Soler & Thomas, 2020). However, a reduction in meat consumption has not been perceived in the world because the increment on beef demand actually comes from countries where the growth rate is greater. In Chile and like in most of the countries around the world the relative consumption of beef has decreased compared to pork and poultry (FAOSTAT, 2020; USDA, 2002) generating differences in trends for different meats, but not in general consumption.

2.2 Beef production systems

The domestication of cattle ancestors (*Bos taurus)*, occurred more than 10,000 years ago in the Middle East, expanding from there to the rest of the world (MacHugh, *et al,* 2017). Since then, some members of this cattle family have been bred for work force, food production and useful purposive materials, reaching today about 1.5 billion animals around the world (FAOSTAT, 2020). These animals are ruminants, which means that they ruminate and regurgitate the food they consumed. Their upper part of their digestive system is made up of four compartments letting them use plant material and digest the food rich in cellulose and fibre with a higher efficiency than other herbivorous mammals and, for this reason, its original habitat were the large grasslands and prairies (Chen *et al*., 2019). For these reasons, cattle in the past were mostly raised in pastoral systems, in which cattle was allowed to forage their own food. However, since the late 1950s, with the world population increase and the need to produce more food and pursuing a much better efficiency and productivity, intensive confined

production systems began to be developed especially after the “green revolution” within the development of high productivity crops (Fraser, 2008).

Current animal production, specifically beef cattle, is done in either pasture-based or intensive systems. Pasture-based systems are those where animals are kept in herds on pastureland and fed directly from the meadow accessing to a forage-based diet from either perennial or annual forages, without no or little non-forage supplementation (USDA-AMS, 2007). Intensive systems are often landless, animals are housed in confinement and feed is produced by the same breeders or bought to others, and brought to them (Leenstra, 2013). There is also the possibility that livestock rearing is carried out by a mix of both systems, either due to the rearing stages of the animals or the availability of feed in the pastures (Steinfeld & Mäki-Hokkonen, 1995). Within the two types of beef production systems, there are different ways to handle production, animals and feeding managements. For the purpose of this study the confined beef production system and two pasture-based systems, the extensive grazing and the regenerative grazing systems, will be discussed.

Confinement is usually represented in beef production systems as feedlots, which are highly intensified productive systems in which the animals are housed in pens with a high stocking density and given diets with high levels of concentrate and/or grains (Broom, 2019). Despite some variations this type of intensive system usually uses a large amount of external resources, such as growth enhancing hormones or antibiotics and chemical inputs for crop yields for feed and can be established throughout the whole life cycle of the cattle or, most commonly, for the final rearing stage before slaughter (Capper, 2012).

Extensive grazing is the production system in which cattle graze the same grassland for a long part of the grazing season (Crosson *et al.,* 2011) with only occasional changes from one paddock to another, resulting in low instantaneous stocking densities, using relatively large land areas per animal (Allen *et al.,* 2011) . External resources such as fertilizers or other chemicals are not usually used or minimized in these beef production systems (Marriott *et al.,* 2009). In extensive grazing systems, the occupation and the recovery time of the paddocks are not considered within the management, so there is no rational sequence or pattern on which paddocks

are used. Most of the extensive grazing systems have been developed in harsh environments, such as dry lands and cold areas unsuitable for crop production (Gerber *et al.,* 2015).

Regenerative grazing, also known as adaptive multi-paddock grazing, or intensive rotational grazing is a way of doing an intensive grazing of the grazing land. It involves short grazing intervals and high instantaneous stocking densities, attained by a frequent change of the cattle from different paddocks. This system is called regenerative because it seeks to regenerate the life of the soil; for the same reason, the use of external and synthetic inputs is avoided or minimized (Teague, 2020). Some of the practical representations of this system, corresponding to different ways of grazing management, are "Voisin's rational grazing" (Voisin,1959), "management-intensive grazing" (Gerrish, 2004) and "holistic planned grazing" (Savory & Butterfield, 1998).

In 2010, a total of 66 million tons of beef were produced, of which 34% came from pasture-based systems, 59% from mixed systems between pasture-based and confinement and 7% from feedlots (Gerber *et al.,* 2013).. However, there is no clear information on the proportion of grazing systems that are extensive, intensive or regenerative.In the U.S., one of the largest beef producing and consuming countries, 97% of the cattle is finished in confinement, in feedlots, and the remaining 3% in pasture-based systems (Stone Barns Center, 2017).

2.2.1 System's efficiency

Efficiency, understood as more animal product under the same amount of input resources (Van der Werf, 2000), may differ among the beef production systems due to the differences in management and resources used. Under the given definition of efficiency, the most efficient system among those previously exposed would be the confinement, while regenerative grazing would have a medium efficiency and extensive grazing a lowest efficiency (Roche *et al.,* 2017). Differences in efficiency among systems might produce a variation in production intensity, and consequently increased animal productivity might reduce environmental impact per product provided because it can reduce emissions per kilo of product (Crosson et al., 2011).

There is a line of research and development focused on intensification of

agricultural production, known as “sustainable intensification” which argues that intensive food production systems, may be the solution for future challenge of increased food demand because intensified systems produce more food from the same amount of land (Royal Society, 2009). It is a fact that increased food production and quality protein is currently necessary, and it will also be in the future (FAO, 2008), but setting the sole objective of increasing productivity as a response to this challenge is not sufficient (Godfray & Garnett 2014). So, considering the incipient environmental crisis we are facing, and that agriculture and animal production contribute to the crisis (Steinfeld *et al.,* 2006) an increase in productivity without considering other aspects could generate major problems in the sustainability of production and the environment. Therefore, it is necessary to evaluate all the mentioned edges in which a production system affects the environment and its productivity to achieve a complete analysis (Godfray, 2015; (Leenstra, 2013).

Extensive grazing beef production systems with low inputs and labour were the most predominant for a long time in South America (Modernel *et al.,* 2013). However, because of the increased demand for beef, increasingly intensive meat production systems have been adopted and, as a result, the environmental impact of meat production also changed and worsened (Ogino *et al.,* 2016).

2.2.2 Environmental impact of beef production systems

Animal production can affect to the environment positively or negatively depending on the resource usage and management. Some of the most commented effects of beef production on the environment are greenhouse gases emission (GHG), water pollution, soil erosion, biodiversity, nutrient imbalances and land degradation (Steinfield *et al.,* 2006).

Beef production activity is considered one of the main contributors to GHG emissions from anthropogenic origin, with an estimated 7% to 18% of the total GHG emission worldwide (IPCC 2019; IPCC, 2014) it has a higher carbon footprint compared to other animal edible products (Capper, 2012; Geber *et al*., 2015). Greenhouse gases emitted in beef production are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) and the main sources of emission are enteric fermentation (methane) followed by

urine and manure decomposition (nitrous oxide) (Cerri *et al.,* 2016) Therefore, considering the climate crisis that we are experiencing nowadays and the constant demand increase for beef, it is extremely necessary to reduce GHG emissions in beef production.

One of the options that have been proposed to mitigate or reduce the emission of GHG in beef production is to enhance the efficiency of the systems by increasing productivity per land portion, which would result in a decrease in emissions by surface area (Garnett *et al.,* 2014). Increased efficiency would also mean a decrease in emissions by quantity of final product produced, which means that beef from confined systems would have lower GHG emissions compared to grazing systems, and in turn, regenerative grazing would have lower emissions compared to extensive grazing due to differences in their efficiencies (Campbell *et al.,* 2014). However, estimating the environmental impact of the systems by the amount of emissions per product provided is somewhat a simplistic look, because systems in confinement are more efficient in terms of more beef production per year, compared to the grazing systems. In the confined system is possible to achieve twice as many animals for slaughter compared to grazing systems, which means that emissions per amount of product provided would be lower, but the emissions per land portion would be higher (Broom, 2019). On the other hand, under the previous conceptualization, the soil capacity to capture carbon is being neglected, which turns out to be a key ecosystem issue of the grasslands and an alternative for the mitigation of GHG emitted in beef production (Wang *et al.,* 2015; Griscom *et al.,* 2017). And by using regenerative alternatives for managing grazing livestock, the soil carbon sequestration may benefit, increasing the mitigation power that beef production has on its own emissions (Stanley *et al.,* 2018).

