JOÃO ANDRÉ DOS SANTOS FERNANDES CERQUEIRA

ASSOCIATION BETWEEN ANIMAL WELFARE, PRODUCTIVE PERFORMANCE, AND STAFF SATISFACTION IN PORTUGUESE DAIRY FARMS

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Universidade Lusófona de Humanidades e Tecnologias

Faculdade de Medicina Veterinária

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Dissertação defendida em provas públicas para a obtenção do Grau de Mestre em Medicina Veterinária no curso de Mestrado Integrado em Medicina Veterinária, conferido pela Universidade Lusófona de Humanidades e Tecnologias, com o Despacho de Nomeação nº 84/2022, de 21 de março de 2022, com a seguinte composição de júri:
Presidente: Prof. Doutor David Ramilo, por delegação da Prof.ª Doutora Laurentina Pedroso;
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To my parents.

Acknowledgments

At the end of this 6-year journey, I would like to thank:

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To my sister for her patience and friendship that the years have only made stronger, and to my grandmother who prayed so hard to see her grandson become a doctor.

Lastly, to my parents, to whom I owe my deepest thanks. The greatest effort was yours, and so this work is proudly yours.

Resumo

O objetivo deste estudo foi avaliar a relação entre indicadores de bem-estar animal com: a) performance produtiva; b) medidas extra de bem-estar animal, e c) satisfação no local de trabalho, em explorações leiteiras em Portugal. Estabelecemos a hipótese que existem correlações positivas entre os resultados Welfare Quality®, performance produtiva e satisfação no local de trabalho, assim como uma correlação negativa com o uso de antibióticos. Dez explorações foram avaliadas, utilizando o protocolo Welfare Quality®. As medidas adicionais de bem-estar animal foram obtidas através do Bovinfor®, Lactinfo©, e através dos registos de tratamento dos produtores. Finalmente, a satisfação no local de trabalho foi avaliada com um questionário e com o cálculo do índice de satisfação dos trabalhadores.

Os resultados finais Welfare Quality® mostraram-se relacionados com a produção média diária (p= 0,002), produção total aos 305 DEL (p= 0,024), e tenderam a estar relacionados com o número de animais que atingiram 305 DEL (p= 0,090). O uso de antibióticos de importância crítica tenderam a estar relacionados com o critério "Absence of disease" (p= 0,071). Finalmente, a satisfação no local de trabalho mostrou um sector leiteiro subdesenvolvido, quando comparado com os restantes países europeus.

Com estes resultados podemos aceitar a hipótese de que os resultados Welfare Quality® estão positivamente relacionados com a performance produtiva, negativamente correlacionados com o uso de antibióticos e que a satisfação no local de trabalho precisa de ser aprofundada.

Palavras-chave: Bem-estar animal, Welfare Quality®, Vaca leiteira, Performance produtiva, Satisfação no trabalho

Abstract

The objective of this study was to evaluate the relationship of animal welfare indicators with: a) productive performance; b) animal welfare extra measures, and c) workplace satisfaction, in dairy farms in Portugal. We hypothesized that there are positive correlations among the Welfare Quality® results, productive performance, and workplace satisfaction and a negative correlation with antibiotic usage. Ten farms were evaluated for animal welfare using the Welfare Quality® protocol. The additional animal welfare indicators were obtained via Bovinfor®, Lactinfo©, and by the farmers treatment records. Finally, workplace satisfaction was assessed with a questionnaire and with the calculation of the employee satisfaction index.

The Welfare Quality® final score results were related with average daily production (p= 0,002), 305 DIM cumulative production (p= 0,024), and tended to be related with number of animals reaching 305 DIM (p= 0,090). In addition, critical importance antibiotics tended to be related with the absence of disease criteria (p= 0,071). Finally, workplace satisfaction showed an underdeveloped dairy sector, when compared to the remaining European countries.

With these results we can accept the hypothesis that Welfare Quality® results are positively related with productive performance, negatively correlated with antibiotic usage and that workplace satisfaction needs to be deepened.

Keywords: Animal welfare, Welfare Quality®, Dairy cow, Productive performance, Job Satisfaction

List of Abbreviations

AMR- Antimicrobial Resistance

AW- Animal Welfare

BCS- Body Condition Score

C1- Absence of prolonged hunger criteria

C10- Expression of other behaviors criteria

C11- Good human-animal relationship criteria

C12- Positive emotional state criteria

C2- Absence of prolonged thirst criteria

C3- Comfort around resting criteria

C4- Thermal Comfort criteria

C5- Ease of movement

C6- Absence of injuries criteria

C7- Absence of disease criteria

C8- Absence of pain induced by management procedures criteria

C9- Expression of social behaviors criteria

CI- Calving Interval

CMT- California Mastitis Test

DEL- Dias em Leite

DIM- Days in Milk

ESI- Employee Satisfaction Index

EU- European Union

EU-27- European Union member states from acceptance of Croatia in 2013, excluding the UK

EU-28- European Union member states from the acceptance of Croatia in 2013 to the withdrawal of the United Kingdom in 2020

FAWC- Farm Animal Welfare Committee

FS- Final Score

GnRH- Gonadotropin-releasing hormone

HPA- Hypothalamic-Pituitary-Adrenal Axis

P1- Good Feeding Principle

P2- Good Housing Principle

P3- Good Health Principle

P4- Appropriate Behavior Principle

QBA- Qualitative Behavioral Assessment

SCC- Somatic Cells Count

SMS- Sympathomedullary System

THI- Temperature Humidity Index

WFQ- Welfare Quality®

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I. Training Period Description

Veterinarians have the most diverse practice areas and professional development at their disposal. The training period occurred at *Lacticoop UCRL*, under Dr. Rui d'Orey Branco's guidance. The training lasted four months, which began on November 2, 2020, and ended on February 28, 2021, followed by a professional internship.

Lacticoop - União de Cooperativas de entre Douro e Mondego was a fundamental part of the author's development during these months. Established in 1924, proceeding with the merge of two dairy cooperatives, it has exercised a constant and fundamental role in the dairy industry.

During the author internship, he had the opportunity to visit numerous dairy farms across Portugal. Therefore, the monthly schedule included: Reproductive management, animal welfare (AW), milk quality, and "Programa Vitelos Saudáveis". These visits allowed the author to know the production reality and better understand the differences between farmers and farms across all regions. As a result, the author communication skills have grown in a professional context. Specifically, knowing how to listen, interpret, expose, and communicate ideas, points of view, decisions, and expectations in an organized, directed, and straightforward way showed up to become a landmark.

Table 1. Monthly schedule distribution during the training period at Lacticoop.

Monthly Schedule Distribution	**%**
Reproductive management	20%
Animal Welfare	40%
Milk Quality	20%
"Programa Vitelos Saudáveis"	20%
Total	**100%**

Even though no clinical component existed, clinical thinking and case discussion were always given priority. That way, agile, practical, and critical thinking was present daily.

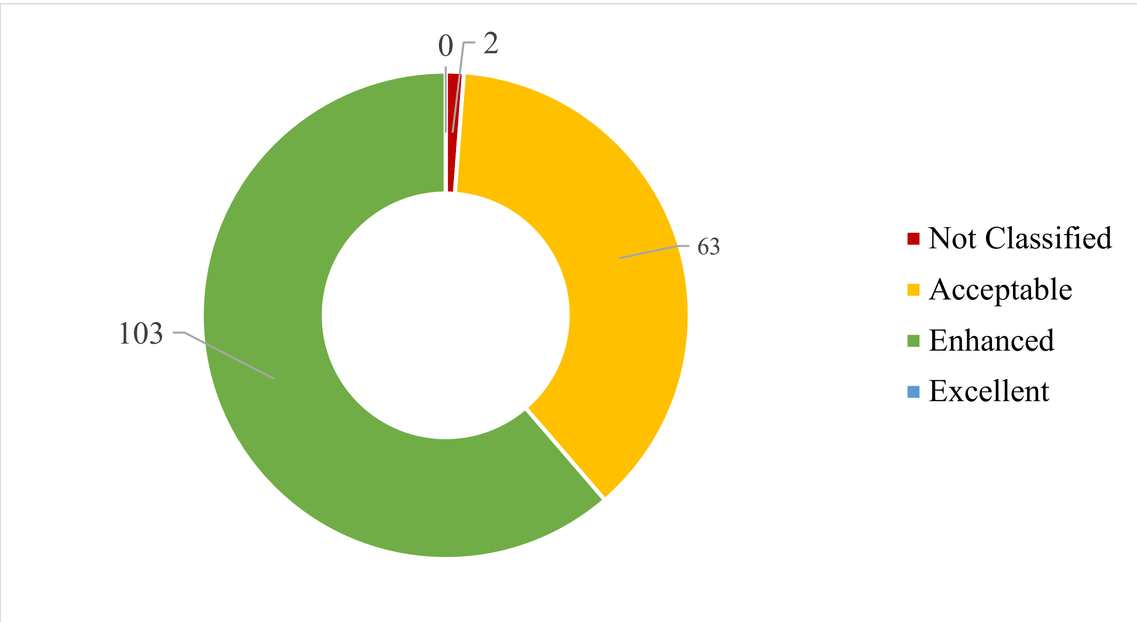
The following report summarizes the activities throughout the training period at Lacticoop's "*Serviços de Melhoramento Animal"*.

1. Animal Welfare

Animal welfare is undoubtedly the most preeminent area in Lacticoop's "*Serviços de Melhoramento Animal*". All 166 dairy farms included in Lacticoop's universe were audited to animal welfare during 2021 using their developed app based on the Welfare Quality® (WFQ) protocol (Welfare Quality, 2009). Composed mainly by animal-based indicators, 30 measures are evaluated to compile into 12 criteria. Those 12 criteria culminate in 4 principles (good feeding, good housing, good health, and appropriate behavior) that are meticulously evaluated to provide a final score (FS) to each farm which is then given a level:

- Excellent;
- Enhanced;
- Acceptable;
- Not Acceptable (Welfare Quality, 2009).

During the author's time at Lacticoop and after being given proper training in animal welfare assessment, the author performed 91 (55%) of the 166 internal audits for the 2021 cycle. Each guideline provided by the WFQ protocol was meticulously followed. Graphic 1 illustrates the Overall level distribution for the entire cycle of internal audits for 2021.



Graphic 1. *Welfare Quality® protocol level distribution.*

2. Reproductive Management

Another significant area of work was reproductive management appointments. Farms included were visited once a week, once every two weeks, or once a month. The total number of farms within the reproductive program was eight.

Most of the exams consisted of pregnancy diagnosis and staging using transrectal palpation with ultrasound aid. Postpartum follow-up included cases of metritis, endometritis, pyometra, retained fetal membranes, and ovarian cysts, and were present in 55% of the animals postpartum animals, with 45% having a normal uterine involution. Also, among the animals diagnosed for pregnancy, 54% showed a positive pregnancy, while 46% showed a negative pregnancy. Table 2 statistically describes the reproductive management results.

It allowed the author to work on a better interpretation capability when monitoring the herd's reproduction. For example, at the herd level, creating annual reproductive follow-up reports provides an up-to-date picture of the farm's reproductive status. However, reproductive follow-up and constant decision-making at the individual level led to a stratification of thinking, making it more field-decision directed.

The following table shows the detailed statistical analysis of reproduction appointments.

Table 2. *Reproductive management statistical analysis.*

Reproductive Management		**Number of animals**	**(%)**
Pregnancy diagnosis	Positive pregnancy	1542	54%
	Negative Pregnancy	1329	46%
	Total	**2871**	**100%**
Postpartum follow-up	Normal involution	795	45%
	Postpartum complication	987	55%
	Total	**1782**	**100%**

3. Milk Quality

Another service the author participated in was monthly milk quality control. Farms included in this service were evaluated according to individual (contrast) and bulk milk records. In addition, each lactating animal was analyzed in quantity and quality parameters such as somatic cell count (SCC), days in milk (DIM), average production, and fat and protein content to provide the farmer a general and specific scope on what regards their milk production parameters.

Also, dry-off therapy was advised to all the animals approaching the final third of the gestation period, always creating awareness of the importance of reduced use of antibiotics by introducing selective dry therapy options to our producers.

Finally, every farm included in the service was visited one time to perform a general evaluation of the udder health and milk quality. Every lactating cow was submitted to a California mastitis test (CMT) and a milk sample collection. Following the CMT, a milk sample was collected from every animal. Animals with intense positive reactions were then submitted to an extra collection of the affected teat. The samples were then submitted to somatic cell count analysis, microbiological identification, and antibiogram. A yearly report was created to advise, adapt, and apply alterations to management practices and dry-off therapies from that analysis.

4. "Programa Vitelos Saudáveis"

"Programa Vitelos Saudáveis" is a program based on the "calf health scoring" system from the University of Wisconsin and underlines the need for a more consistent and meticulous calf follow-up. Following the development of an initial stage of the project by Lacticoop's team, the author was given a chance to update the project to assure a complete evaluation from birth to the first calving in three pilot farms.

The first phase of the project (pre-developed by Lacticoop's team) evaluated calf health during the first days of life. Evaluating parameters such as rectal temperature, ocular discharge, nasal discharge, ear position, and fecal consistency allowed producers to reduce the number of animals treated for respiratory complex and neonatal diarrhea. Also, it promoted a more stratified thinking to establish better management practices. Also, every calf born was submitted to a blood collection on the third day of life to evaluate the efficiency of the passive transfer by measuring blood serum Brix (%) (Deelen et al., 2014).

The project second phase consisted of developing adaptative weaning to the first calving follow-up. For this second phase, the author proposed the measurement of average daily gains in well-defined stages with established goals. Those goals were adapted every six months according to the adult weight and height of the considered farm. The stages proposed were:

- Weaning;
- First Service;
- First calving;

Due to several impossibilities, the project's second phase was never applied in the field context. Therefore, the following table briefly describes the number of animals evaluated on each farm and median total serum protein (%) during the first nine months of the project.