The soil mitigation potential has been underestimated in many studies. When carrying out life cycle analysis (LCA), which is an analysis of the complete production cycle emissions of a product, most of scientific studies have considered that the carbon in the soil is stable and that there is no capture of the GHG emitted there. Nevertheless, well-managed regenerative grazing can results in a reduction in the total emissions if the gases emitted and the amount of carbon captured are considered in the final calculation (Stanley *et al.,* 2018; Teague & Barnes, 2017; McSherry & Ritchie, 2013).

So, if the ecosystem service of carbon sequestration by soils and its potential on the gas emitted mitigation is taken into account, regenerative grazing is more positive, resulting in a smaller carbon footprint compared to confinement and extensive grazing, as they may emit more GHG and comparatively sequester less carbon (Capper, 2012). Therefore, the idea that the carbon footprint is higher in beef production systems compared to other animal production systems depends on the management, the system and mainly on the carbon sequestration potential of the system. However, it is important to take into account that the amount of carbon sequestered can reach a saturation point, minimizing the mitigation power (Machmuller *et al.,* 2015).

Regarding land use, it is known that as a result of the efficiency of conversion and productivity, confinement is the system that uses the least land; in contrast, extensive grazing the one that needs the most for the production of the same amount of product. Beside the amount of land used in each system, the issue of soil erosion - the loss of its top layer - is highly discussed in the beef production sector. Soil erosion can occur for many reasons, including mechanical or chemical intervention, therefore, confinement systems is the system that generates a higher degree of soil erosion, due to the high intensification for feed production, while extensive grazing can produce a medium or high soil erosion (Gerber *et al.,* 2013). Regenerative grazing generates little or no erosion, since cattle occupy each paddock for a short time, and therefore they are not able to generate sufficient mechanical pressure for erosion and destruction of the physical structure of the soil (Pinheiro Machado, 2004; Savory & Butterfield, 2016). Regarding the balance of nutrients, between 55% to 95% of the nitrogen (N), and about 70% of the phosphorus (P) ingested by livestock is excreted as urine or faeces (Menzi *et al.,* 2010). Tehrefore, these nutrients can be recycled and reused for the fertilization of the prairies, returning the nutrients to the soil, or lost through gaseous emissions, draining and runoff. Pasture-based systems have a better balance of nutrients (Savory & Butterfield, 2016). In confined systems, the loss and waste or nutrients these mostly occur due to nutrient excretions that substantially exceed the land absorption capacity (Menzi & Gerber, 2006).

Producers of confinement systems usually buy their food to others or produce it on farm under monoculture systems for the production of the main crops such as corn

and soybeans and consider a lesser extent forage for feeding animals. Therefore, confinement impacts biodiversity through land conversion, habitats destruction, monocultures, soil erosion and soil contamination with chemical inputs (Machovina, *et al.,* 2015), which translates this into a loss of biodiversity. However, poor grazing management can also lead to the loss of biodiversity as a result of land degradation, selectivity of grazing animals resulting in overgrazing, which can happen in extensive grazing systems (Gerber *et al.,* 2015). On the other hand, good grazing management, i.e., respecting the plants' resting periods, the nutrient cycles and the time of occupation of the paddocks, can generate an increase in biodiversity favouring the proliferation of diverse plant and animal species and microorganism (Savory & Butterfield, 2016; Pinheiro Machado, 2004; Pinherio Machado & Pinheiro Machado Filho, 2016). It should also be noted that as the management of beef production can favour biodiversity, a rich biodiversity could also favour beef production, there is a reciprocal benefit, since greater biodiversity means an increase in the available plant biomass and variety of nutrients for animals (Finn *et al.,* 2013).

2.2.3 Animal welfare in beef production systems

Animal welfare concerns have always existed among farmers, animal owners and veterinarians, but after 1964, when Ruth Harrison published her book "Animal Machines", it began to be an important topic for the society. In response to societies' concerns the UK Parliament established the "Brambell committee" to enquire animal welfare (Brambell 1965). Since then, animal welfare has been an ethical concern issue both for society and for scientists who have dedicated themselves to the research and development of this concept, and it has been understood as the animal ability to cope with its external and internal environment (Fraser *et al.,* 1997). The interpretation generally used to evaluate the welfare of animals has been the 5 freedoms that correspond to freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express normal behaviour and freedom from fear and distress (FAWC, 1992; Mellor, 2017). Nevertheless, nowadays the understanding of animal welfare has expanded the barriers of the 5 freedoms, and it is considered that the interaction between physiological mechanisms and the generation of particular

subjective experiences, which are the affective states that animal might experience. The affective states that the animal might experience can be either positive or negative, should be evaluated and taken into account, turning the 5 freedoms into 5 domains of potential welfare compromise (Mellor *et al.,* 2020; Mellor, 2012). Regarding the relationship between the affective states of animals and the 5 freedoms mentioned above, animal welfare is not achieved with negative affective states avoidance. Therefore, it is not enough just to assess that the animals are free of negative affective states, but it is necessary that the animals have "a life worth living" that can be fostered through the experience of positive affective states (Mellor *et al.,* 2020). As above, it can be inferred that the type of cattle production and housing system can affect their welfare in many ways as the 5 freedoms can be modified between them and adaptation conditions and ability of the animals for each system are not always the same.

Public concern has been focused on what seems more "natural" or "unnatural" from a human point of view and the effect that naturalness has on animal welfare, because of this, all indoor housing and confined systems have generated a great concern among society (Rusheen *et al.,* 2007). Such response is a product of the perception that exists regarding the restriction of space and movement and the inability in some cases of animals to express their "natural" behaviour (Cardoso *et al.,* 2018; Hötzel *et al.,* 2017). A "natural life" involves cattle grazing. Naturalness is a difficult concept because there is no clear limit to define what is natural for cattle and what is not (Špinka, 2006). However, livestock welfare is not necessarily better in pasture-based systems than in confined systems. As a matter of fact, it is possible that animals in the pasture (an environment perceived as "natural") during the winter months may not have access to enough forage or they may be kept in areas with rough pastureland, with a possible undernutrition affecting their welfare, or may be exposed to extreme climatic conditions, suffering heat or cold distress, parasites, predators attacks and other contagious diseases (Špinka, 2006; Mee & Boyle, 2020). This is an example of why it is necessary to analyse the effect that each systems have on the animal welfare from the three approaches proposed by Fraser *et al,* (1997) which are the biological functioning of the animal, natural living and the affective state.

Biological functioning refer to the health status and productivity of the animal,

affective states refer to whether the animal is experiencing positive or negative emotional states, and naturalness refers to whether the animal is being able to express its natural and innate behaviour (Fraser *et al.,* 2017). Nevertheless, the third approach is the most difficult to study (von Keyserlingk *et al.,* 2019). There are several studies analysing the welfare of cattle, more specifically of dairy cows in different housing systems (i.e. Arnott, *et al.,* 2016; Costal *et al.,* 2013, Smid *et al.,* 2020) and from these it is concluded that exposure of cattle to pastures may benefit animal welfare, but does not mean that welfare is necessarily better in pasture-based systems than in confinement. However, there is no research that directly evaluates the welfare of cattle raised in different beef production systems or the welfare of cattle in systems under regenerative grazing.

2.3 Public attitudes and behaviour

2.3.1 Conceptualization of attitudes and behaviour

Attitudes arise from peoples' valuation of a particular object, behaviour or process, and can be positive or negative as they resonate with the persons' beliefs (Ajzen, 2001). They represent an individual's degree of favourableness or unfavourableness in front of that particular object depending on what they like and what they don't, as a result of cognitive, affective and behavioural processes (Ajzen & Fishbein, 2000). Attitudes are not static, since they depend on the context and the information that people have regarding the object of evaluation at a respective moment (Zepeda & Deal, 2009) which means that they can change as the person sees himself in another context or receives new information (Wilson *et al.,* 2000). Behaviour is how a person acts or conducts itself towards a particular object (situation, object or stimulus) and attitudes are drivers of behaviour. However, the attitudes-behaviour relationship is quite complex and the existing literature that tries to explain this relationship is quite extensive. Since behaviour is not exclusively dependent on how favourable or unfavourable people's attitude is towards something, because there are many other moderators involved in this relationship and the identification of these moderators has been very important topics in social and psychological investigations (Armitage & Christian, 2003). However,

a first step of approach to knowing the reaction of a person towards something are the attitudes.

For the purpose of this research, it is important to consider that the attitudes and behaviours of a person in its role as a citizen may be different since people's attitudes as consumers may be driven by the evaluation of the economic aspects of products and purchasing power, while people in their role as citizens can express their attitudes without considering the economic limitations that they could have as consumers (Grunert, 2006). For this reason, the methodology of this study will be oriented towards citizens and not consumers, so that the economic aspect is not a limitation at the moment of assessing participants attitudes.

2.3.2 Public attitudes towards beef production and beef consumption

In recent decades, various studies have been carried out evaluating the attitudes and opinions of citizens regarding animal production, mainly in most developed countries of Europe and North America (i.e. Spooner *et al.,* 2014; Heleski *et al.,* 2004; Martelli, 2009), but in recent years the amount of research has also increased in less developed countries and in South America (Yunes *et al.,* 2017; Teixeira *et al.,* 2018; Vargas-Bello-Pérez *et al.,* 2017). In addition, considering that social pressure has been one of the main driving forces to improve animal production standards and to adapt systems to public values, assessing citizens' attitudes and preferences is essential to continue developing a more sustainable industry (von Keyserlingk & Hötzel, 2015)

Citizens' preference for pasture-based systems (Teixeira *et al.,* 2018; Conner *et al.,* 2008; Morales *et al.,* 2013), which many consider more "natural" than other systems (Verbeke *et al.,* 2010; Pricket, 2010), is because animal welfare is perceived as better. Animal welfare is perceive as more positive in these systems mainly due to the freedom of movement and space, compared to the restriction to which animals can be subjected in confined systems (Yunes *et al.,* 2017). Consumers are also willing to pay more for beef produced in pasture based than for beef from a confined system (Xue *et al.,* 2010; García-Torres *et al.,* 2016).

Another important aspect for this research regarding the attitudes and consumption

of beef are the attitudes and perceptions of vegetarians or vegans. Considering vegetarians as people avoiding all animal products and other products occasionally eating meat, fish, and poultry (Weinsier, 2020) and vegans as people who only eat vegetable-derived foods and avoid all animal products (Beardsworth & Keil, 1991). As Ruby (2012) mentioned, an increasing number of people are choosing to eliminate beef and meat from their diets, and vegetarianism is a "blossoming field of study"., In this sense, vegetarians have more negative attitudes towards the production and consumption of meat than meat eaters, and vegans have even more negative attitudes than vegetarians (Ruby, 2012; De Backer & Hudders, 2015).

3 MATERIALS AND METHODS

3.1 Survey and data collection

This study consisted of a survey applied to 1591 Chilean participants, and was carried out in two parts differing in the type of participants' recruitment. The first part of the recruitment was done face-to-face in February 2020 in Santiago de Chile; the second one was done online in April and May 2020, due to the outbreak of Covid-19. In both, data collection was conducted using a self-administered questionnaire, with no interaction between recruiter and respondent after the acceptance to participate. Face-to-face participants were recruited personally in public spaces with a large influx of people (civil registry offices, bus stations, outside notary offices and the international airport), who were awaiting or had free time. The online version of the questionnaire was carried out through Google Forms Online platform (www.docs.google.com). Online participants were recruited through different social networks such as Whatsapp, Instagram, Facebook and by email sharing the questionnaire link and inviting participants to respond and share the survey. Participants were invited to complete a survey about animal production, with no specification of the nature of the issue to reduce self-selection bias. Only participants that were at least 18 years old and had Chilean nationality participated of the study. The identity of the participants was not required.

For both versions of the questionnaire, the 15 first responses were conducted as a pilot study and answers and comments were discussed among the research team and reviewed and some refinements were made to the questionnaire. The final questionnaire included 15 closed questions and 2 open-ended questions. Participants who agreed to participate in the survey were asked to read an informed consent that had to be accepted before starting the questionnaire. It clarified the purpose of the investigation, the anonymity of the participation and how the information collected was going to be used. It also explained that participants did not run any risk by participating in the investigation, that there was no compensation for doing so and that they could withdraw at any time if they wished, without any repercussion.

Participants were randomized into four groups, which corresponded to different type of information about different housing and beef production systems: one group received no information (NOInf) about the production system and the others received information about one of three beef production systems: confinement (CONF), extensive grazing (EXTgra) or regenerative grazing (REGgra). Participants that received information about the beef production systems (CONF, EXTgra, and REGgra) were first invited to read a description about the respective beef production system that they were assigned, including information about how animals are housed, how much space they have, and some of the main management practices used in each system. It also included information about each system's productivity, greenhouse gases emissions per unit of product, water contamination, soil erosion, biodiversity and carbon sequestration. Information provided in each survey was as follows:

(CONF): *"The most common beef productive systems in Chile are confinement and grazing, which can be extensive or intensive. Grazing is the system in which cattle is kept in pastures and get their food directly from it.* ***Confinement*** *is the system in which cattle is kept together within closed spaces or sheds. A smaller space per animal and a smaller area for the production of food that covers the nutritional requirements of the animals is allocated in comparison to grazing systems. This is a highly productive system, generally making low greenhouse gas emissions per kilogram of meat produced, but with low soil carbon sequestration. This system usually generates a high degree of water contamination and soil erosion. Furthermore, this system generally reduces the biodiversity in the ecosystem".*

(EXTgra): *"The most common beef productive systems in Chile are confinement and grazing, which can be extensive or intensive. Grazing is the system in which cattle is kept in pastures and they get their food directly from it.* ***Extensive grazing*** *is the system in which cattle is left free with a large space per animal in the pastures, allocating a large area for the production of its food. This system has low productivity, generally causing high greenhouse gas*

emissions per kilogram of meat produced, intermediate or low carbon sequestration and intermediate or high contamination and soil erosion that also results in low biodiversity"

(REGgra): *"The most common beef productive systems in Chile are confinement and grazing, which can be extensive or intensive. Grazing is the system in which cattle is kept in pastures and they get their food directly from it.* ***Intensive or regenerative grazing*** *is a way of managing grazing in which a small space is assigned for the animals for a short period and then they are moved to the next space, controlling the time the animals spend in each paddock. Thus, feeding area is usually intermediate, ensuring that the cattle meet their nutritional requirements. This system has a medium productivity, so it also has medium greenhouse gases emissions per kilogram of meat produced. It is characterized by high carbon sequestration, little water pollution and little or no soil erosion, and it can also lead to increased biodiversity."*

For tthe description of the systems, the characteristics to be defined within each of them were taken and then the information corresponding to each of the systems was obtained from bibliographic sources.