Table 3. *"Programa Vitelos Saudáveis" median Brix in blood serum results from the three farms included in "Programa Vitelos Saudáveis".*

Farm	*Number of animals evaluated*	*Median Brix in blood serum (%)*
A	223	9,00%
B	50	9,00%
C	46	8.6%
Total	*319*	

II. Introduction

In recent years, animal products ethical consumption has become a very present reality in society (Ritter et al., 2019). For example, the Counsil of the European Union (2020) stated in 2015 that 85% of consumers considered that AW should be better maintained, and 52% of respondents were looking for animal welfare labels on their products at the time of purchase. Growing consumer demand and ongoing pressure by regulators continually lead the industry to rethink the final product's production and presentation.

The dairy industry is no exception. The steady decline in fresh milk consumption does not necessarily indicate an entire sector's decline. The European Union's milk production rate is expected to grow subtly by 0.6% a year until 2030, despite the possible decrease of up to 7% of the total dairy herd. Individual milk production per year is foreseen to reach 8400 Kg/cow/year compared to the 6200 Kg/cow/year in 2010. Additionally, an increase in fat-solids and non-fat solids in milk is anticipated to increase by 0.8% and 0.9% per year, respectively (European Commission, 2015). So, the milk production outlook and the rate of world populations growth indicates that production efficiency will be necessary more than ever. Therefore, establishing positive relationships between welfare and productivity will reinforce confidence amongst the consumers, and aid farmers in investing in animal welfare to meet the expectancy (Grimard et al., 2019).

For example, as Sawa & Bogucki described in 2011, loose housing animals have shown a lower culling rate due to infertility than tethered barns (26% vs. 36%).

Also, Grimard et al. (2019) assessed, using the WFQ protocol, the direct relationship between welfare and reproductive performance measures at the herd level. The authors showed that calving to first service interval was up to eleven days shorter in farms with better scoring than the worst farms.

Moreover, Neave et al. (2018) exposed that subclinical metritic cows ate 1 kg/day less than healthy cows and that pre-metritic cows spent less time lying down and had shorter lying bouts.

Finally, farms with lower welfare quality assessment scores showed lower milk production (30.5 ± 4.0 L) and higher SCC (264.2 ± 110.9 x 10^3 cells/mL). Also, when compared to farms with higher scores who showed bigger milk yields (34.4 ± 3.8 L) and smaller somatic cell count (217.1 ± 62.5 x 10^3 cells/mL) (Verdes et al., 2020).

Therefore, the need to interlink animals' natural living, biological function, and the affective state as three main areas of welfare (Fraser et al., 1997) will affect productivity, health, and behavior (von Keyserlingk et al., 2009). A vital aspect of the entire operation is to determine which elements of natural living are essential for animals and how producers can incorporate these needs into the best management practices to guarantee most of the animals' biological function and affective state (Polsky & von Keyserlingk, 2017)

However, human resource management is still one of the most significant problems in dairy farms (Moore et al., 2020). As farms expand, the need to increase human resources turns mandatory, leading to a change in farm managers responsibilities, often being forced to step aside from on-field work (Hadley et al., 2002). Usually composed of foreign staff, staff/manager relationships weaken due to cultural differences and communication obstacles which might compromise the farm productivity and success (Stup et al., 2006). Likewise, Stup et al. (2006) showed that milk quality incentives showed considerable significance among workers and clarified the need for studies that relate workplace satisfaction and commitment to the organization.

III. Literature Review

1. Animal Welfare

To this day, the definition of animal welfare (AW) does not meet a fair agreement throughout the scientific community (Fraser, 2008). On its own, the topic comprises scientific, economic, ethical and political parts (Carenzi & Verga, 2009).

From its first attempt of approach, in 1965, with the Five Freedoms concept, Farm Animal Welfare Committee (FAWC) established an important landmark towards the scientific development of the topic (FAWC, 2009). It allows a practical approach to animal study and is considered the anchor to much active legislation regarding AW. On the other hand, it is seen as a broad approach, and topics might overlap when evaluated (Manteca et al., 2012). The Five Freedoms are:

- Freedom from hunger and thirst, by ready access to water and a diet to maintain health and vigor.
- Freedom from discomfort by providing an appropriate environment.
- Freedom from pain, injury, and disease, by prevention or rapid diagnosis and treatment.
- Freedom to express normal behavior by providing sufficient space, proper facilities, and appropriate company of the animal's own kind.
- Freedom from fear and distress by ensuring conditions and treatment, which avoid mental suffering (FAWC, 2009).

Nevertheless, different approaches to assess and define AW using the same concepts as the proposed Five Freedoms were developed (Manteca et al., 2012). Fraser (2008) defended that the AW concept should consist of three main areas: essential health and function, affective state, and natural living. In addition, this proposal aimed to bring a more amenable concept to the scientific community to assure a flowing investigation capability (von Keyserlingk et al., 2009).

Subsequently, the animal/human relationship when assessing welfare is intrinsically related to ethical values, despite the scientific approach. Thus, the need to add value to empiric information through ethical reflection aims to better understand human/animal relationships and assume the valid concept of AW (Carenzi & Verga, 2009).

Therefore, despite different approaches from different cultures, AW science must embrace the subjective force of value positions to standardize studies (David Fraser, 2008).

Hence, AW can be defined as an animal's physical and mental state in relation to the conditions in which it lives and dies (OIE, 2019).

1.1 Welfare Indicators

There are three types of indicators when assessing welfare: resource-based, management-based, and animal-based indicators (Stilwell, 2017).

Resource-based indicators evaluate physical conditions provided to the animal, such as housing and environmental conditions provided to the animals (EFSA, 2007). Management-based indicators are meant to evaluate all protocols and procedures used on the animals, like genetic, group selection, prophylactic protocols, and ultimately, animal/human relationship. These indicators assess indirect parameters, and they do not necessarily reflect high welfare at the individual or herd level. They do not require animals' presence and are objective ways of measuring, providing mainly input as influencing factors to the manifestation of animal-related indicators (Stilwell, 2017; Winckler, 2004). On the other hand, animal-based indicators directly reflect animal welfare by assessing physiological, pathological, behavioral, and productive parameters in response to resource and management-based indicators (EFSA, 2007). Therefore, when properly assessed, it is the most reliable source of the welfare status of the farm, providing an output to resource and management-based parameters (Beggs et al., 2019; Winckler, 2004).

Consequently, identifying welfare issues and suitable indicators that allow its assessment reveals itself as a challenge. Moreover, welfare indicators interact in many ways with the pillars of biological function, affective state, and natural living (Leliveld, 2020).

Overall, each parameter's value is as good as its most precise indicator. Furthermore, the indicator chosen to guarantee a practical assessment must be valid, reliable, and feasible. An indicator's validity assures that the chosen indicator measures the specific component. Reliability assesses if an indicator, when repeated by several people or the same person, presents consistent results. Finally, feasibility refers to an indicator's practical value and whether it is possible to measure in a practical context or not. Therefore, AW assessment approaches must embrace its whole dimension of criteria, define its needs and apply it using the most reliable indicators (Stilwell, 2017).

1.2. Animal Welfare Assessment

1.2.1 Welfare Quality® Protocol

The WFQ project underlines the need for practical on-farm overall welfare assessment. First introduced in 2004 by the European Union (EU), it is a system that assesses AW by converting welfare measurement into summarized information (Welfare Quality, 2009).

After the scientific approach, four main criteria were identified as all-inclusive in an AW multidimensional perspective. Good Feeding (P1), Good Housing (P2), Good Health (P3), and Appropriate Behavior (P4) were then divided into 12 criteria that properly represent AW's whole scope. From the 12 criteria, practical measurements were created to accurately translate how the animal unit reflects those criteria providing a hierarchical scope to the whole assessment project. Furthermore, the measurements provided in the protocol tend to be based on animal-based measures as it directly reflects the animal's physical and mental state. However, when no animal-based measurement is reliable enough, environment or resource-based indicators can be used to integrate the criteria needs best (Veissier et al., 2011; Welfare Quality, 2009). The principles and criteria of the WFQ protocol are described in table 4, as well as the corresponding abbreviation code.

Table 4. *Principles and criteria of WFQ protocol. Twelve principles compile into four criteria which provide a final score and consequent level* (Welfare Quality, 2009).

Code	**WFQ**
C1	Absence of prolonged hunger
C2	Absence of prolonged thirst
P1	**Good Feeding**
C3	Comfort around resting
C4	Thermal Comfort
C5	Ease of movement
P2	**Good Housing**
C6	Absence of injuries
C7	Absence of disease
C8	Absence of pain induced by management procedures
P3	**Good Health**
C9	Expression of social behaviors

C10	Expression of other behaviors
C11	Good human-animal relationship
C12	Positive emotional state
P4	**Appropriate Behavior**
FS	**Final Score**

1.2.1.1. Good Feeding

1.2.1.1.1. Absence of Prolonged Hunger

Body condition (BCS) score evaluates the body fat reserves present in an animal in a subjective way. Interchangeable depending on the production phase, BCS tends to be lower when the milk production peak is reached or 50 to 100-day post-calving. Thus, over or under conditioning compromises milk production, reproductive performance, health, and even the immune system (Roche et al., 2009b).

Obese cows are more likely to suffer from oxidative stress and suppressed immune system. Likewise, higher BCS cows at calving have a greater risk of metabolic diseases due to higher body fat mobilization and reduced dry matter intake. On the other hand, lower BCS during the dry period increases the risk of dystocia and periparturient disorders (Jones et al., 2016; Roche et al., 2009). Nevertheless, only low BCS is scored negative on the calculations of the Good Feeding principle.

1.2.1.1.2. Absence of Prolonged Thirst

Dairy cows can drink up to 120 liters of water per day (Eenige, M & Counotte, Guillaume & Noordhuizen, 2013).

Inadequate watering in dairy systems directly reflects lower milk yields and threatens BCS. Also, it encourages the development of aggressive behaviors within the group towards drinkers and drinking behavior as well as it promotes reduced rumen contractions, respiratory rates and increases hematocrit and blood urea (Burgos et al., 2001; Little et al., 1980).

In addition, water quality can become compromised when contaminated. For example, water origin, external contamination, or even biofilm development in the watering points compromise drinking water's microbiological and chemical quality, negatively influencing productivity and ruminal homeostasis (Eenige, M & Counotte, Guillaume & Noordhuizen, 2013; Willms et al., 2002).

1.2.1.2. Good Housing

1.2.1.2.1. Comfort Around Resting

Motivation to lie down is intrinsic to dairy cows and can spend up to twelve hours a day resting (Temple et al., 2016; Tucker et al., 2021). When this behavior becomes endangered, whether from environmental or animal factors, cows can demonstrate signs of increased dirtiness, illness and lameness, reduced milk production and rumination, reduced sleep and higher hormonal stress response (Tucker et al., 2021). In fact, when lying down, cows have an increased blood diffusion distribution through the udder (5 liters/min) when compared with a standing animal (3 liters/min), demonstrate less chance of developing ruminal acidosis, and lameness, promoting a more consolidated milk production (Temple et al., 2016). Also, animals with dirtier udders have greater predisposition to mastitis (de Pinho Manzi et al., 2012).

Inadequate environmental factors such as stall design, bedding, flooring type alongside inadequate management procedures can trigger behaviors such as animals lying outside the resting area and collisions when lying, as well as it compromises herd health, welfare and productivity (Temple et al., 2016). Also, unwanted behaviors like collisions when lying down can be justified by inadequate cubicle design, or secondarily to an injured limb (Popescu et al., 2013).

According to Gieseke et al., (2020) deep-bedded cubicles are positively correlated with the cleanliness, integument alterations and time lying down. Besides, when dirtier, cows quickly develop integument alterations, diminished antimicrobial defense ,and decreased skin and thermoregulatory function (Winckler, 2004).

1.2.1.2.2. Ease of Movement

In modern farming, tie stall barns are seen as inhibitors of the animals natural behaviors as well as voluntary and natural movements (EFSA, 2009). Also, when in tethered barns, animals without access to exercise have lower welfare quality when compared to those who have regular exercise (Popescu et al., 2013). On the other hand, loose housing systems with access to regular outdoor exercise, provide a better kept welfare and health, when compared to tie stall kept animals (Regula et al., 2004).

1.2.1.3. Good Health

1.2.1.3.1. Absence of Injuries

Lameness is multifactorial and negatively compromises welfare and productivity (Andreasen & Forkman, 2012). Several studies show that lame cows have lower productive performance with reduced milk yields and are more likely to be culled (Alsaaod et al., 2012; Booth et al., 2004; Navarro et al., 2013; Walker et al., 2008). Also, lame cows demonstrate higher lying times, have reduced dry matter intake, consequently leading to lower BCS, and spend less time standing and walking, leading to a reduced manifestation of estrus behavior compared to healthy animals (Walker et al., 2008).

Independent of the cause, physical limitation imposed by lameness intensifies the chance of developing integument alterations. Likewise, consequent urgent need to lie down after long periods of standing, such as milking routines, enhance the chance of contracting mastitis due to insufficient time provided for the teat canal to close (Ózsvári, 2017; Tucker et al., 2021).

Integument alterations are a common alteration in housed dairy cows and may show divergence between the animals and the environment they live in (Brenninkmeyer et al., 2015). Defined as hairless patches and lesions, it can result from contact with hard floors, cubicles, drinkers, or feeders (Andreasen & Forkman, 2012; Winckler, 2004). According to Winckler (2004), the most usual anatomic locations for integument alterations are around the carpal, fetlock, hock and stifle joint, neck, shoulder blade, dewlap, hip, and ischial tuberosity.

However, bedding type, quantity, and quality influence integument alteration incidence. For example, cows housed in mattress bed stalls have a higher incidence of hock lesions, unlike sand bedded stalls, which show fewer or no hock lesions when compared (Lombard et al., 2010). Likewise, Andreasen & Forkman (2012) stated that sand bedded stalls were less likely to cause integument alterations, lameness and could keep the animals cleaner when compared to mattresses or mattressed rubber stalls.

1.2.1.3.2. Absence of Disease

Hampered respiration, coughing, nasal discharge, and ocular discharge can be indicators of respiratory illness (Molina, 2020). Being of multifactorial origin, respiratory disease is also multifactorial (Vandermeulen et al., 2016). Poorly ventilated barns, weak husbandry practices, inaccurate prophylactic care, and inappropriate nutrition are some of the risk factors which can lead to a weakened immune system, higher stress response, and higher incidence of respiratory disease (Gorden & Plummer, 2010). However, hampered respiration can also be associated as a compensation mechanism to heat stress (Polsky & von Keyserlingk, 2017).

Likewise, ocular discharge is multifactorial. High ammonia concentrations in the barn, infectious processes most likely by *Moraxella bovis*, congenital disabilities like obstruction of the nasolacrimal duct, inflammatory processes or even neoplasic processes like squamous cell carcinoma can originate ocular discharge (H. J. Davidson & Phillip Pickett, 2009).

Diarrhea can manifest as a primary clinical sign or as a secondary manifestation of a disease, and it can be from infectious or non-infectious causes. Among the most common causes of infectious diarrhea, salmonellosis, Bovine Diarrhea Virus, Johne's disease, and coronavirus have a preponderant incidence in adult animals. Similarly, parasitic diarrheas like fasciolosis and coccidiosis can also have a considerable incidence. On the other hand, copper deficiency, lead or plant poisoning, or even mycotoxins are amongst the toxic causes of diarrhea (Otter & Cranwell, 2007).

When from a secondary manifestation of a disease, diarrhea can occur from cases of ruminal acidosis, mastitis, or even endometritis followed by endotoxemia (Otter & Cranwell, 2007; Plaizier et al., 2008).

Uterine disorders such as metritis, and endometritis are a sign of compromised health and can represent insufficient productive performance (Giuliodori et al., 2013; Sheldon et al., 2006). Commonly associated with the puerperal stage, risk factors such first calving, dystocia or human intervention, or even high prepartum negative energy balance enhance the risk for developing metritis (Giuliodori et al., 2013).

Observed until 21 days postpartum, clinical signs such as the enlarged uterus, vulvar discharge with or without fever or signs of systemic illness allows to differentiate between clinical or puerperal metritis. On the other hand, it can be denomined as endometritis when similar signs as shown in clinical metritis with 21 days or more of parturition without signs of fever or systemic illness (Sheldon et al., 2006).

SCC in milk is considered a biomarker to detect inflammation of the mammary gland and udder health status (Cobirka et al., 2020; Rainard et al., 2018). Intramammary infection by bacteria is the most common cause of higher SCC. Other microorganisms like Algae, Yeasts, Fungi and viral infections can cause higher SCC as well (Cobirka et al., 2020; Jánosil et al., 2001; Krukowski et al., 2006; Wellenberg et al., 2002). Nevertheless, there are some animal-related non-infections factors such as age, stage of lactation, season, stress and management procedures that affect SCC (Riekerink et al., 2007).

Both, subclinical or clinical, mastitis compromises milk yield and milk composition it also increases culling rate and costs of veterinary services (Gröhn et al., 2003; Halasa et al., 2007).

From the welfare perspective, mastitis is reported to be one of the most painful events. Animals with mastitis show behavior and physiological alterations such as hyperalgesia, discomfort, depression, anorexia, diminished time spent lying down and reduced rumination. Among other considerations, management-related risk factors such as inadequate bedding hygiene, and milking equipment and procedures e Also, treatment of clinical cases, identifying subclinical ones as well as dry therapy choices can contribute to the incidence of higher SCC and mastitis (Mainau et al., 2014). For the propose of the WFQ assessment, the absence of individual milk record automatically considers that all the animals are higher than the limit, therefore they are penalized. This is due to the fact that we cannot assess the records and we must apply the worst-case scenario.

Dystocia can be defined as calving difficulty resulting from prolonged spontaneous calving or prolonged or severe assisted extraction (Mee, 2004). Primiparous cows are tendentially more affected than multiparous cows due to their smaller fetal-maternal size (Johanson & Berger, 2003; Lombard et al., 2007), however, factors such as BCS before calving, pelvic diameter, calf dimension, stress, seasonal effects or even metabolic disorders can affect normal calving (Johanson & Berger, 2003; Mee et al., 2011). Nonetheless, higher dystocia rates lead to more significant chances of retained placenta, uterine disease, mastitis, hypocalcemia and ultimately higher mortality and cull rates (Lombard et al., 2007, 2010; Tenhagen et al., 2007).

In addition, downer cow syndrome occurs when a cow is recumbent and unable to stand up for more than one day, generally in the early postpartum period. Commonly associated with hypocalcemia it can also be linked to other macromineral deficiency, ans other risk factors like nerve and muscle damage and fatty liver (Kalaitzakis et al., 2010; Poulton et al., 2019).

Furthermore, when recumbent for several hours, secondary musculoskeletal or neurological damage is deeply associated with the primary cause of the recumbency. Therefore, downer and periparturient cows should be provided with a soft, deep, dry, and clean bed with enough traction. Also, downer cows should be kept as much as possible in sternal recumbency and repositioned as much as possible (Stull et al., 2007).

Furthermore, downer cow syndrome, is associated unpaired productive performance, diminished productive lifespan with higher premature culling rates, as well as weaker postpartum recovery with slower uterine involution (Khan et al., 2015; Perween et al., 2018).

Finally, mortality can be defined as animals dying unassisted or euthanized on-farm (Thomsen & Houe, 2018). Higher mortality can result from a growing health problem. Likewise, an increasing number of animals dying unassisted compromises AW as the animal suffers before dying (Thomsen & Houe, 2006). However, risk factors such as first calving episodes, lower milk yields, higher incidences of metabolic diseases, mastitis, higher SCC, lameness, as well as traumatic events and older lactations, offer a more considerable mortality threat to farms (Alvåsen et al., 2014). Therefore, Thomsen (2006) stated that the average mortality in intensive dairy systems should around between 1-5% per year.

1.2.1.3.3. Absence of Pain Induced by Management Procedures

Polled animals are less likely to injure themselves, are easier to manage, need less space to feed and rest, and show less dominance-related behaviors (Bouissou, 1972; Manteca et al., 2012).

Both dehorning and disbudding causes pain, discomfort and promotes a behavioral and physiological response. Head shaking, ear flicking, kicking, scratching, decreased feeding and rumination are examples of behavioral reactions associated with restraining and disbudding calves. Also, physiological responses like increased respiratory and heart rates, decreased average daily gains, and higher cortisol levels within hours after the procedure are also associated with the (Manteca et al., 2012; von Keyserlingk et al., 2009). Therefore, sedation, local anesthetic, and non-steroidal anti-inflammatory are recommended to attenuate the procedure's pain response, inflammatory mediation, post-operative stress, and control the physical restraint associated with some methods such as hot-iron disbudding (von Keyserlingk et al., 2009).

Caustic paste and hot-iron disbudding are the most used disbudding techniques (Stilwell et al., 2010). Although both techniques are performed between the first 4 to 8 weeks of life, hot-iron method is recommended over caustic paste (Bøtner et al., 2012; Stilwell et al., 2010). Dehorning promotes longer and more intense pain when compared to other methods due to the tissue, skin, and horn lesion associated with the procedure (Stilwell et al., 2007). From the AW point of view, dehorning/disbudding should be avoided as a routine practice, and options such as genetic selection of poled animals profoundly diminish the need for invasive techniques (Manteca et al., 2012; Spurlock et al., 2014).

Tail docking enhances cows' cleanliness, provides easier milking procedures, and ultimately improves udder health (Tucker et al., 2001). However, despite its advantages, tail docking seriously compromises communication among animals, inhibits natural behaviors such as fly avoidance, undoubtedly compromising welfare (Stull et al., 2002). Ultimately, the procedure can result in chronic pain, possibly due to nerve trauma and subsequent neuroma formation (Stull et al., 2002). Furthermore, this procedure is not legal in Portugal.

1.2.1.4. Appropriate Behavior

Social behavior within the herd is a vital welfare characteristic (Foris et al., 2019). Loose housing systems tendentially support healthier social behaviors allowing animals to interact more naturally and liberally (Lutz et al., 2019). Likewise, Lutz et al., (2019) described that bigger spaces allowed horned cows to demonstrate minimal contact-related agonistic behaviors than dehorned cows that naturally manifest more body contact behaviors. In addition, cows with estrus manifestation show a higher chance of manifesting agonistic behaviors, disrupting the social order of the herd (Kerbrat & Disenhaus, 2004).

Besides, attitudes like regular competition over resources, and animal regrouping enhance agonistic behaviors in the group, especially in indoor environments (von Keyserlingk et al., 2009, 2008).

In addition, the possibility of access to pasture intensifies the search for better welfare-kept animals. Indoor housing systems can provide higher production rates within a limited space with minimal labor (Burow et al., 2013; Robbins et al., 2016) Also, animals kept all year indoors have better protection against weather conditions and endoparasites (Charlier et al., 2005; Van laer et al., 2014). On the other side, indoor systems tend to enhance the presence of integument alterations like hock lesions (Burow et al., 2013), mastitis (Haskell et al., 2006), and lameness (Goldberg et al., 1992). In addition, when provided with both indoor and pasture access, animals with higher nutritional requirements choose to spend more time indoors where they have access to Total Mixed Ration, and feel more motivated to access the pasture by night time, probably due to lower temperature-humidity index (THI)(Charlton & Rutter, 2017; Legrand et al., 2009).

Therefore, access to pasture provides healthier lying behaviors, with extended lying periods associated with higher rumination, grazing behavior, and lower agonistic behaviors rates when compared to indoor housing (Crump et al., 2019). In addition, access to pasture stimulates herd synchronized behavior such as feeding or milking. Nonetheless, dairy cows tend to exercise more when access to pasture, contributing to improved locomotive health, lower heart rates, and plasma lactate concentration in gestating cows (Crump et al., 2019; J. A. Davidson & Beede, 2009) .

Also, farm animals look up to humans with fear. The frequency, nature, and intensity of the human-animal interaction like inadequate handling, and management can compromise welfare, productive performance, and health status of the herd (Rushen & Passillé, 2015; Rushen et al., 1999)

For example, handling dairy cows influence the human-animal relationship and their productive performance due to the higher stress levels in response to fear (Waiblinger et al., 2002, 2006). While few interactions can act as positive reinforcement, like feeding, most negatively impacts the animals' behavioral response such as veterinarian appointments, herd regrouping and aversive stockpersons attitude towards animals. (Waiblinger et al., 2006).

Also, Qualitative Behavior Assessment (QBA) is a vital welfare indicator in dairy cows. QBA acts as an integrative tool that evaluates the animal's behavior and body language to determine its emotional state (Brscic et al., 2019). It uses behavioral descriptors ranging from high to low arousal and positive and negative (Mattiello et al., 2019). In addition, QBA adds value to the quantitative indicators, offers inter and intra-observer reliability and coherence to quantitative physiological and behavioral measurements (Wemelsfelder & Millard, 2009).

1.3. Other Animal Welfare Measures

1.3.1. Productive Life and Cull Rate

Technological advances, demographic alterations, economic pressure, and public concerns regarding natural living conditions influence productive life and AW in dairy farming (Barkema et al., 2015). Nowadays, the average productive lifespan of a dairy cow is between 2.5 to 4 lactations per animal (A. De Vries & Marcondes, 2020).

However, culling rates directly affect lifespan and can be voluntary or involuntary. Voluntary culling can be due to low milk production, economic reasons, or behavioral conditions, while involuntary culling occurs due to injury, disease, fertility problems, or death (J Fetrow et al., 2006).

Higher involuntary culling rates can assumingly represent a welfare, economic, and management problem in youngstock and producing animals (Schuster et al., 2020). Decreased udder health, higher incidence of locomotive disorders, or inability to reach optimum reproductive performance can stimulate the need for higher culling rates in producing animals (Bascom & Young, 1998). According to Brickell & Wathes (2011) and 11% of youngstock never reaches the first lactation. For Hultgren et al. (2008), the same value can reach 22%.

Ultimately, rearing conditions and management practices influences mortality and productive life (Hultgren & Svensson, 2009) in an area representing up to 20% of the farm's yearly budget, followed only by productive herd feeding costs (Gabler et al., 2000).

1.3.2. General Use of Antibiotics

Antimicrobial resistance (AMR) is a natural phenomenon to bacteria. However, for the last years, AMR has become a growing menace to public health and food safety (Wall et al., 2016). However, this growing problematic not only affects public health, but also plays a fundamental role in animal health and welfare (Bengtsson & Greko, 2014).

In fact, infectious diseases shapes AW. At the individual level, clinical signs such as hyperemia, weakness or even diarrhea, associated with the acute infectious process, promote reduced animal comfort. At the herd level, weight loss, reduced growth and productive performance stimulates hierarchic behavior towards sick cows (Nielsen et al., 2021). Moreover, higher productive demands in order to assure economic success pushed animals into a constant productive stress which can predispose to compromised immune status (Mulligan & Doherty, 2008).

In dairy farming specifically, antibiotic therapy is commonly associated with the resolution of mastitis and dry therapy (Page & Gautier, 2012). In order to reduce the amount of unnecessary antibiotic usage, selective dry therapy has been proposed as an alternative to blanket dry cow therapy. Kabera et al. (2021) reviewed that selective dry cow therapy in farms with low SCC is as effective as blanket therapy in cows with mastitis as dry off with no compromised milk yield in the following lactation.

2. Productive Performance

2.1. Reproductive Performance

2.1.1. Stress Factors and Reproductive Performance Output

Stress triggers a behavioral and physiological response to threatened homeostasis (Chrousos & Gold, 1992). Stress response is triggered by various stressors, ranging from seasonal, environmental, management or even social impairment (Burdick et al., 2011; Collier et al., 2017).

There are two response mechanisms related to stress: the Sympathomedullary System (SMS), and the Hypothalamic-Pituitary-Adrenal Axis (HPA) and both systems act accordingly to one another. This interspecific relationship allows the organism to increase catabolic and cardiovascular output while repressing body systems such as immune, reproductive and digestive systems in order to respond to the aggression (Burdick et al., 2011; Butcher & Lord, 2004; Chrousos & Gold, 1992).