3.2 Participants' socio-demographics and characterization

The first questions addressed participants' socio-demographic information relating to their sex (female; male), age (18–25; 26–35; 36–45; 46–55; 56–65; over 66 years old) and education (no university education; or complete or incomplete university education). They were also asked what their consumption habits in relation to meat (omnivore; vegetarian; vegan; other). For the purpose of the analysis participants were classified as meat consumers (if they consumed beef, pork, poultry, or small ruminants), and as not meat consumers. Participants who were classified as meat consumers were asked how often they ate beef (7 days per week; 3 to 6 times per

week; 1 or 2 times per week or less than 1 day per week). Finally, all the respondents were asked if they had any type of relationship with animal production (yes, I currently have some kind of relationship; I grew up in a place related to animal production or no relationship).

3.3 Attitudes towards beef production systems, beef production and beef consumption questions

Thereafter, participants were asked their opinion towards beef production systems and beef consumption behaviour. Questions and options for answers are detailed in Table 1.

TABLE 1. Questions regarding participants' opinions towards beef production systems and beef consumption behaviour

	Options
Attitudes towards beef production systems [1]	
(Q1a) do you approve this system of housing and beef production and (Q1b) why (Q2) would you approve that the beef you normally eat came from this system (Q3) do you approve that the system described in the text should be the beef production system of the future	From 1: totally disapprove to 5: totally approve
Statements of agreement (how much they agree with the given sentences) (Q4)	
(Q4a) "Beef consumption is bad for human health" (Q4b) "Beef consumption is bad for the environment" (Q4c) "Greenhouse gases are emitted in beef production"	from 0: totally disagree; 4: totally agree, or I do not know
Beef consuming attitudes and habits	
(Q5) how do you considered your level of beef consumption[2]	Low Intermediate High
(Q6a) have you reduced your meat consumption in the last year and (Q6b) why[2]	Yes No I do not remember
(Q7) what do you plan to do with your beef consumption in 3 to 5 more years[2]	Maintain Reduce Increase
(Q8) which was/were the main reason(s) for you to not consuming beef[3]	Price; health; religion; environment; I do not like the taste; I do not know how to cook beef; the animals; other
Prospective beef consumption	
(Q9) what do you think the Chilean population will do about	Maintain

their beef consumption in the future	
(Q10a) what do you think the Chilean population should do regarding their beef consumption in the future	Reduce Increase
(Q10b) which was the main reason for your last answer	Economics; environment; animals; human health; production level; other
(Q11) Which meat or meat substitute you consider that Chileans will eat most in the future, choosing one or more options[4]	Beef; pork; poultry; fish; lamb; vegetable meat substitutes; cultured meat; insects; other

[1] Only for the participants that received information about the different beef production systems; [2] Only for meat consumers; [3] Only for not meat consumers; [4] Only for online participants

3.4 Statistical analysis

From the initial 1591 questionnaires completed, 82 were excluded for various reasons including responses from non Chileans, repeated responses (due to platform problems), incomplete surveys and responses that were not readable or understandable resulting in 386 face-to-face and 1205 online usable surveys, i.e., a total of 1509 that were considered for analysis.

Responses to the face-to-face questionnaire were transferred to the platform Google Forms Online and all information was automatically transcribed to a Microsoft Excel (version 2013) sheet. Descriptive statistics for the responses were calculated using Microsoft® Excel for Mac and all other statistical analyses were conducted using SAS 9.3. Age 56–65 and over 66 years old, as well as professional involvement and grew up in an agriculture environment were respectively grouped due to the low number of participants in these categories.

An initial exploration for the first three attitude questions (Q1a, Q2 and Q3) was done using Spearman Correlation coefficients. As the questions were highly correlated ($R^2 > 0.82$; $P < 0.001$) the responses were averaged to create an “attitude” construct. These data were normally distributed as evaluated using the Univariate procedure. A generalized linear model (GLM) was then used to evaluate effects on attitudes, including treatment (CONF, EXTgra and REGgra), sex, age, questionnaire type, educational level, meat consumption and involvement with animal production as explanatory variables and all double interactions among them were also included in the

model.

Multinomial logistic regression models were used to analyse associations between the type of recruitment and socio-demographic data and opinions regarding agreement with statements about beef consumption and human health (Q4a), environment (Q4b) and greenhouse gases emission (Q4c). To easy data interpretation, the “totally agree” and “agree” categories as the “totally disagree” and “disagree” categories were respectively grouped. Treatment (CONF, EXTgra and REGgra), sex, age, questionnaire type, educational level, meat consumption and involvement with animal production were included in the model as explanatory variables. For the associations between socio-demographic data and participants’ prospective beef consumption (Q7), the explanatory variables initially considered in the multinomial regression model were beef consumption frequency, beef consumption self-assessment (Q5) and reduction in beef consumption last year (Q6). For the question about what Chileans would (Q9) and should (Q10a) do about their prospective beef consumption, the explanatory variables included in the analyses were beef production system, questionnaire type (online or face to face), sex, age, education level, involvement with animal production, meat consumption, beef consumption frequency and what participants thought that Chileans would do about their future beef consumption. The same explanatory variables were used for question about which meat or meat substitute participants considered that Chileans will eat most in the future (Q11).

In both approaches, only the predictor variables with $P < 0.20$ were initially used to build multivariate models. Finally, the backward selection was used to eliminate predictor variables until only those with $P < 0.05$ remained in the models. For the normally distributed variables, results are presented as least square means and standard error (LSM ± SE); for the categorical and ordinal variables, results are presented as odds ratio (ODDS) and 95% confidence interval (95% CI). Statistics associations were reported when $P < 0.05$ and tendency when $0.05 < P < 0.1$.

3.5 Thematic analysis

The analysis of the two open-ended questions (Q1b and Q6b) were submitted to thematic analysis (Braun & Clarke, 2006). The thematic analysis was done in three stages: coding information (data reduction) organization of the information (data display) and patterns and themes observation and confirmatory tactics (conclusion drawing and verification). To ensure that the coding of themes were appropriate, three readers, initially, analysed 50 random responses for each of the four treatments and independently developed codes. Then, the three coders (VMdlF and two other independent people) shared and compared their results and discussed discrepancies until agreement was reached for the creation of the codes and future codification of all answers.

4 RESUSLTS

4.1 Socio-demographic characterization

Socio-demographic data (Table 2) are shown separately for the face-to-face and the online parts of the questionnaire. Most participants were not involved with animal production, had on-going or completed university education and were meat consumers; 713 (74%) females and 469 (87%) males declared themselves as meat consumers.