Seasonal effects tend to have more extension in the reproductive performance within dairy cows when compared to other stressors (Collier et al., 2017). For example, a higher THI can decrease reproductive parameters with lower conception rates, softer follicular dynamic and weak embryonic and fetal development (Collier et al., 2017).

Also, heat-stressed animals have lower expression of dominant follicles in the first and second follicular wave, have lower plasmatic estradiol levels and later regression of the corpus luteum during the estrous cycle show higher concentrations of ghrelin (Collier et al., 2017). In addition, heat-stressed animals show higher concentrations of ghrelin, induced by the lower dry matter intake and consequent negative energy balance, contributing to the inhibition of gonadotrophine-realising hormone (GnRH) via negative feedback (D'Occhio et al., 2019; Wertz-Lutz et al., 2006).

Regarding group hierarchy, social behavior and appropriate installations, social stress plays a fundamental role in stress and indirectly affects reproductive performance. For example, dominant cows tend to monopolize feeding space, drinkers and shadow, causing frustration and aggressive behavior towards the group secondary to improper cooling (Coimbra et al., 2012; Polsky & von Keyserlingk, 2017).

2.1.2. Calving Interval

Cow fertility has been declining as the average milk yield per animal has increased over the last decades (Walsh et al., 2011).

Gaines & Palfrey (1931) defines calving interval (CI) as the period between calving. the calving interval is considered optimum when between 12 to 13 months (Arbel et al., 2001) and has economic relevance to the farm. Financial losses due to poor fertility are positively correlated with higher calving intervals, insemination costs, and forced replacement of animals.

Therefore, calving interval can be used as a primary indicator of reproductive performance (John Fetrow et al., 2007). However, the need for at least two calving episodes to have available data alongside management-related bias or even seasonal calving periods can compromise the calving interval as a reproductive performance indicator (Olori et al., 2002; E. Wall et al., 2003).

2.2. Milk Quality

2.2.1. Stress Factors and Milk Quality Output

The lactating period is a demanding challenge for lactating cows as maintenance and productive energy demands severely increase to keep the homeostatic balance (Collier et al., 2017).

However, several stressors can compromise milk production and quality. For example, heat-stressed animals have increased metabolic requirements and show reduced dry matter intake by up to when compared to thermoneutral cows leading to a reduced milk production and consequent yield (Collier et al., 2017; Rhoads et al., 2009). Additionally, in order to compensate for the inability to dissipate heat, physiological adaptations occur, adding increased chances of developing respiratory alkalosis, ketosis and ruminal acidosis (Collier et al., 2017). Likewise, increased THI is associated with decreased protein and fat content, as well as augmented SCC in milk (Gantner et al., 2011).

Poor housing conditions, poor nutrition or even social stress as stated above reduce feed intake, enhance mobilization of nutrient reserves, and alters behaviors promoting lower yields and overall milk quality (Collier et al., 2017).

2.2.2. Milk Quality Parameters

2.2.2.1. Somatic Cells Count and Milk Yield

As described earlier, higher SCC deeply compromises animal welfare and health status. Increased SCC, influence productivity levels in quantity and quality, reducing its technological value (Atasever, 2012). When assessing final product, Barbano et al. (2006) refers to SCC as the second most important factor when assessing shelf-life of pasteurized milk, followed only by raw milk bacterial count.

Likewise, milk yield has improved over the last years conditioned by genetic, nutrition, and environmental factors such as housing, and management being often prioritized over health and fertility in order to promote profitability (Niozas et al., 2019; Pryce et al., 1997, 2004). In fact, weaker health status is related with reduced milk production as higher yielding cows become more susceptible to bigger incidence of metabolic stress, lameness, as well as declined fertility and longevity (Coignard et al., 2014).

2.2.2.2. Days in milk

By definition, days in milk (DIM) is considered the number of days from calving to the current day if the animal is milking. Therefore, dairy cows are expected to deliver one calf per cow per year, following an optimum 305-day lactation with a 60-day dry period to promote maximum production in the following lactation (Andersen et al., 2005; Zobel et al., 2015).

However, promoting higher DIM can be well interpreted, as deliberately increasing CI can stimulate higher cumulative production without compromising overall milk quality and promote a healthier postpartum recovery and subsequent reproductive behavior (Sehested et al., 2019). However, applying extended lactation in low producing animals may increase culling rates for insufficient productivity secondary to the extended lactation (Niozas et al., 2019).

3. Workplace Satisfaction

3.1. Human Resource Management and Influence in Productive Performance

Modern dairy farmers constantly deal with various stressors, psychological demands, and productive expectations (Lunner Kolstrup et al., 2013). With dairy farms being forced to become larger and step out of the family-based business, farmers are now more than ever in need of external labor (Barkema et al., 2015). However, managing human resources continues to be one of the most demanding challenges in dairy farming. With high turnover rates, whether from work seasonality or low educational levels, human resource management practices are fundamental to ensure farm employee performance quality (Hagevoort et al., 2013). Good human resources management principles are more likely to have lower turnover rates, higher recruitment success, and improved employee satisfaction (Durst et al., 2018).

In that way, job satisfaction is vital in modern farming, and it is referred to as the positive attitudes or emotional dispositions people may gain from work or through aspects of work (Hansen & Stræte, 2020). Spector (1997) considered the nature of the work itself, communication, monetary bonus, career development, management, fringe benefits, contingent rewards, work conditions, and colleagues to be representative of a job satisfaction assessment. For example, Stup et al. (2006) stated that continuous training positively correlated with return on financial equity. Also, (Hanna et al., 2009) identified a positive correlation between job satisfaction and cumulative milk yield.

Therefore, improving stockmanship and job satisfaction plays a fulcral role when applied to animal welfare and productivity in modern farming (Rushen & Passillé, 2015).

IV. "Association of Animal Welfare, Productive Performance, and Staff Satisfaction in Portuguese Dairy Farms"

1. Overall Objectives

The following study aimed to:

a) Assess the correlation between animal welfare and productive performance of ten dairy farms in Portugal.
b) Evaluate if animal welfare indicators are correlated with antibiotic usage, average lactations, and cull rates.
c) Characterize and assess workplace satisfaction, and its association with animal welfare and productive performance.

2. Materials and Methods

2.1 Dairy Farms

The study was executed between January 2021 and December 2021. All data collected and used in the study was approved by Lacticoop with a signed Data Usage Agreement (Appendix I).

Ten dairy farms were randomly selected over a universe of 166 farms distributed across Portugal. Farms location is Lisbon (Farm A); Coimbra (B, C, D, G and J); Aveiro (F and I); Santarém (E); and Leiria (H). All farms were visited at least once during the study period. Farms B, C, D, G, J, F, and H were visited between January and June 2021, while farm A was visited in September 2021.

Farms varied from 35 to 789 milking cows at the time of the welfare audit, and the animals' distribution is described in table 1. All farms were included in a monthly milking record program. The predominant breed present was Holstein-Friesian. However, farms B and C were in a crossbreeding program with Montbéliarde and VikingRed.

All animals were kept on an intensive-based production system with four different bedding choices: Farm A had access to deep sanded beds; Farms C, F, and G had access to mattressed cubicles; Farms D, I, and J were kept in cement cubicles; Farms E, and H had access to free straw bedding.

All cows were milked at least twice a day with morning and night milking sessions. In addition, farm A had a third milking session in the afternoon period.

Table 5. *Total number of animals in each farm at the time of the welfare audit and the number of animals in each milking production stage.*

Farm	Total animals	Milking cows	Dry cows/Heifers
A	1549	789	141
B	901	412	89
C	297	194	30
D	224	145	30
E	146	103	15
F	115	75	0
G	102	92	5
H	76	43	9
I	75	48	14
J	65	37	6

2.2. Animal Welfare Assessment

AW was assessed using the WFQ (Welfare Quality, 2009) assessment protocol for dairy cows. Farms included in the study were submitted to an AW audit, where every WFQ measure was collected and calculated to obtain the FS and corresponding level.

To obtain the FS, the thirty measures applied to the animal unit were compiled into twelve criteria and scored from 0 to 100. The scored criteria culminate into the four principles (good feeding, good housing, good health, and appropriate behavior) that are also scored from 0 to 100. Then, a Final Score is stablished using complex mathematic calculations, and the farm is included in one of 4 levels:

- Excellent if it scores more than 55 on all principles and more than 80 on two of them.

- Enhanced if the Final Score is equal or higher than 55; if it scores more than 20 on all principles and more than 55 on two of them.

- Acceptable if the Final Score is equal or higher than 20; score more than ten on all principles and more than 20 on three of them.

- Not Acceptable if the Final Score is lower than 20 (Welfare Quality, 2009).

2.3. Animal Welfare Extra Meausures

Average lactations and Cull rate data were obtained from Bovinfor®. Bovinfor® is a national data base for milk producers, from ANABLE (from the portuguese: *"Associação Nacional para o Melhoramento dos Bovinos Leiteiros").*

Average lactations from the year prior to the AW audit were obtained automatically from the monthly milking records, available at Bovinfor® while cull rates needed to be calculated using Microsoft® Excel for Mac version 16.56.

Cull rates were calculated for three main stages of production: pre-weaning, weaning to first calving, and after first calving. Only data from the year prior to the AW audit was considered, resembling the Welfare Quality protocol indicator of mortality. For every farm, the following data was collected:

- List of total existences, considering identification, date of birth, and productive status of the animals;
- List of deaths, considering identification, date of death, and productive status of the animal at the time of death of the animals.

2.3.1. General Use of Antibiotics

Antibiotic use was obtained from the farmers treatment records. Only data from the year prior to the AW audit was considered. The data was then stored in a Microsoft® Excel for Mac version 16.56.

General use of antibiotics was calculated using the Fifth OIE Annual Report on Antimicrobial Agents Intended for Use in Animals (OIE, 2021) guidelines. For each farm, animal biomass was calculated, only considering the Welfare Quality protocol sample as eligible. For each milking cow, an average weight of 450kg was considered. As for dried-up cows and heifers, a correlation of 0.8 of the milking cows was applied.

Treatment records from the year prior to the AW visit were transferred into a Microsoft® Excel for Mac version 16.56 sheet, and antimicrobial usage was flagged and separated into:

- Critical importance antibiotic, if the active substance used was either from groups "A- Avoid" or "B- Restrict" of the Antimicrobial Advice Expert Group categorization;
- Non-critical importance antibiotic, if the active substance used was either from groups "C- Caution" or "D- Prudence" of the Antimicrobial Advice Expert Group categorization (EMA, 2019).

Finally, the Fifth OIE Annual Report on Antimicrobial Agents Intended for Use in Animals (OIE, 2021) adapted formula was applied to both critical and non-critical antibiotics and correspondent productive biomass:

$$Antibiotic\ usage\ \left(\frac{mg}{Kg}\right) = \frac{Antimicrobial\ agents\ reported\ (mg)}{Productive\ biomass\ (Kg)}$$

2.4. Productive Performance

2.4.1. Reproductive Performance

The CI was calculated using Microsoft® Excel for Mac version 16.56. Calving data was obtained from Bovinfor®.

2.4.2. Milk Quality

All data regarding milk quality was extracted in similarity to the Welfare Quality time context of 3 months preceding the AW visit. Average production (Kg/day) and average SCC (cells x1000/ml) were calculated using Microsoft® Excel for Mac version 16.56 with data retrieved from Lactinfo©. Lactinfo© is an internal data base from Lacticoop, which contains detailed information regarding milk quantity and quality from all the milk producers in Lacticoop's universe. The number of animals reaching 305 DIM and the cumulative production at 305 DIM was directly obtained from Bovinfor®.

2.5. Workplace Satisfaction

Workplace satisfaction was accessed using a questionnaire. For each farm, a questionnaire was delivered to the farm manager (Appendix II) and to all the working staff (Appendix III). The questionnaire is an adaptation of the one used by Phillip Durst et al. (2018) in "Evaluation by employees of employee management on large US dairy farms". The questionnaire was adapted and divided into three stages. All data was organized in Microsoft® Excel for Mac version 16.56.

The questionnaire was divided into 4 parts. Part 1 of the questionnaire consisted in a demographic and work conditions characterization with multiple selection, and short answer questions.

Parts 2,3, and 4 were the parts considered in the Employee Satisfaction Index (ESI) calculation and referred to work environment, satisfaction, and relationship with manager. Part 2 consisted of a binary response ("Yes"- 5; "No"-1). Parts 3 and 4 answers were obtained using a 5-point Likert scale.

In order to assess workplace satisfaction, ESI was calculated, using the guidelines proposed by Singh et al., (2014). All negative answers were aligned to provide a correct answer scale. Both managers and staff questionnaires were considered in the calculation of ESI. Afterwards, the applied formula was:

$$Employee\ Satisfaction\ Index\ (\%) = \left(\frac{Total\ score\ received}{Maximum\ total\ score\ possible}\right) \times 100$$

3. Statistical Analysis

All data was collected and organized in Microsoft® Excel for Mac version 16.56, and posteriorly analyzed in RStudio® Mac version 2021.09.

The descriptive statistical analysis was calculated using RStudio® Mac version 2021.09, and all the proposed correlations were assessed using Spearman's bivariate correlation with a significance level of 5% ($P < 0,05$).

3. Results

3.1 WFQ Assessment

From the farms (n=10) considered in the study, 80% obtained the "Enhanced" level, while farms H and I were classified as "Acceptable" as the FS. No farms were classified as "Excellent" or "Not Classified". Table 6 shows the WFQ results, summary for each criteria, and principle in detail, as well as the abbreviation code.

***Table 6** Statistical description of the WFQ results for ten dairy farms in Portugal, with minimum, mean, and maximum values for each WFQ criteria, principle, and ultimately, final score.*

Code	WFQ	Minimum	Mean	Maximum
C1	Absence of prolonged hunger	53,50	77,65 (± 18,25)	100,00
C2	Absence of prolonged thirst	3,00	68,30 (±32,25)	100,00
P1	**Good Feeding**	9,10	66,30 (±27,34)	100,00
C3	Comfort around resting	26,80	48,85 (± 17,31)	80,20
C4	Thermal Comfort		N/A	
C5	Ease of movement	100,00	100,00 (±0,00)	100,00
P2	**Good Housing**	53,90	67,78 (±10,90)	87,50
C6	Absence of injuries	26,70	47,85 (±12,18)	63,70
C7	Absence of disease	24,70	40,28 (±11,15)	56,60
C8	Absence of pain induced by management procedures	20,00	45,8 (±22,46)	75,00
P3	**Good Health**	24,40	38,3 (±10,36)	59,10
C9	Expression of social behaviors	77,70	94,81 (±6,50)	98,70
C10	Expression of other behaviors	0,00	0,00 (±0,00)	0,00
C11	Good human-animal relationship	43,70	63,37 (±14,34)	85,50
C12	Positive emotional state	53,00	59,27 (±8,13)	78,20
P4	**Appropriate Behavior**	28,40	33,52 (±4,35)	42,80
FS	**Final Score**	30,00	53,5 (±9,71)	63,00

P1 and P2 showed the highest mean values among the four principles. P1 led to a mean value of 66,3 (±27,34). The P2 mean value was set at 67,78 (±10,90). Both P1 and P2 were classified as "Enhanced". P3 and P4, however, were both classified as "Acceptable". Mean values showed a less broad range, setting at 38,3 (±10,36); and 33,52 (±4,35), respectively. FS mean value was 53,5 (±9,71), which corresponds to the "Acceptable" level, even though 80% of the study sample obtained the "Enhanced" level.

Among all the twelve considered criteria, C2 showed the broader range with a minimum value of 3,0; the mean value of 68,30 (±32,25); and a maximum value of 100,00. C4 is not applicable because the WFQ protocol does not have a suitable measure to assess thermal comfort. Finally, C10 scores were set at 0,00 because none of the farms included in the study had access to pasture.

3.2. Animal Welfare Extra Measures

Table 7 describes the data regarding the extra measures proposed. Farms showed mean lactations per animal to be 2,33 (±0,31) with a maximum value of 2,91 lactations and a minimum value of 2,07 lactations per animal.

Considering cull rates, mean values distributed from 5,17% (±3,92%) (cull rate at weaning); 10,99% (±7,31%) (Cull rate from weaning to first labor), and 18,73% (±6,12%) (Cull rate after first labor).

When approaching antimicrobial usage, both critical and non-critical importance antibiotics had minimum values of 0,00 mg/kg. Regarding mean values, critical antibiotic was established at 1,09 (±1,96) mg/kg, while non-critical antibiotics usage mean value was 9,86 (±11,48) mg/kg.

Table 7. *Animal welfare extra measures minimum, mean and maximum values.*

Extra Indicators	**Minimum**	**Mean**	**Maximum**
Mean Lactations	2,07	2,33 (±0,31)	2,91
Cull rate at weaning (%)	0,00	5,17 (±3,92)	12,18
Cull rate from weaning to first labor (%)	2,61	10,99 (±7,31)	21,63
Cull rate after first labor (%)	6,25	18,73 (±6,12)	30,72
Use of Critical Importance Antibiotics (mg/Kg)	0,00	1,09 (±1,96)	6,54
Use of Non-critical importance Antibiotics (mg/Kg)	0,00	9,86 (±11,48)	33,40

3.3. Productive Performance

Table 8 describes the productive performance results. Productive performance was divided into reproductive performance and milk quality and production.

Calving interval was the chosen measure to assess reproductive performance. The mean value for the calving interval was set at 426,60 (±31,67) days, with a minimum value of 382 days and a maximum value of 477 days.

Regarding milk quality and production, the sample's average daily production mean value was 27,65 (±3,91) kg/day, with a minimum value of 21,420 kg/day and a maximum value of 35,980 kg/day. Likewise, the somatic cell count mean value was 248,50 (±62,97) cells x1000/ml. Furthermore, there was a significant amplitude of results when considering the number of animals reaching 305 days in milk. The mean value was 58,9 (±70,22) animals reaching 305 days in milk, while minimum and maximum values were 4 and 227 animals, respectively. Finally, at 305 days in milk, cumulative production ranged from 6565 kg to 11435 kg, with a mean cumulative production of 9334 (±1589,72) kg.

Table 8. *Productive performance results with minimum, mean and maximum values for the proposed parameters.*

Productive Performance	**Minimum**	**Mean**	**Maximum**
Calving Interval (days)	381,80	426,60 (±31,67)	477,30
Average daily production (Kg/day)	21,42	27,65 (±3,91)	35,98
Somatic Cell Count (x1000)	148,60	248,50 (±62,97)	372,30
Number of animals reaching 305 days in milk	4,00	58,9 (±70,22)	227,00
305 days in milk cumulative production (Kg)	6565,00	9334 (±1589,72)	11435,00

3.4. Workplace Satisfaction

Thirty six (63%) of staff members answered the questionnaire. Among all ten farms, A had 26 staff members at the welfare audit, and farm B had nine staff members. In addition, farms C and E had four staff members each, while farms D, F, and G had three staff members each. Finally, farm H had two staff members; farms H, and J had only one employee each.

All ten managers answered the questionnaire. Table 9 describes the response rate between all the farms, including the managers.

***Table 9**. Descriptive statistics of respondents for the Workplace satisfaction questionnaire which include both managers and staff members as the number of eligible respondents.*

Farm	Number of eligible respondents	Number of respondents	% of respondents
A	20	6	30%
B	11	10	90%
C	6	6	100%
D	4	4	100%
E	5	5	100%
F	4	4	100%
G	4	4	100%
H	2	2	100%
I	3	3	100%
J	2	2	100%
Total	61	46	75%

3.4.1 Managers Characterization

Among the farm managers, 4 (40%) were between 36-45 years old, 2 (20%) were between 45-65 years old; and 4 (40%) were older than 55 years old. Eight (80%) of the managers were male, while 2 (20%) were female. Amongst the respondents, 5 (50%) had elementary education (4^{th} grade), while 2 (20%) had professional education, with the remaining 3 (30%) being divided between high school (10%), elementary school (9^{th} grade) (10%) and bachelor's degree (10%).

They all worked on a full-time regime and worked on that same dairy farm for over ten years. Also, all farm managers have worked for the dairy industry for over ten years. However, only 2 (20%) of the farm managers worked on the farm they are currently in for less than five years, and 4 (40%) of the respondents affirm staying in their current position until retirement. The other 6 (60%) showed intentions of staying in the same position for over ten years.

Regarding fixed salaries, 4 managers assumed to not have a stable income at the end of the month, while 3 contested that their fixed salary was between 1000-1250€. The remaining 3 were equally distributed between a fixed salary inferior to 750€, between 750-1000€, and superior to 1250€. In addition, 4 (40%) managers enquired had food allowance, while only 1 (10%) had health and insurance, and the remaining 5 (50%) did not have any variable salary.

However, only 2 (20%) think that 80% to 100% of their staff will make a career working on that farm.

3.4.2 Staff Characterization

Male staff members represented 25 (69,4%) of the respondents, while female represented 11 (30,6%). Nine staff members (25%) had between 18-25 years; 4 (11,11%) had between 26-35 years; 11 (30,6%) had between 36-45 years; 5 (13,9%) had between 46-55 years, and 7 (19,4%) had over 55 years old. Only 9 (25%) of the respondents were relatives to the farm manager.

Amongst the respondents, 12 (33,3%) had elementary education (4^{th} grade); 11 (30,6%) had basic education (9^{th} grade); 8 (22,2%) attended high school (12^{th} grade); 4 (11,1%) had professional education, and 1 (2,8%) had a bachelor's degree.

Twenty-five staff members (69%) worked on a full-time regime, while 10 (27,7%) worked on a part-time regime. Only one staff member was employed as an intern. Four staff members (11,1%) worked in the dairy industry for under a year, 13 (36,1%) worked in the dairy industry from 1 to 5 years, 6 (16,7%) worked on the dairy industry from 6 to 10 years, and 13 (36,1%) worked on the dairy industry for over ten years. On the other hand, 5 (13,9%) of the employees worked on that specific farm for under a year, while 14 (38,9%) worked there between 1 to 5 years. Alongside, 6 (16,7%) staff members worked on the same farm between 6 to 10 years, and 11 (30,6%) staff members worked on the same farm for over ten years.

Regarding fixed salaries, 1 (2,8%) staff member said that had a fixed salary inferior to 630€, while the majority represented by 17 staff members (47,2%) received between 630€ to 750€. Also, 10 (27,8%) staff members received between 750€ to 1000€, while 4 (11,1%) received between 1000€ and 1250€. Also, 4 (11,1%) staff members didn´t have a regular fixed salary. In addition, 12 (33,3%) staff members did not have variable salary, while 14 (38,9%) had food allowance. Also, habitation was provided to 11 (30,6%) of the staff members, and 6 (16,7%) had health insurance. Finally; 3 (8,3%) of staff members had travel allowance.

Among all the respondents, 15 (41,7%) were milkers; 9 (25%) were general employees; 3 (8,3%) were responsible for feeding the animals; 1 (2,8%) was responsible for the rearing animals; 1 (2,8%); and 2 (5,6%) were responsible for the calves. Also, 2 (5,5%) staff members were animal keepers, and 3 (8,3%) were agricultural workers.

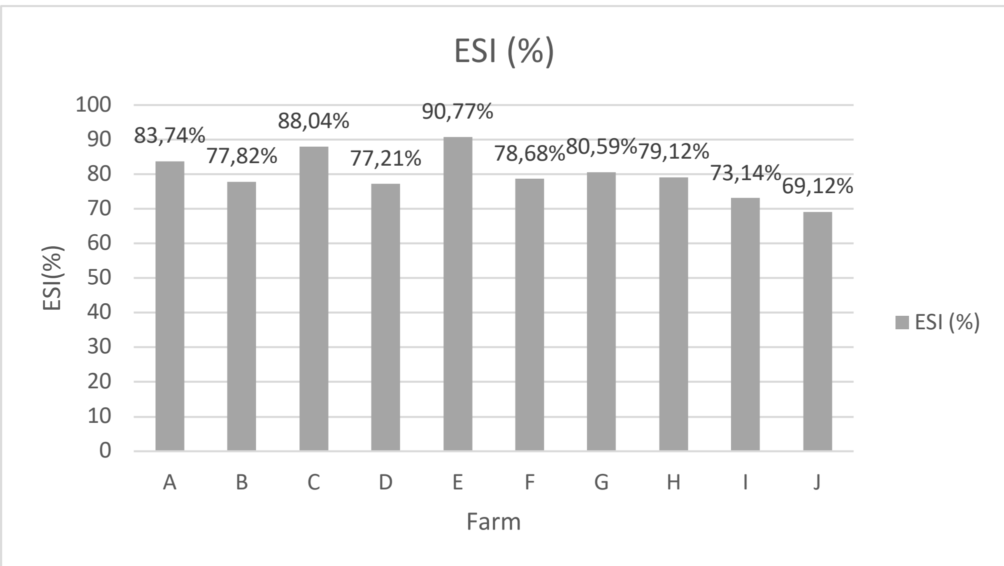
Around 5 (13,9%) staff members had the same responsibility for less than a year, while 15 (41,7%) had the same responsibility for 1 to 5 years. In addition, 5 (13,9%) of the staff members had the same position for over six years and less than ten years, and 11 (30,6%) had the same position for over ten years.

Finally, 20 (55,6%) of the employees saw themselves in the same position until retirement, while 9 (25%) saw themselves in the same position for over ten years. Also, 4 (11,11%) affirmed that they wished to stay in the same position between 1 to 5 years, whereas 1 (2,8%) wished to stay in the same position between 6 to 10 years, and 2 (5,6%) wished to stay in the same position for less than a year.

3.4.3. Employee Satisfaction Index

Employee Satisfaction Index (ESI) showed a minimum value of 69,12%, mean value of 79,82 (±6,46) % and a maximum value of 90,77%. Individually, farms E (90,77%), C (88,04%), A (83,74%), and G (80, 59%) showed the highest ESI. Also, farms H (79,12%), F (78,68%), B (78,68%), D (77,21%), and I (73,14%) showed an intermediate ESI score. Finally, farm G showed a lower ESI score of 69,12%. All ESI results are described in graphic 2.

Graphic 2. *Employee Satisfaction Index Results.*



3.5. Correlation Between WFQ and Productive Performance

The correlations between the WFQ protocol and the productive performance were assessed.

3.5.1. WFQ Protocol and Calving Interval

The correlations between the WFQ protocol and the calving interval are described in table 11. There was no significant correlation between WFQ FS and the calving interval (p= 0,389). Also, there were no significant correlations with P1 (p= 0,828), P2 (p= 0,510), P3 (p= 0,829), and P4 (p= 0,934). Finally, there were no significant correlations with C1 (p= 0,880), C2 (p= 0,859), C3 (p= 0,510), C6 (p= 0,907), C7 (p= 0,762), C8 (p= 0,986), C9 (p= 0,446), C11 (p= 0,580), and C12 (p= 0,789).

Table 10. *Correlation between the WFQ protocol and the calving interval.*

Code	**WFQ**	**ρ**	***p*-value**
C1	Absence of prolonged hunger	-0,05	0,880
C2	Absence of prolonged thirst	-0,06	0,859
P1	**Good Feeding**	-0,08	0,828
C3	Comfort around resting	-0,24	0,510
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	-0,24	0,510
C6	Absence of injuries	0,04	0,907
C7	Absence of disease	-0,11	0,762
C8	Absence of pain induced by management procedures	0,01	0,986
P3	**Good Health**	-0,08	0,829
C9	Expression of social behaviors	-0,27	0,446
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	-0,20	0,580
C12	Positive emotional state	0,10	0,789
P4	**Appropriate Behavior**	-0,03	0,934
FS	**Final Score**	-0,31	0,389

ρ, Spearman's Rho

3.5.2. WFQ Protocol and Milk Quality

3.5.2.1. WFQ Protocol and Average Daily Production

Average daily production showed a strong and significant positive correlation with FS (*p*= 0,002). Also, it a strong significant correlation with P1 (*p*= 0,012). The correlations between average daily production and P3 (*p*= 0,117), and P4 (*p*= 0,405) were not significant. There was a strong significant positive correlation with C1 (*p*= 0,017), and C2 (*p*= 0,025). Likewise, the strong positive correlation with C3 (*p*= 0,055), and P2 (*p*= 0,055) tended to be significant. There were no significant correlations between the average daily production, and C3 (*p*= 0,055), C6 (*p*= 0,328), C7 (*p*= 0,421), C8 (*p*= 0,245), C9 (*p*= 0,138), C11 (*p*= 0,934), and C12 (*p*= 0,055). The correlations between the WFQ protocol and the average daily production are described in table 12.