TABLE 2. Socio demographic information of survey participants for the face-to-face (n = 367) and the online version of the questionnaire (n = 1142)**.**

	Face-to-face		Online		Total	
Variable	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**
Sex						
Male	161	44	380	33	541	36
Female	206	56	762	67	968	64
Age						
18 to 25 years old	108	29	390	34	498	33
26 to 35 years old	99	27	275	24	374	25
36 to 45 years old	63	17	168	15	231	15
46 to 55 years old	51	14	171	15	222	15
56 years old and over	46	13	138	12	184	12
Beef production system information						
NOInf	106	29	319	28	425	28
CONF	100	27	252	22	352	23
EXTgra	96	26	299	26	395	26
REGgra	65	18	272	24	337	22
Meat consumption						
Yes	284	77	903	79	1187	79
No	83	23	239	21	322	21
Beef consumption frequency						
1 to 2 times per week	167	46	652	57	819	54
3 to 6 times per week	74	20	211	18	285	19
Every day	8	2	16	1	24	2
Less than 1 time per week	33	9	26	2	59	4
Involvement with animal production						
No	318	87	1009	88	1327	88
Yes	48	13	133	12	181	12
Education						
No university education	102	28	214	19	316	21
University education complete or on-going	265	72	928	81	1193	79

4.2 Attitudes towards beef production systems

Attitudes evaluated as an attitudinal construct (average of the 3 approval questions of the beef production systems (Q1a, Q2 and Q3) ranged from 1 (negative attitudes) to 5 (positive or favourable attitudes) towards the respective beef production system. Attitudes towards CONF were lower than for EXTgra, which were lower than for REGgra (1.94, 2.83 and 2.94 SEM 0.078; P < 0.001). Participants that had involvement in animal production (2.76 vs. 2.38 SEM 0.068; P < 0.001) had more favourable attitudes towards the beef production systems versus those that without involvement. There were interactions between sex and meat consumption with beef production systems type (Table 3). Males had higher (P < 0.01) attitudes towards CONF than females but both sexes had greater (P < 0.001) attitudes towards both pasture-based systems than for CONF. While meat consumers had greater (P < 0.01) attitudes towards the REGgra than the EXTgra, not meat consumers had similar attitudes towards both pasture-based systems, but regardless of their meat consumption habit, both had the lowest attitudes towards CONF.

TABLE 3. Participants' attitude towards the different beef production systems (Q1a, Q2 and Q3; CONF = Confinement; EXTgra = Extensive grazing; REGgra = Regenerative grazing) (n = 1087).

	Beef production systems				*P* - value	
	CONF	**EXTgra**	**REGgra**	**SEM**	**Main effect**	**Interaction with BPS**
Sex					< 0.05	< 0.05
Male	2.13 (12)[1]	2.84 (12)	2.96 (12)	0.107		
Female	1.76 (20)	2.82 (14)	2.92 (19)	0.085		
Meat consumption					< 0.001	< 0.001
Yes	2.36 (26)	3.41 (28)	3.74 (24)	0.070		
No	1.53 (7)	2.24 (8)	2.13 (7)	0.126		

SEM = Standard error of the mean.

Rank = From 1 to 5 (1 = Totally disapprove; 2 = Disapprove; 3 = I do not approve or disapprove; 4 = Approve; 5 = Totally approve).

[1]Percentage of participants for each category in parenthesis.

Ten themes emerged as justifications for the citizens' attitudes towards the systems (Q1b) (Table 4). Some responses included more than one theme, so they were assigned into multiple themes and some responses had no valid justification, so they were classified as "no justification". The two main themes covered by participants for approving or disapproving their respective beef production system were animal welfare (29%) and environment (23%), the other themes, less mentioned were ethical issues (8%), disagreement with all meat production (6%), productivity (5%), natural system (4%), lack of knowledge (4%), beef quality (3%) indifference (3%), other reasons (2%), and the remaining percentage did not give any justification (14%). While the animal welfare related aspects were the most mentioned reasons for disapproval of the CONF and REGgra, the reasons related to the environment were the most commented for disapproval of the EXTgra. Productivity related aspects were the major reasons for approval of the CONF.

TABLE 4. Emerging themes in participants' justification for approval or disapproval the different beef production systems (Q1b; CONF = Confinement; EXTgra = Extensive grazing; REGgra = Regenerative grazing), and percentages of mentions (n=1087).

	CONF			EXTgra			REGgra		
	0-1	**2**	**3-4**	**0-1**	**2**	**3-4**	**0-1**	**2**	**3-4**
Animal welfare *(Space, freedom to move, adequate feeding, animals' feelings, stress, shelter, health and the treatment that humans give them)*	40	7	7	7	6	56	35	9	24
Environment *(Contamination, greenhouse gases, biodiversity, soil erosion, water pollution, air pollution and odours)*	18	-	-	51	2	8	14	4	39
Beef quality *(Nutritional and organoleptic quality)*	4	2	-	1	-	4	1	2	2
Natural system *(Natural feeding or housing)*	5	2	-	0	-	10	3	2	4
Productivity *(Efficiency, sustainability and profitability)*	2	7	49	6	-	3	1	4	9
Ethical issues *(Respect, animal rights, moral and ethics)*	13	-	-	10	-	4	15	2	-
Lack of knowledge	0	20	-	-	42	-	1	26	1
Indifference	-	32	-	-	23	1	-	23	-
Disagreement with meat production *(No meat should be produced)*	5	-	-	14	2	-	22	2	-

Others	1	2	5	0	-	1	2	-	6
No justification	10	27	40	9	26	14	7	26	14

Rank = From 1 to 5 (Disapp = Totally disapprove (0) and disapprove (1); Not app or disapp = I do not approve or disapprove (2); App = Approve (3) and Totally approve (4))

4.3 Statements agreement

For the "Beef is bad for human health" statement (Q4a), more participants did not agree (43%) than agreed (30%), while the rest were in between (23%) or did not know (4%). Instead, for the "Beef is bad for the environment" (Q4b), more participants agreed (50%) than disagreed (27%), 21% were in between and 2% did not know. The same happened for the "Greenhouse gases are emitted in beef production" as more participants agreed (62%) than disagreed (13%), but, there were less participants with a medium level of agreement (12%) and more participants that did not know what to answer (13%).

The level of agreement of participants with the three different sentences related to beef production systems are presented in Table 5. Females had higher odds of reaching a higher level of agreement for the first and second statement compared to males ($P < 0.001$). Participants over 26 years old had lower odds of agreeing that beef is bad for the environment and that greenhouse gases are emitted in its production versus the younger respondents ($P < 0.001$), but respondents between 26 to 35 years old had higher odds than younger ones of agreeing that beef is bad for human health ($P < 0.05$). In addition, participants that did not eat meat had higher odds of agreeing with each of the three statements ($P < 0.001$) compared to meat consumers. Similarly, respondents with university education had higher odds of agreeing with the second and third statement compared to participants without university education ($P < 0.05$). In contrast, participants involved with animal production had lower odds of agreeing that beef is bad for the environment versus participants without involvement ($P < 0.001$). There were also differences in the level of agreement according to the type of questionnaire (online or face-to-face) ($P < 0.05$). The online respondents had lower odds of agreeing that beef is bad for the environment and that greenhouses gases are emitted in its' production than the respondents of the face-to-face version of the questionnaire, and had lower odds of being neutral for the "Beef consumption is bad for human health" statement.

TABLE 5. Factors influencing participants' level of agreement towards 3 different sentences related to beef production systems (Q4a, Q4b, Q4c). Totally disagree or disagree were the reference category.

	Level of agreement						
	Not agree or disagree			Agree or Totally agree			
	n	OR	95% CI	n	OR	95% CI	*P* - value
(Q4a) "Beef consumption is bad for human health"							
Sex							<0.001
Male	118			120			
Female	234	1.53	1.15-2.03	331	1.76	1.28-2.42	
Age							<0.05
18-25	125			162			
26-35	81	0.85	0.59-1.24	134	1.83	1.21-2.76	
36-45	47	0.70	0.46-1.07	62	1.33	0.83-2.11	
46-55	49	0.71	0.46-1.08	23	1.21	0.76-1.93	
56 or more	50	0.98	0.64-1.51	40	1.31	0.79-2.16	
Meat consumption							<0.001
Yes	297			226			
No	55	2.34	1.31-4.18	225	8.91	5.29-15	
Animal production involvement							<0.001
No	313			429			
Yes	39	0.55	0.36-0.82	22	0.26	0.15-0.46	
Questionnaire type							<0.01
Face-to-face	102			110			
Online	250	0.62	0.45-0.84	341	0.74	0.53-1.05	

(Q4b) "Beef consumption is bad for the environment"							
	Not agree or disagree			Agree or Totally agree			
	n	OR	95% CI	n	OR	95% CI	*P* - value
Sex							<0.001
Male	142						