Table 11. *Correlation between the WFQ protocol and the average daily production.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,73	0,017
C2	Absence of prolonged thirst	0,70	0,025
P1	**Good Feeding**	0,75	0,012
C3	Comfort around resting	0,62	0,055
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	0,62	0,055
C6	Absence of injuries	0,34	0,328
C7	Absence of disease	0,29	0,421
C8	Absence of pain induced by management procedures	0,40	0,245
P3	**Good Health**	0,53	0,117
C9	Expression of social behaviors	0,50	0,138
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	0,03	0,934
C12	Positive emotional state	0,62	0,055
P4	**Appropriate Behavior**	0,30	0,405
FS	**Final Score**	0,85	0,002

ρ, Spearman's Rho

3.5.2.2. WFQ Protocol and Somatic Cells Count

There was no significant correlation between the somatic cells count and FS (*p*= 0,331). Also, there were no significant correlations with P1 (*p*= 0,354), P2 (*p*= 0,725), P3 (*p*= 0,803), and P4 (*p*= 0,090). Lastly, there were no significant correlations between the somatic cells count, and C1 (*p*= 0,960), C2 (*p*= 0,323), C3 (*p*= 0,726), C6 (*p*= 0,881), C7 (*p*= 0,893), C8 (*p*= 0,599), C9 (*p*= 0,556), C11 (*p*= 0,117), and C12 (*p*= 0,960). The correlations between the WFQ protocol and the somatic cells count is described in table 13.

Table 12. *Correlation between the WFQ protocol and somatic cells count.*

Code	**WFQ**	**ρ**	***p*-value**
C1	Absence of prolonged hunger	-0,02	0,960
C2	Absence of prolonged thirst	-0,35	0,323
P1	**Good Feeding**	-0,328	0,354
C3	Comfort around resting	-0,13	0,726
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	-0,128	0,725
C6	Absence of injuries	0,05	0,881
C7	Absence of disease	-0,05	0,893
C8	Absence of pain induced by management procedures	0,19	0,599
P3	**Good Health**	0,091	0,803
C9	Expression of social behaviors	-0,21	0,556
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	-0,53	0,117
C12	Positive emotional state	0,02	0,960
P4	**Appropriate Behavior**	-0,564	0,090
FS	**Final Score**	-0,34	0,331

ρ, Spearman's Rho

3.5.4.3. WFQ Protocol and Number of Animals Reaching 305 DIM

There was no significant correlation between the FS and the number of animals reaching 305 DIM (*p*= 0,090). There was a strong significant positive correlation between P3 and the number of animals reaching 305 DIM (*p*= 0,016). The correlations between the number of animals reaching 305 DIM, P1 (*p*= 0,173), and P4 (*p*= 0,881) showed no significance. Likewise, there was a strong significant positive correlation with C8 (*p*= 0,030), and C9 (*p*= 0,025). The strong positive correlation with C3 (*p*= 0,053), and P2 (*p*= 0,053), tended to be significant. There were no significant correlations between the number of animals reaching 305 DIM and C1 (*p*= 0,112), C2 (*p*= 0,372), C6 (*p*= 0,200), C7 (*p*= 0,151), C11 (*p*= 0,651), and C12 (*p*= 0,738). Table 14 describes the correlations between the WFQ protocol and the number of animals reaching 305 DIM.

Table 13. *Correlation between WFQ protocol and the number of animals reaching 305 DIM.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,53	0,112
C2	Absence of prolonged thirst	0,32	0,372
P1	**Good Feeding**	0,47	0,173
C3	Comfort around resting	0,63	0,053
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	0,63	0,053
C6	Absence of injuries	0,44	0,200
C7	Absence of disease	0,49	0,151
C8	Absence of pain induced by management procedures	0,68	0,030
P3	**Good Health**	0,73	0,016
C9	Expression of social behaviors	0,70	0,025
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	-0,16	0,651
C12	Positive emotional state	0,12	0,738
P4	**Appropriate Behavior**	0,055	0,881
FS	**Final Score**	0,563	0,090

ρ, Spearman's Rho

3.5.4.4. WFQ Protocol and 305 DIM Cumulative Production

There was a strong positive significant correlation between the FS and the 305 DIM cumulative production (*p*= 0,024). The correlation between 305 days in milk cumulative production, and P4 (*p*= 0,854) showed no significance. However, there was a moderately strong significant positive correlation between 305 days in milk cumulative production and P2 (*p*= 0,030), and a strong positive significant correlation between 305 days in milk cumulative production and P3 (*p*= 0,002). Also, there were strong significant correlations between 305 DIM cumulative production, C3 (*p*= 0,030), C6 (*p*= 0,037), and C7 (*p*= 0,016). The moderate positive correlations with C1 (*p*= 0,084), P1(*p*= 0,087), and C8 (*p*= 0,091) tended to be significant.

The correlations between 305 DIM cumulative production, C2 (*p*= 0,124), C9 (*p*= 0,111), C11 (*p*= 0,510), and C12 (*p*= 0,372) were not significant. Table 15 describes the correlations between the WFQ protocol and the 305 DIM cumulative production.

Table 14. *Correlation between WFQ protocol and the 305 DIM cumulative production.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,57	0,084
C2	Absence of prolonged thirst	0,52	0,124
P1	**Good Feeding**	0,57	0,087
C3	Comfort around resting	0,68	0,030
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	0,683	0,030
C6	Absence of injuries	0,66	0,037
C7	Absence of disease	0,73	0,016
C8	Absence of pain induced by management procedures	0,56	0,091
P3	**Good Health**	0,845	0,002
C9	Expression of social behaviors	0,53	0,111
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	-0,24	0,510
C12	Positive emotional state	0,32	0,372
P4	**Appropriate Behavior**	0,067	0,854
FS	**Final Score**	0,70	0,024

ρ, Spearman's Rho

3.6. Correlation Between WFQ and Animal Welfare Extra Measures

The correlations between the WFQ protocol and animal welfare extra measures were assessed.

3.6.1. WFQ Protocol and Mean Lactations

There was no significant correlation between the FS and mean lactations (*p*= 0,104). There were no significant correlations between mean lactations, P2 (*p*= 0,258), and P4 (*p*= 0,533). There was a strong negative significant correlation between mean lactations, and C12 (*p*= 0,035). The correlation with C1 (*p*= 0,056), P1 (*p*= 0,073), P1 (*p*= 0,073), P3 (*p*= 0,074) tended to be significant. Mean lactations weren't significantly correlated with C2 (*p*= 0,126), C3 (*p*= 0,258), C7 (*p*= 0,297), C8 (*p*= 0,141), C9 (*p*= 0,445), and C11 (*p*= 0,701). The correlations between the WFQ protocol and mean lactations are described in table 16.

Table 15. *Correlation between the WFQ protocol and mean lactations.*

Code	**WFQ**	**ρ**	***p*-value**
C1	Absence of prolonged hunger	-0,62	0,056
C2	Absence of prolonged thirst	-0,52	0,126
P1	**Good Feeding**	-0,590	0,073
C3	Comfort around resting	-0,40	0,258
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	-0,40	0,258
C6	Absence of injuries	-0,61	0,060
C7	Absence of disease	-0,37	0,297
C8	Absence of pain induced by management procedures	-0,50	0,141
P3	**Good Health**	-0,588	0,074
C9	Expression of social behaviors	-0,27	0,445
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	0,14	0,701
C12	Positive emotional state	-0,67	0,035
P4	**Appropriate Behavior**	0,224	0,533
FS	**Final Score**	-0,544	0,104

ρ, Spearman's Rho

3.6.2. WFQ Protocol and Cull Rates

3.6.2.1. WFQ Protocol and Cull Rate at Weaning

There was no significant correlation between cull rate at weaning and FS (*p*= 0,442). There were no significant correlations between cull rate at weaning, and P1 (*p*= 0,413), P2 (*p*= 0,243), P3 (*p*= 0,627)., and P4 (*p*= 0,090). Also, there were no significant correlations between cull rate ate weaning, and C1 (*p*= 0,575), C2 (*p*= 0,426), C3 (*p*= 0,243), C6 (*p*= 0,881), C7 (*p*= 0,518), C8 (*p*= 0,862), C9 (*p*= 0,533), C11 (*p*= 0,117), and C12 (*p*= 0,137). The correlations between the WFQ protocol and the cull rate at weaning are described in table 17.

Table 16.*Correlation between the WFQ protocol and the cull rate at weaning.*

Code	**WFQ**	**ρ**	***p*-value**
C1	Absence of prolonged hunger	0,20	0,575
C2	Absence of prolonged thirst	0,28	0,426
P1	**Good Feeding**	0,29	0,413
C3	Comfort around resting	-0,41	0,243
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	-0,41	0,243
C6	Absence of injuries	0,05	0,881
C7	Absence of disease	0,23	0,518
C8	Absence of pain induced by management procedures	-0,06	0,862
P3	**Good Health**	0,18	0,627
C9	Expression of social behaviors	0,22	0,533
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	0,53	0,117
C12	Positive emotional state	0,50	0,137
P4	**Appropriate Behavior**	0,56	0,090
FS	**Final Score**	0,275	0,442

ρ, Spearman's Rho

3.6.2.2. WFQ Protocol and Cull Rate from Weaning to First Labor

There was no significant correlation between cull rate from weaning to first labor and FS (*p*= 0,353). There were no significant correlations between cull rate from weaning to first labor, and P1 (*p*= 0,362), P2 (*p*= 0,136), P3 (*p*= 0,920), and P4 (*p*= 1). Finally, there were no significant correlations between cull rate ate weaning, and C1 (*p*= 0,387), C2 (*p*= 0,441), C3 (*p*= 0,136), C6 (*p*= 0,920), C7 (*p*= 0,295), C8 (*p*= 0,370), C9 (*p*= 0,776), C11 (*p*= 0,651), and C12 (*p*= 0,834). The correlations between the WFQ protocol and the cull rate from weaning to first labor are described in table 18.

Table 17. *Correlation between the WFQ protocol and the cull rate from weaning to first labor.*

Code	**WFQ**	**ρ**	***p*-value**
C1	Absence of prolonged hunger	-0,31	0,387
C2	Absence of prolonged thirst	-0,27	0,441
P1	**Good Feeding**	-0,32	0,362
C3	Comfort around resting	-0,51	0,136
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	-0,51	0,136
C6	Absence of injuries	0,04	0,920
C7	Absence of disease	0,37	0,295
C8	Absence of pain induced by management procedures	-0,32	0,370
P3	**Good Health**	0,04	0,920
C9	Expression of social behaviors	-0,10	0,776
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	0,16	0,651
C12	Positive emotional state	-0,08	0,834
P4	**Appropriate Behavior**	0	1
FS	**Final Score**	-0,33	0,353

ρ, Spearman's Rho

3.6.2.3. WFQ Protocol and Cull Rate After First Labor

There was no significant correlation between cull rate after first labor and FS (*p*= 0,616). There were no significant correlations between cull rate after first labor, and P1 (*p*= 0,987), P2 (*p*= 0,789), P3 (*p*= 0,244), and P4 (*p*= 0,405). Finally, there were no significant correlations between cull rate ate weaning, and C1 (*p*= 0,340), C2 (*p*= 0,831), C3 (*p*= 0,789), C6 (*p*= 0,603), C7 (*p*= 0,518), C8 (*p*= 0,353), C9 (*p*= 0,511), C11 (*p*= 0,425), and C12 (*p*= 0,318). The correlations between the WFQ protocol and the cull rate after first labor are described in table 19.

Table 18. *Correlation between the WFQ protocol and the cull rate after first labor.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	-0,34	0,340
C2	Absence of prolonged thirst	0,08	0,831
P1	**Good Feeding**	-0,01	0,987
C3	Comfort around resting	-0,10	0,789
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	-0,10	0,789
C6	Absence of injuries	-0,19	0,603
C7	Absence of disease	-0,23	0,518
C8	Absence of pain induced by management procedures	-0,33	0,353
P3	**Good Health**	-0,41	0,244
C9	Expression of social behaviors	-0,24	0,511
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	0,28	0,425
C12	Positive emotional state	-0,35	0,318
P4	**Appropriate Behavior**	0,30	0,405
FS	**Final Score**	-0,18	0,616

ρ, Spearman's Rho

3.6.6. WFQ Protocol and Use of Antibiotics

3.6.6.1. WFQ Protocol and Critical Importance Antibiotics

There was no significant correlation between FS, and the use of critical importance antibiotics (*p*= 0,567). There were no significant correlations between the use of critical importance antibiotics, and P1 (*p*= 0,663), P2 (*p*= 0,466), P3 (*p*= 0,405), and P4 (*p*= 0,366). The moderate negative correlation with C7 (*p*= 0,071), tended to be significant. Finally, there were no significant correlations between the use of critical importance antibiotics, and C1 (*p*=

0,987), C2 (*p*= 0,506), C3 (*p*= 0,466), C6 (*p*= 0,366), C8 (*p*= 0,675), C9 (*p*= 0,627), C11 (*p*= 0,652), and C12 (*p*= 0,828). The correlations between the WFQ protocol and the use of critical importance antibiotics are described in table 20.

Table 19. *Correlation between the WFQ Protocol and the use of critical importance antibiotics.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,01	0,987
C2	Absence of prolonged thirst	0,24	0,506
P1	**Good Feeding**	0,16	0,663
C3	Comfort around resting	-0,26	0,466
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	-0,26	0,466
C6	Absence of injuries	-0,32	0,366
C7	Absence of disease	-0,59	0,071
C8	Absence of pain induced by management procedures	0,15	0,675
P3	**Good Health**	-0,30	0,405
C9	Expression of social behaviors	-0,18	0,627
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	0,16	0,652
C12	Positive emotional state	0,08	0,828
P4	**Appropriate Behavior**	0,32	0,366
FS	**Final Score**	0,206	0,567

ρ, Spearman's Rho

3.6.6.2. WFQ Protocol and the Use of Non-Critical Importance Antibiotics

There was no significant correlation between FS, and the use of non-critical importance antibiotics (*p*= 0,185). There were no significant correlations between the use of critical importance antibiotics, and P1 (*p*= 0,206), P2 (*p*= 0,960), P3 (*p*= 0,446), and P4 (*p*= 0,652). Finally, there were no significant correlations between the use of critical importance antibiotics, and C1 (*p*= 0,238), C2 (*p*= 0,211), C3 (*p*= 0,960), C6 (*p*= 0,726), C7 (*p*= 0,907), C8 (*p*= 0,526), C9 (*p*= 0,580), C11 (*p*= 0,489), and C12 (*p*= 0,160). The correlations between the WFQ protocol and the use of non-critical importance antibiotics are described in table 21.

Table 20. *Correlation between the WFQ Protocol and the use of non-critical importance antibiotics.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,41	0,238
C2	Absence of prolonged thirst	0,43	0,211
P1	**Good Feeding**	0,44	0,206
C3	Comfort around resting	0,02	0,960
C4	Thermal Comfort		N/A
C5	Ease of movement		N/A
P2	**Good Housing**	0,02	0,960
C6	Absence of injuries	0,13	0,726
C7	Absence of disease	0,04	0,907
C8	Absence of pain induced by management procedures	0,23	0,526
P3	**Good Health**	0,27	0,446
C9	Expression of social behaviors	0,20	0,580
C10	Expression of other behaviors		N/A
C11	Good human-animal relationship	0,25	0,489
C12	Positive emotional state	0,48	0,160
P4	**Appropriate Behavior**	0,164	0,652
FS	**Final Score**	0,46	0,185

ρ, Spearman's Rho

3.7. Correlation Between Employee Satisfaction Index and Animal Welfare

The correlations between ESI and AW were assessed.

3.7.1. ESI and WFQ Protocol

There was no significant correlation between ESI and FS (*p*= 0,891). Similarly, there were no significant correlations between ESI, and P1 (*p*= 0,614), P3 (*p*= 0,215), and P4 (*p*= 0,150). The strong positive correlation with C3 (*p*= 0,069) and P2 (*p*= 0,069), tended to be significant.

There was a strong negative significative correlation between ESI and C11 (p= 0,042). There were no significant correlations between ESI, C1 (*p*= 0,483), C2 (*p*= 0,695), C6 (*p*= 0,117), C7 (*p*= 0,496), C8 (*p*= 0,192), C9 (*p*= 0,934), and C12 (*p*= 0,894). The correlations between ESI and the WFQ protocol are described in table 22.

Table 21. *Correlation between ESI and the WFQ protocol.*

Code	WFQ	ρ	*p*-value
C1	Absence of prolonged hunger	0,25	0,483
C2	Absence of prolonged thirst	0,14	0,695
P1	**Good Feeding**	0,18	0,614
C3	Comfort around resting	0,60	0,069
C4	Thermal Comfort	N/A	
C5	Ease of movement	N/A	
P2	**Good Housing**	0,60	0,069
C6	Absence of injuries	0,53	0,117
C7	Absence of disease	0,24	0,496
C8	Absence of pain induced by management procedures	0,45	0,192
P3	**Good Health**	0,43	0,215
C9	Expression of social behaviors	-0,03	0,934
C10	Expression of other behaviors	N/A	
C11	Good human-animal relationship	-0,65	0,042
C12	Positive emotional state	-0,05	0,894
P4	**Appropriate Behavior**	-0,49	0,150
FS	**Final Score**	-0,05	0,891

ρ, Spearman's Rho

3.7.2. ESI and Animal Welfare Extra Measures

There was no significant correlation between ESI and mean lactations (*p*= 0,489). Also, there was no significant correlation between ESI, cull rate at weaning (*p*= 0,187), cull rate from weaning to first labor (*p*= 0,354), and cull rate after first labor (*p*= 0,676). Finally, there were no significant correlations between ESI, the use of critical importance antibiotics (*p*= 0,777), and the use of non-critical of antibiotics (*p*= 0,511). The correlations between ESI and animal welfare extra measures are described in table 23.

Table 23. *Correlation between ESI and animal welfare extra measures.*

	ρ	***p*-value**
Mean lactations	-0,25	0,489
Cull rate at weaning	-0,45	0,187
Cull rate from weaning to first labor	-0,33	0,354
Cull rate after first labor	0,15	0,676
Critical usage of Antibiotics (mg/kg)	-0,10	0,777
Non-critical usage of Antibiotics (mg/kg)	-0,24	0,511

ρ, Spearman's Rho

3.8. Correlation Between ESI and Productive Performance

There was no significant correlation between ESI and calving interval (*p*= 0,215). Also, the correlation between ESI, average daily production (*p*= 0,934), somatic cell count (*p*= 0,467), number of animals reaching 305 days in milk (*p*= 0,310), and 305 DIM cumulative production (*p*= 0,510) showed no significance. The correlations between ESI and productive performance are described in table 24.

Table 24. *Correlation Between ESI and Productive Performance.*

	ρ	***p*-value**
Calving Interval	0,43	0,215
Average daily production (Kg/day)	0,03	0,934
Somatic Cell Count (cells x1000/ml)	0,26	0,467
Number of animals reaching 305 days in milk	0,36	0,310
305 days in milk cumulative production (Kg)	0,24	0,510

ρ, Spearman's Rho

4. Discussion

The study's main objective was to assess and correlate animal welfare with the productive performance in ten dairy farms in Portugal. Also, the study aimed to evaluate if animal welfare indicators were correlated with antibiotic usage, average lactations, and cull rates. Finally, it aimed to characterize and assess workplace satisfaction and its association with animal welfare and productive performance.

At first, the WFQ results showed a predictable distribution when considering the overall welfare level and the reality of the total universe of 166 farms. However, in the practical context of an animal welfare certification, the total number of possible farms to be included in this study had already been audited at least once during the past year. That procedure led to a natural exclusion of the "Not Classified" farms, leaving the remaining "Enhanced" and "Acceptable" farms to work within the year of this study. For instance, Grimard et al. (2019) showed that between a universe of 2755 dairy farms that 55,4% were "Acceptable" alongside 41,6% of "Enhanced" farms and only 3,0% of "Not Acceptable" farms, which might show a less filtered WFQ distribution.

It is to notice that the WFQ protocol does not have a suitable measure to assess C4. Also, there were no animals kept in tie-stall barns, as well as there was no access to pasture in any of the farms included in the study. Therefore, none of the correlations proposed with C4, C5, and C10 were assessed.

When considering AW extra measures, the average lactations per animal was 2,33 (±0,31). Comparing these values with De Vries (2020), which defends three years of productive life in normal reproductive conditions, the number of lactations is lesser per animal when compared to the referred study. Therefore, the new measurement proposed for the WFQ protocol aims to include longevity as a measure, so we predict a potential issue with this factor in these farms. Among these issues, we believe that financially there is more net income per animal if we can make this animal have a prolonged productive life with more pronounced production output. Unfortunately, in this study, we could not calculate longevity due to the inaccuracy of the data provided by the farmers.

Also, antibiotic usage of critical and non-critical importance was considered low compared to the estimated mg/kg of antimicrobial used in bovine in Europe in 2016 (24,96 mg/kg) (OIE, 2021). However, the mean value of 9,86 (±11,48) mg/kg of non-critical importance antibiotics and 1,09 (±11,48) mg/kg of critical importance antibiotics might be related to poor practices coming from old management routines and unawareness of the sector to the antibiotic resistance thematic. We also believe that poor calf and heifer management has a strong relationship with both antibiotic group usage and the culling rates at weaning mean value of 5,17% (±9,32), cull rate from weaning to first labor mean value of 10,99 (±7,31), and cull rate after first labor mean value of 18,73% (±6,12). However, we hypothesize that the minimum value of 0,00% of cull rate at weaning may be related to the animals not being identified at birth, which results in a misleading calculation.

The productive performance results show high variability in the methodology of production. For instance, CI varies from 381 to 477 days, with only three farms showing a CI shorter than 400 days, which goes accordingly to the traditional CI of 365 days. However, like Hare et al. (2006) described, CI has been increasing among all general breeds, which goes according to the CI mean value. Though, CI alone as a productive performance measure should be avoided as it may reflect inaccurate data as defended by Olori et al. (2002), stating that the need for two calving episodes for each animal, or even exclusion of the voluntary culled animals due to reproductive problems, compromise the accuracy of the proposed measure. Likewise, calving seasonality, which is not a regular management procedure in Portugal, would undoubtedly affect the CI. Also, another reason for increased CI is deliberately extending it in high-yielding animals to promote the productivity potential of the animal (Arbel et al., 2001).

On the other hand, following the same demarked variance, average daily production, the number of animals reaching 305 DIM, and 305 DIM cumulative production had a wide range of results. The 305 DIM cumulative production differs from 6565,00 kg to 11435,00 kg. This difference of 4870 kg can represent a substantial economic gap of 1996,70€ per animal considering the average European Union price of 41,30 €/100kg in December 2021 (European Commission, 2022). This productive and theoretical economic gap in the context of recent years production, characterized by overwhelming production costs and volatile raw milk prices, promotes unstable production, compromises farm rentability, but also it can result and perpetuate from weaker herd genetic traits, poor management practices, and promote chronic insufficient productive parameters within the herd.

However, not only productive characteristics determine a dairy farm's production, rentability, and mindset. According to Kuipers et al. (2021), dairy farmers do not show incentive or sufficient information to approach the constant market shift, agri-political conditions, and the overall challenges they have to face.

Following, we can point out several topics when approaching managers' characterization. Beginning with age, 40% of the managers enquired were older than 55 years old. Also, 80% of the managers were male. Comparing the results with the EU-28 space in 2016, where 57,9% of farm managers were over 55 years old, and 71,5% were male, we can say that this study follows a similar characterization. Likewise, the total absence of farm managers below the age of 25 and only 20% of the managers being below 45 years can be seen as an alarm. In 2016, Portugal showed only 4,2% of farm managers below 40 years when compared to Austria (22,3%).

Finally, age and adequate training present a challenge in modern farming in Portugal. Fifty percent of the enquired managers in this study had elementary education with no agriculture training, like the 68,3% of farm managers in the same condition reported by Eurostat (Eurostat, 2020). On the other hand, employee characterization was in accordance with the above-mentioned managers' characterization. Male employees (69,4%) outnumbered females (30,6%). This data is in concordance with the EU-28 data from 2013, on which 64,8% of the farms' labor force was composed be males (Eurostat, 2016). However, compared to our managers' characterization, 66,71% of employees were below 45 years old. Also, only 13,9% continued to study after high school, following the same trend of inadequate training seen above.

Another point to discuss is the percentage of the familiar labor force. In this study, only 25% of the employees were related to the manager. This value contrasts with the 77,6% of family labor in the EU-28 farming in 2013 (Eurostat, 2016).

One of the most prominent points was related to fixed salaries. In this study, fixed salaries inferior to 750€ were attributed to 50,00% of employees. Comparing the results with the managers' fixed salaries, 40% affirmed not having a stable income at the end of the month, and 10% had a fixed salary inferior to 750€. Considering the average wage of dairy farms for the EU-27 from 201-2012 to be 8,00 €/hour (European Union, 2015), we can say that fixed salaries in our study are considerably lower compared to the European average. However, despite the reported above, 55,6% of enquired employees showed intentions of remaining in the same position until retirement. These considerations bring to the fact that only 20% of the managers that think 80-100% of their team will make a career working on their farm. So, we can sustain that employees look at their professional progression with limitations, and dairy farms managers are constantly expecting high turnover rates, weakening the sector's development.

To our knowledge, this study was the first in Portugal to assess the satisfaction of the working force in dairy farms. However, the calculation of ESI had some limitations. Even though the questionnaire was completely anonymous and untraceable, there was always the possibility of the questionnaires having unrealistic answers. We believe that the leading cause is related to the fear of being punished for showing disagreement or discontent. Another limitation relates to having only 30% of respondents in farm A. This low value can reflect an inaccurate ESI value for the farm and the consequent correlations.

When assessing the correlation between AW and productive performance, several aspects showed a positive understanding towards AW and productivity. First, average daily production was associated with the WFQ protocol. Access to water, water consumption, and milk yield are positively correlated (Daros et al., 2019; Kramer et al., 2008). Like Burgos et al. (2001) described, animals with water restriction had reduced milk yield by around 27% compared to the control period. Also, BCS goes along the same line of thought as water intake. Dairy cows' physiology aims at well-balanced BCS to promote enhanced productive performance and avoid metabolic complications such as ketosis in over-conditioned postpartum animals (Roche et al., 2009b). In the same study stated above, Burgos et al. (2001) showed that a 50% water restriction presented a reduced dry matter intake by up to 20% when compared to *ad libitum* situations. So, in our thought, these results between average milk yield and 305 DIM cumulative production can be explained in the way that lower classified farms in C2 did not guarantee the minimum number or size of drinkers (6cm/linear drinker or one individual drinker for ten animals) for the considered sample, were dirty or did not have sufficient water flow as described in the WFQ protocol (Welfare Quality, 2009). Therefore, we believe that water availability and BCS assessment are deeply correlated.