Female	172	1.00	0.73-1.38		1.79	1.33-2.4	
Age							<0.001
18-25	84			335			
26-35	98	0.96	0.61-1.49	189	0.54	0.36-0.8	
36-45	46	0.52	0.32-0.85	97	0.35	0.22-0.54	
46-55	45	0.39	0.24-0.64	77	0.23	0.15-0.35	
56 or more	41	0.45	0.27-0.74	58	0.22	0.13-0.34	
Meat consumption							<0.001
Yes	22			282			
No	292	1.78	0.74-4.29	474	8.17	3.97-16.82	
Animal production involvement							<0.001
No	275			707			
Yes	39	0.43	0.28-0.66	49	0.21	0.14-0.32	
Questionnaire type							<0.001
Face-to-face	95			191			
Online	219	0.45	0.31-0.65	565	0.52	0.37-0.74	
Education							<0.05
No university education	68			133			
University education	246	1.15	0.79-1.68	623	1.58	1.11-2.24	

(Q4c) "Greenhouse gases are emitted in beef production"

	Not agree or disagree			**Agree or Totally agree**			
	n	**OR**	**95% CI**	**n**	**OR**	**95% CI**	***P* - value**
Age							<0.001
18-25	44			374			
26-35	339	0.73	0.38-1.41	252	0.62	0.37-1.05	
36-45	32	0.68	0.35-1.33	131	0.41	0.24-0.7	
46-55	32	0.57	0.29-1.09	106	0.30	0.18-0.51	
56 or more	37	0.66	0.35-1.26	68	0.19	0.11-0.32	
Meat consumption							<0.001
Yes	13			271			

No	171	0.99	0.36-2.71	660	3.11	1.46-6.66	
Questionnaire type							<0.05
Face-to-face	44			244			
Online	140	0.67	0.4-1.11	687	0.56	0.37-0.85	
Education							<0.001
No university education	44			153			
University education	140	1.52	0.95-2.44	778	2.19	1.49-3.21	

OR = Odds ratio.
CI = Confidence interval.
Rank from 0 to 4 (0 = "Totally disagree" and 4 = " Totally agree")

4.4 Beef consumption: attitudes and habits

Among the 1187 meat consumers participants, 39% of them perceived its' consumption as low, 42% as intermediate and 19% as high (Q5). Fifty percent of participants answered that they have reduced beef consumption during the previous year (Q6a), while 37% did not and the others did not know or did not remember. Almost half of participants (44%) intended to maintain their beef consumption level in the future, 42% intended to reduce and only 1% were willing to increase consumption. The themes that emerged as a reason for having reduced or maintain meat consumption (Q6b) are presented in Table 6. Some responses included more than one theme, so they were assigned into multiple themes and some responses had no valid answer, so they were classified as "no reason".

TABLE 6. Emerging themes in participants' reasons for having reduced or not beef consumption last year, number of mentions and percentages of mentions. (n=1313). Data are presented as percentage of participants (%).

Reasons	Reduction of beef consumption	
	No	Yes
Health issues *(Nutrients, diet, medical recommendation, fats and others)*	23	28
Dependence *(When the participant's meat consumption depended on other people or factors)*	8	5
Willingness	17	4
Environmental issues *(Environmental impact of meat production, resources use or contamination, carbon footprint)*	0	14
Animals *(Animal welfare issues)*	0	7
Diversification *(Consumption of other products of animal origin or other origin)*	1	12
Economic issues *(Beef price, price of other products, income or salary)*	2	11
Organoleptic reasons *(Taste, smell or texture)*	3	4
Accesibility *(Distance to sales point, beef supply or beef origin)*	2	2
Ethical reasons *(Ethics and morals, respect, vegetarians for ethical reasons)*	0	5
Habits *(Beef as part of habits)*	11	0
Others	3	0
No reasons	30	8

Among the participants that intended to reduce beef consumption in the future (Q7; Table 7), there were higher odds that they perceived their beef consumption level as high rather than intermediate ($P < 0.01$), and those who said that they had already reduced beef consumption in the past, had higher odds of intending to reduce it in the future than those who did not ($P < 0.001$). In addition, there were lower odds that participants involved with animal production intended to reduce beef consumption in the future than those who did not have any type of relation with animal production ($P <$

0.001). None of the categories considered in the analysis showed a significant effect on participants' intention to increase their increase their beef consumption (data not shown).

TABLE 7. Factors influencing participants' intention to reduce beef consumption in 3 to 5 more years (Q7). Maintain beef consumption was the reference category.

		Reduce beef in the future		
	n	**OR**	**95% CI**	***P* - value**
Beef consumption self assesment				< 0.01
Intermediate	307			
Low	239	1.18	0.86-1.6	
High	123	1.95	1.38-2.75	
Reduced beef consumption last year				< 0.001
No	148			
Yes	500	5.47	4.13-7.24	
Involvement with animal production				< 0.001
No	613			
Yes	56	0.39	0.26-0.58	

OR = Odds ratio.
CI = Confidence Interval

The three main reasons cited by participants to justify not eating beef (Q8) were environmental (31%), animal welfare (31%) and human health (24%). The other reasons were taste (8%), price (2%) and other (4%).

4.5 Prospective beef consumption

Participants considered that Chileans should (Q10) maintain (18%), reduce (80%) or increase (2%) their beef consumption, but 46% of the participants considered that Chileans will (Q9) effectively maintain, 47% reduce and 6% increase their beef consumption. Participants not related with animal production had higher odds of saying that Chileans should reduce beef consumption than participants related with animal production ($P < 0.001$) as also did women compared to men ($P < 0.001$; Table 8). Participants who ate meat 3 or more times per week had lower odds than those who ate

meat only 1 to 2 times per week of saying that Chileans should reduce meat consumption, while those who ate meat less than once a week were more likely to say that Chileans should reduce meat consumption compared to those who consumed meat once or twice a week (P < 0.001; Table 8). The main reasons given by participants for saying that Chileans should reduce beef consumption (Q10b) were the environment (48%), human health (23%) and for the animals (18%). Participants who mentioned the level of production, human health and economic reasons for changing their beef consumption had lower odds of saying that Chileans should reduce meat consumption compared to those who mentioned the animals as reasons for changing their beef consumption (P < 0.001; Table 8).

TABLE 8. Factors influencing participant's attitude towards what Chileans should do in the future about their beef consumption level (Q10) and the main reasons for it. Chileans should maintain beef consumption was the reference category.

	"Chileans should reduce beef consumption"			
	n	**OR**	**95% CI**	***P* - value**
Sex				< 0.001
Males	376			
Females	826	2	1.45-2.78	
Involvement with animal production				< 0.001
No	1103			
Yes	99	0.41	0.27-0.63	
Beef consumption frequency				< 0.001
1 to 2 times per week	659			
3 to 6 times per week	179	0.52	0.36-0.74	
Every day	12	0.23	0.07-0.74	
Less than 1 time per week	156	8.25	2.9-23.42	
Main reasons for changing consumption				< 0.001
The animals	221			
The environment	538	0.91	0.29-2.83	
The level of production	53	0.03	0.01-0.1	
Human health	272	0.06	0.02-0.16	
Economic reasons	58	0.03	0.01-0.09	
Other	60	0.03	0.01-0.09	

OR = Odds ratios.

CI = 95% confidence interval.

Participants with links with animal production had higher odds of saying that Chileans should increase beef consumption than participants not related to animal production (3.36; 95% CI 1.47 – 7.59; P < 0.001) and saying that Chileans will increase consumption compared to maintaining it (3.48; 95% CI 1.01 – 11.97; P < 0.01). Participants who mentioned the level of production as the reason for changing their beef consumption had lower odds of saying that Chileans should increase meat consumption compared to those who mentioned the animals as reasons for changing their beef consumption (0.08; 95% CI 0.01 – 080; P < 0.001).

The most popular future proteins chose by participants (Q11) were poultry (24%), vegetable meat substitutes (24%), fish (21%) and beef (13%). The least popular options were pork (9%), cultured meat (4%), lamb (3%), insects (1%) and other sources (1%). Participants' responses about future protein sources were influenced by their sex, age, beef consumption frequency and level of education (Table 9). Females had more odds of choosing exclusively non-animal future protein sources than males (P < 0.05). Participants over 26 years had higher odds of choosing exclusively non-animal future protein sources or exclusively animal products compared to participants under 25 years old (P < 0.001). Participants who ate beef between 3 and 6 times per week had higher odds than those who consumed it 1 or 2 times per week of choosing exclusively animal protein sources of protein (P < 0.001); in contrast, participants who ate beef less than one time per week had lower odds of choosing exclusively animal protein sources than those who eat once or twice per week (P < 0.001).

	Exclusively non-animal protein sources			Exclusively animal protein sources			
	n	**OR**	**95% CI**	**n**	**OR**	**95% CI**	***P* - value**
Sex							< 0.05
Male	62			182			
Female	173	1.65	1.08-2.51	305	0.99	0.72-1.35	
Age							< 0.001
18 to 25 years old	70			127			
26 to 35 years old	69	2.2	1.32-3.68	118	1.95	1.31-2.91	
36 to 45 years old	35	2.96	1.63-5.36	85	2.43	1.52-3.89	
46 to 55 years old	39	2.7	1.51-4.82	84	2.12	1.33-3.37	
56 years old and over	22	2.12	1.12-4.02	73	2.24	1.38-3.64	
Beef consumption frequency							< 0.001
1-2 times a week	122			308			
3-6 days a week	28	0.89	0.53-1.49	120	1.45	1-2.1	
Every day a week	3	2.86	0.45-18.08	11	3.77	0.8-17.75	
Never	25	0.86	0.5-1.49	25	0.35	0.21-0.6	
Education							< 0.001
No university education	38			123			
University education complete or on-going	197	0.79	0.47-1.32	364	0.45	0.31-0.69	

TABLE 9. Factors influencing participants' opinion about future protein sources. Mixed animal protein sources and non-animal sources were the reference category.

OR = Odds ratios. CI = 95% confidence interval.

5 DISCUSSION

5.1 Support for different beef production systems

Participants had more positive attitudes towards the pasture-based beef production systems compared to the CONF system, similar to other studies in developed and developing countries (Stampa *et al.,* 2020; Yunes *et al.,* 2017; Schnettler *et al.,* 2009). Animal welfare and environmental impacts were the main reasons underlying support and more positive attitudes towards EXTgra and REGra, respectively, as well as the main reasons for opposition and negative attitudes towards CONF. Only few people disapproved the pasture-based systems, based on concerns with lower productivity, which was the major reason for approval of the CONF. Increased productivity has environmental pros and cons (Campbell *et al.,* 2014; Struik & Kuyper 2017) but participants were not eager to accept a trade-off between the animal welfare and environmental issues with productivity of the CONF.

Animal welfare was one of the main factors shaping of participants' attitudes towards beef production systems. Consumers perceive animal welfare as one of the most important quality attributes in beef (Henchion *et al.,* 2017), and is one of the main reasons underlying preferences for pasture-based systems (Stampa *et al.,* 2020). Citizens often consider space per animal, freedom of movement, grazing and access to pasture important animal welfare attributes (Cardoso *et al.,* 2016; Schuppli *et al.,* 2014; von Keyserlingk & Hötzel, 2014), which could explain the more positive attitude towards EXTgra. Indeed, the greater space availability for cattle in EXTgra than in the other systems was cited as a reason for the positive attitude towards animal welfare in the EXTgra system. Participants perceived that the animals in REGgra have less available space as a result of the greater instantaneous stocking density. In addition, the lack of knowledge about beef production systems and low level of involvement with animal production of the participants would have resulted in a misinterpretation of the space availability in the systems, since the perception of space is not easily communicated (Yunes *et al.,* 2017; Marie, 2016). Therefore, studies with images or visits to the different beef production systems as in Cummins *et al.,* (2016) may have different impact on citizens' attitudes and warrants further investigation.

Although the general public commonly perceive beef cattle welfare as better in pastured-based than in confined systems, some issues are still a concern. On the one hand, pasture-based systems may reduce the risk factors for some health beef cattle problems (i.e., acidosis, liver abscesses and hoof related pathologies (Tucker *et al.,* 2015)), may allow animals to express their natural behaviours (grazing, better lying/resting behaviour) and result in calmer animals (Arnott *et al.,* 2017; Mee and Boyle, 2020; Stafford and Gregory 2008). On the other hand, cattle in pasture-based systems may be under greater risk of being exposed to parasites, weather extremes and experience malnutrition (Mee and Boyle, 2020), especially under overstocking situations (Stafford and Gregory 2008). To the best of our knowledge, there are no studies comparing beef cattle welfare in EXTgra and REGgra systems. Such information is needed to support an evidence-based discussion of the issue.

Only few (30%) participants agreed with the statement "Beef consumption is bad for human health", which appears as a novelty compared to previously published studies (Hopwood *et al.,* 2020; Fox & Ward, 2008). The existing information regarding the impacts of beef on health is diverse, with authors arguing that beef is harmful for human health (Springmann *et al.,* 2020 Kaluza *et al.,* 2012; Appleby *et al.,* 2011) and others arguing about its benefits (Wyness, 2015; McAfee *et al.,* 2010; Biesalski, 2005). In contrast to other studies (Sanchez-Sabate & Sabate, 2019; Sanchez-Sabate *et al.,* 2019; Macdiarmid *et al.,* 2015) environmental consciousness was markedly present and was important in shaping citizens' attitudes in this study. Participants' awareness regarding the environmental impact of beef production could be observed in the proportion of participants agreeing that beef is bad for the environment and that greenhouse gases are emitted in its production, as well as in the justification for participants not to consume or having reduced beef consumption, and in the number of participants that thought that Chileans should reduce beef consumption for environmental reasons. The impact of beef production on the environment was also identified among the reasons presented for disapproving CONF and EXTgra and for approving REGgra. Effectively, while it is commonly cited that CONF has lower global warming potential (kg CO_2 equivalent per kg of produced product) than pasture-based systems (i}.e., Bragaglio *et al*., 2017; Godfray & Garnett, 2014), CONF systems may have greater water acidification and eutrophication potential (Bragaglio *et al*., 2017), may cause soil erosion and land degradation, loss of biodiversity, and have low or no

carbon sequestration, than pasture-based systems (Gerber *et al.,* 2013; Stanley *et al.,* 2018). Moreover, some authors have highlighted that the high soil carbon sequestration potential of REGgra may outbalance the greenhouse gasses emissions caused by the system, even resulting in global warming potential abatement (Stanley *et al.,* 2018; Pinheiro Machado, 2004; Rhodes, 2017; Teague & Barnes, 2017). The environmental awareness concerning beef production identified in this study could be related to the increasing media coverage of the impacts of food and meat production on the environment during the last years and the fact that a reduction in meat consumption is repeatedly proposed as a way to mitigate greenhouse gases emissions of anthropogenic origin (Mayes, 2016; Almiron & Zoppeddu, 2014; IPCC 2019; IPCC, 2014). These proposals, however, ignore the fact that some production systems, instead of aggravating the environmental problems, can positively contribute to the food and meat production problem, given that some beef production systems can have positive consequences in the ecosystem such as land restoration, improved resources cycles and biodiversity, and soil carbon sequestration helping to mitigate climate change (Gosnell *et al*., 2020; Stanley *et al.,* 2018; Pinheiro Machado, 2004). In fact, the REGgra systems, towards which the participants had most positive attitudes, present such potentials, which highlights the need to further develop and popularise these systems.

Providing information about beef production systems influenced only attitudes to beef production systems as differences were found in the attitude construct between the treatments but had minimal effect on the other issues covered in the study. In the statement agreement of beef production and the other consumption questions, no differences were found between the responses of the different treatments. This may be due to the fact that our participants did not trust the information provided, did not take the time to read it consciously, or the information given was not a factor to modify the existing attitude towards a specific topic, as it did not create new knowledge for participants (Zepeda & Deal, 2009).

5.2 Current habits and prospective beef consumption

Some participants expressed interest in reducing beef consumption, with those that had already reduced it intending to continue with this behaviour and believing that other Chileans should also reduce beef consumption. In line with participants' attitudes

towards the different beef production systems, animal welfare and environmental issues were the main reasons mentioned to justify willingness to reduce beef consumption. In general, intended and expected reduction in beef consumption reflects citizens' negative attitude towards beef production. Sahlin *et al. (*2020) discussed that eating 'less but better' meat is often equated to sustainable diets, and argued that the definition of both terms is not clear. We can argue that for our participants, eating "less" meant a relative reduction in individual and collective consumption compared to current consumption, whereas "better" meant beef produced in systems with superior animal welfare and environmental performance, represented in this study by REGgra. The development of this system and increased public knowledge about its characteristics and imapcts on animal welfare and the environment may lead to greater public support of sustainable production; if well applied, it may contribute with the conservation of natural resources and mitigation of some of the negative consequences that some beef production systems generate in the environment (Savory & Butterfield, 2016; Pinheiro Machado, 2004; Pinheiro Machado & Pinheiro Machado Filho, 2016).

Among the meat consumers of the sample, 50% had reduced their beef consumption and 42% intended to reduce it in the future. Yet, overall beef consumption has been increasing since the 90's in Chile, driven both by an increase in the population and an increase in per capita consumption (Ortega *et al.*, 2020), and also doubled in the developing countries since de 80's (FAO, 2019) and increased globally (FAO, 2020). The large discrepancies shown in these figures and corroborated in the fact that half of the participants said that they had reduced their meat consumption while the increase in average meat consumption in Chile, have been also reported by Hagmann *et al.* (2019). Discrepancies between consumers' self-perceived behaviour and real behaviour may also be partly explained by the social bias that occurs in self-reported research (Sackett, 1979) as it is possible that participants may have responded aiming to present a favourable image of themselves (Van de Mortel, 2008; Higgs & Ruddock, 2020). This may have been motivated by recent proposals by many organizations and institutions of beef consumption reduction as an alternative to increase food sustainability and to improve human health (see Sahlin *et al.,* 2020). Interestingly, participants who perceived current beef consumption level as high or low rather than intermediate were both more likely to intend to reduce their future beef consumption. Those with high consumption may want to decrease it because they might perceive

their consumption as excessive, whereas those who have already decreased meat consumption may have a more positive attitude towards reduction. The latter is supported in the fact that participants that had already decreased consumption had more than 5 times the odds of intending to continue decreasing meat consumption in the future than those who had not.

Although 80% of the sample believed that Chileans should reduce their beef consumption, only 47% believe that they will do it, showing an expectation of change and low confidence for it to actually happen. The reason for the latter may be related to the Chilean context, in which beef consumption is deeply rooted. In the Western societies, including Chile, meat - and specially beef - plays an essential role in society and food (Chiles & Fitzgerald, 2018) turning its consumption into a habit among citizens, which was given as a reason by some participants for not having reduced beef consumption. Additionally, since eating is a cultural act, and beef consumption is rooted in in the Chilean culture (Higgs & Ruddock, 2020), participants may perceive the resistance among Chileans to reduce beef consumption.

A reduction in beef consumption would imply an overall reduction in protein consumption and/or its substitution with other protein sources. The development of beef substitutes is a topic that has had wide coverage during the last years (Tziva *et al.,* 2019). Vegetable meat substitutes and poultry were the most chosen future protein sources, following national and international consumer trends (Hyun *et al.,* 2020; Ortega *et al.,* 2017). Almost 25% of participants chose “vegetable meat substitutes” and 15% chose exclusively non-animal protein sources as the future sources of protein. Acceptance of “vegetable meat substitutes” is still low (Elzerman *et al.,* 2011), but it has been shown that low meat consumption and perception of the environmental impact of meat boost consumption of “vegetable meat substitutes” (Siegrist & Hartmann, 2019). Indeed, the participants who had a more negative attitude towards meat consumption also had higher odds of choosing “vegetable meat substitutes” and the other non-animal protein sources. Cultured meat had a low level of selection among participants (4%) unlike to what was found in other preliminary studies, where cultured meat had a high level of acceptance among participants (Valente *et al.,* 2019; Bryant & Barnett, 2020). It is possible that this discrepancy is related to the recent uncertainties raised about cultured meat’ animal welfare and environmental potential advantages when compared to traditional meat production (Chriki & Hocquette, 2020).

5.3 Demographics and sampling limitations to the interpretation of results

The sample obtained, which consists of a higher percentage of females and young people with higher education, is similar to samples obtained in previous surveys carried out online on the same subject (Clonan *et al.,* 2015; Graça *et al.,* 2015; Bollani *et al.,* 2019) allowed to identify influence of some demographics on outcome variables. Females had more negative attitudes towards all beef production systems, as well as more negative perceptions towards beef consumption than males. These results are in agreement with other studies that have reported that women have more negative attitudes towards farm animal welfare, and more often follow low meat and meatless diets, vegetarianism and ethical food choices (Ruby, 2012; Potts & White 2008; Judge & Wilson, 2018). Participants involved in animal production, in contrast, had more favourable attitudes towards the three beef production systems, beef production in general and beef consumption, even agreeing that Chileans should increase their beef consumption, compared to participants not involved with animal production. These findings corroborate other studies that showed that farmers and lay urban citizens have different values on animal production and their husbandry (Cardoso *et al.,* 2019; Umberger *et al.,* 2009; Benard & de Cok, 2013), and supports the idea that farmers and lay urban citizens have different values regarding animal production, which may be the product of urbane lives and unawareness about the productive systems (Pieper *et al.,* 2016; Hötzel *et al.,* 2017).

Differences found between the two versions of the questionnaire (face-to-face vs. online) for the questions that asked about agreement with statements may be related to the different sociodemographic characteristics of the participants of both questionnaires. Online recruitment usually creates bias between the sample and society, as they are only accessible for people with Internet access (Duffy *et al.,* 2005). However, differences between the online and face-to-face results are common to find even in equivalent samples for the sociodemographic characteristics in both types of recruitment (Blasius & Brandt 2010). The online portion of the sample had a much higher proportion of females, younger people and participants with complete or on-going university education compared to the face-to-face version. Additionally, online surveys usually attract a more knowledgeable, viewpoint-orientated sample than face-to-face surveys (Duffy *et al.,* 2005).

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Participants had more positive attitudes towards the pasture-based systems than to systems were cattle have no access to pasture. The two main reasons underlying the attitudes towards the systems were animal welfare and the environmental impact they generate. Providing information about the different beef production systems had no effect on participants' responses related to beef production or their meat consumption habits and prospective beef consumption. Participants believed that there is a need to reduce beef consumption, both personally and at society level. Support for beef production as well as consumption may benefit if production systems adopt characteristics that are perceived by the public as positive for the environment and animal welfare.

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