Likewise, we consider that the comfort provided to the animals at resting plays another fundamental role in productivity. In this study, there was a wide variety of bedding and housing types. Also, while average daily production and the number of animals reaching 305 DIM tended to be positively correlated with the WFQ protocol, 305 DIM cumulative production showed a strong correlation with the WFQ protocol. Verdes et al. (2020) defended that farms with weaker installations, inadequate bedding, or even insufficient maintenance were associated with inadequate hygiene, lower heat detection, higher chances of developing lameness, and ultimately, lower milk yield. Likewise, Ravagnolo et al. (2000) showed, in a study with 134 dairy farms, that daily milk yield reduced by 0,2 kg for every increased unit in THI. Also, Bruckmaier & Blum (1998) indicated that shifts in the environmental routine of dairy cows could lead to an inadequate milk ejection reflex when at milking. Therefore, in our thought, our results may be justified mainly by the inadequate bedding maintenance and

cleaning procedures. Also, overcrowded stables or having cubicles that are not big enough can promote not only higher lying times, but also collisions when lying and more animals lying outside the designated resting area. Also, we associate stressful events like herd movements, increased THI promoted by seasonal effects, or even impaired health status with lower daily, cumulative yields and compromised affective state.
Finally, in our study, most of the AW audits were performed during winter, which can reflect dirtier animals when compared to hotter months. Also, for the same reason, we believe that average daily production should be addressed in a more detailed work to understand if the seasonal oscillation of production allows this measure to be valid, reliable, and feasible.

The result of our study shows that C8 was related to the number of animals reaching 305 DIM and the 305 DIM cumulative production. Being a multivarious factor theme, we believe this association needs to be addressed as an individual topic in future works.

Mean lactations showed a moderately negative relation with C12. Unpaired health often leads to an impaired emotional state (Ebinghaus et al., 2022). Also, to our thought, Qualitative Behavioral Assessment is one of the most underrated tools in evaluating AW. Therefore, it can be expected that, as described by Ebinghaus et al. (2022), subclinical metabolic conditions and lameness are examples of impaired emotional state by suboptimal health. So, promoting unpaired health conditions can lead to higher involuntary cull rates in productive age cows, which represents a setback when assessing AW and productivity.

Critical importance antibiotics tended to be negatively related to C7. Contrarily, the usage of non-critical importance antibiotics was not significantly related to C7. The continuous demand for high productive animals can weaken the animals' health status (Trevisi et al., 2014). In dairy cows specifically, udder health management can represent up to 68% of antibiotic usage (Kuipers et al., 2016). Orjales et al. (2016) stated that organic pasture-based, which did not use antibiotic treatments, had significantly higher SCC ($174x10^3$ cells/ml) when compared to conventional farms ($93x10^3$ cells/ml). Also, Sawant et al. (2005) quantified from a universe of 33 dairy herds, that among calves, 33% of antibiotic usage was due to enteritis and 25% due to pneumonia. However, the antimicrobial resistance thematic has been gaining strength among all animal production community. For that reason, we believe that several reasons can justify this difference in correlations. First, critical importance antibiotics are not readily available as non-critical importance antibiotics. We believe that antibiotic records are incomplete because dairy farmers do not keep continuous treatment administration records, especially in calves and heifers. Also, many dairy farmers in Portugal still perform blanket dry cow therapy which can justify our non-critical importance antibiotics usage and the absence of significant association between the WFQ protocol and SCC. Finally, to control general udder health, active substances like ceftiofur are commonly overused due to its absence of safety interval in milk. Therefore, allied to the ongoing concern with antibiotic resistance, we believe that the indiscriminate use of non-critical importance antibiotics might have been a confounding factor in our proposed correlation. On the other hand, with critical importance antibiotics relation with C7, we can fortify the premise that better-kept animals have a lesser need for antibiotic treatment.

Finally, among the correlations with ESI, C11 was significant. This result leaves us to consider that this negative association needs to be approached by future studies. The reduced number of farms included in this study might have been associated with this result. So, we propose to deepen this association with a multifactorial approach.

5. Conclusion

Our study suggests that AW, assessed by the WFQ protocol, is related to productive performance. We identified positive correlations between what is considered good welfare and productive performance. Better-kept AW was related to average daily production, the number of animals reaching 305 DIM, and the 305 DIM cumulative production.

Also, the use of critical importance antibiotics tended to be related to C7. These results reinforce the need to discuss further the impact of antibiotic use on dairy farming and the AMR problematic. Further research should address this topic in detail.

However, ESI relation with AW showed that this topic needs to be deepened and consolidated in future research.

Furthermore, workplace characterization was the most debatable topic. Our data reinforce the description of a crisis in the dairy sector. Profound economic underdevelopment, aged working-class, insufficient labor force, and lack of investment in training future generations compromise current production and ultimately AW.

So, we propose that future research should strengthen the association between AW, productive performance, and dairy farmers' welfare.

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VI. Appendices

Appendix I- Data Usage Agreement

ACORDO DE TRATAMENTO DE DADOS PESSOAIS

ENTRE

João André dos Santos Fernandes Cerqueira, Número de Identificação Fiscal [redacted] residente em [redacted]a qualidade de primeiro outorgante

E

Lacticoop - União de Cooperativas de entre Douro e Mondego, Número de Identificação Fiscal 500372179 com sede em Rua de Almeida Garret, 5 e 6, 3810-046 Aveiro na qualidade de segundo outorgante

Considerando:

1. Que no presente Acordo a sigla RGPD designa o REGULAMENTO (UE) 2016/679 DO PARLAMENTO EUROPEU E DO CONSELHO de 27 de abril de 2016, relativo à proteção das pessoas singulares no que diz respeito ao tratamento de dados pessoais e à livre circulação desses dados e que revoga a Diretiva 95/46/CE (Regulamento Geral sobre a Proteção de Dados), ou outra legislação que lhe venha a suceder, devendo nesse caso, adaptar-se as referências em conformidade.

2. A definição de «Responsável pelo tratamento», conforme o artigo 4.º do RGPD: "a pessoa singular ou coletiva (...) que, individualmente ou em conjunto com outras, determina as finalidades e os meios de tratamento de dados pessoais;"

3. A definição de «Subcontratante»», conforme o artigo 4.º do RGPD: "uma pessoa singular ou coletiva, (...) que trate os dados pessoais por conta do responsável pelo tratamento destes;"

4. A definição de «Violação de dados pessoais», conforme o artigo 4.º do RGPD: "uma violação da segurança «que provoque, de modo acidental ou ilícito, a destruição, a perda, a alteração, a divulgação ou o acesso, não autorizados, a dados pessoais transmitidos, conservados ou sujeitos a qualquer outro tipo de tratamento;"

As Partes acordam que:

PRIMEIRO

(Responsável)

As Partes concordam que no âmbito do presente acordo, o primeiro outorgante atua como Responsável pelo tratamento, conforme as respetivas definições no RGPD.

SEGUNDO

(Conformidade geral)

O primeiro e segundo outorgantes comprometem-se a cumprir a legislação de proteção de dados pessoais em vigor, nomeadamente o RGPD, e a respeitar os Direitos dos Titulares dos dados.

TERCEIRO

(Objeto e Âmbito)

O presente acordo tem por objeto o estabelecimento das condições para o tratamento dos dados pessoais no âmbito da realização da tese "ASSOCIATION OF ANIMAL WELFARE WITH PRODUCTIVE PERFORMANCE AND STAFF SATISFATION IN DAIRY FARMS" considerando as seguintes explorações:

- [redacted]

Os dados recolhidos dizem respeito à auditoria interna realizada no âmbito do projeto de Bem-estar Animal assim como dados referentes à qualidade de leite retirados da plataforma Bovinfor e Lactinfo.

À semelhança, no âmbito de um relatório de estágio de panorama geral, considera-se também o tratamento de dados da distribuição de dados gerais das auditorias de bem-estar animal, assim como as atividades realizadas durante a duração do estágio curricular e consequente estágio profissional.

QUARTO

(Termos para o tratamento de dados pessoais)

O primeiro outorgante compromete-se a realizar apenas os tratamentos de dados pessoais necessários dentro do objecto e âmbito definidos acima.

QUINTO

(Confidencialidade)

1. O segundo outorgante compromete-se a dar acesso aos dados pessoais no âmbito do presente acordo.

2. O primeiro contratante compromete-se, ao dever de confidencialidade e de limitação de tratamento, conformes com as atribuições individuais.

SEXTO

(Segurança do tratamento)

O primeiro outorgante garante realizar os tratamentos de dados pessoais sob condições de segurança que assegurem a sua confidencialidade, integridade e disponibilidade.

SÉTIMO

(Vigência)

O presente acordo vigorará a partir do momento que seja assinado pelas Partes, e até que termine a elaboração do trabalho científico que lhe está subjacente.

ASSINATURAS

Data:

Pelo Primeiro Outorgante:

(Nome do representante)

Pelo Segundo Outorgante:

(Nome do representante)

Appendix II- Workplace Satisfaction Questionnaire for Farm Managers

Workplace satisfaction Questionnaire

My name is João Cerqueira. I am a finalist student of Veterinary Medicine at Universidade Lusófona. While developing my master's degree dissertation under the theme " Association of Animal Welfare, Productive Performance, and Staff Satisfaction in Portuguese Dairy Farms", I considered including your farm as part of my study group.

Please consider the following topics:

- Participation in the questionnaire is completely **voluntary and confidential**, and no personal information will be requested during the questionnaire.

- This questionnaire is only intended for the dairy farm manager.

- The study aims to relate animal welfare with its reproductive performance and consequent milk production, also addressing the possible impact that team satisfaction may have on these parameters.

- The following is an adaptation of the questionnaire used in the study carried out by Phillip Durst in 2018, under the topic of *"Evaluation by employee management on large US dairy farms"*. Therefore, I do not hold any rights to the questions presented.

- The questions are inserted in themes such as workplace environment and characterization, attitudes, relationship with the dairy staff, happiness in the workplace and dairy sector recognition.

If at any time you have any questions regarding the questionnaire do not hesitate to contact me via email (joao[redacted]

Thank you very much for your collaboration.

Part 1. Please answer the following questions ticking the option that **most fits to you.**

1. Age

☐ 18-25 ☐ 46-55
☐ 26-35 ☐ >55
☐ 36-45

2. Sex

☐ M ☐ F

3. Educational qualifications

☐ Elementary school
☐ Middle School
☐ High School
☐ Graduation
☐ Master's degree
☐ PhD

4. Salary
   a. Fixed salary

☐ <630€ ☐ 1000-1250€
☐ 630-750€ ☐ >1250€
☐ 750-1000€

   b. Variable salary

☐ Travelling allowance
☐ Food allowance
☐ Housing
☐ Health insurance

5. How long have you worked for this farm?

☐ <1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

6. How long have you worked for the dairy industry?

☐ <1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

7. How long have been managing this dairy?

☐ <1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

8. How long you see yourself at this position?

☐ <1 year ☐ >10 years
☐ 1-5 years ☐ Until retirement
☐ 6-10 years

9. What percentage of your employees do you hope will make a career of working on your farm?

☐ <20% ☐ 40%-60%
☐ 80-100%
☐ 20%-40% ☐ 60%-80%

Part 2. Answer the following questions ticking **yes** or **no**

	Yes	**No**
Q1. Do you feel you know what's expected from you?		
Q2. Do you feel that employees know what's expected from them?		
Q3. Does your salary match your responsibility?		
Q4. Do you feel happy in your workplace?		
Q5. Do you think employees would recommend this workplace to others?		
Q6. If employees have a problem and need help, do you think they feel comfortable talking to you about it?		
Q7. Would you say you are irreplaceable to the ongoing operation?		
Q8. Do you feel that the dairy sector is properly recognized?		
Q9. Do you feel respected by your employees?		
Q10. Do you think society recognizes the importance of the dairy farming sector?		
Q11. Do you bring experts in to train your employees or send them to be trained by an external source?		
Q12. Do you feel supported by those who regulate the dairy industry?		

Part 3. Answer the following questions ticking from **1 (Never),** to **5 (Always).**

	1	**2**	**3**	**4**	**5**
Q13. How many times a week do you feel happy in your workplace?					
Q14. Do you feel fulfilled at your work?					
Q15. Do you usually feel bored at your workplace?					
Q16. Do you usually feel frustrated at your workplace?					
Q17. Do you feel motivated by yourself to do your best job?					
Q18. Do you feel consumed by your work, compromising your private life?					
Q19. How often do you provide feedback (good or bad) to employees about their work?					
Q20. How often does your team express ideas to improve the operation?					
Q21. How often does your team receive training to improve their skills?					
Q22. Do you feel that you *enforce* the rules and regulations adequately and fairly across all employees?					

Part 4. Answer the following questions ticking from **1 to 5 according to each classification score.**

	Never 1	2	3	4	Completely 5
Q23. Do you feel that employees know *how what they do* contributes to reach the farm goals?					

	Individualist 1	2	3	4	We are a team 5
Q24. Rate the *teamwork* within the farm.					

	Not satisfied 1	2	3	4	Satisfied 5
Q25. How satisfied are you working at this dairy?					
Q26. Rate the openness and honesty of communication with your team.					
Q27. How do you think your employees would rate their relationship with you?					

	Indiferent 1	2	3	4	Continuous 5
Q28. how would you rate the interest of your employees in learning?					
Q29. How would you rate your employees' commitment to the farm’s success?					

	Dependent				Independent
	1	**2**	**3**	**4**	**5**
Q30. To what degree do you feel that you give employees independence to do their job?					

	Static				Dynamic
	1	**2**	**3**	**4**	**5**
Q31. How would you rate yourself on working to improve the operation?					

	Blame him/her				We improve together
	1	**2**	**3**	**4**	**5**
Q32. When someone makes a mistake, how do you react?					

	Not explicit				Explicit
	1	**2**	**3**	**4**	**5**
Q33. Do you feel that you communicate what the farm goals are to employees?					

Appendix III- Workplace Satisfaction Questionnaire for Farm Employees

Workplace satisfaction questionnaire

My name is João Cerqueira. I am a finalist student of Veterinary Medicine at Universidade Lusófona. While developing my master's degree dissertation, I considered including the farm where you work as part of my study group.

Please have in mind the following instructions:

- Participation in the questionnaire is completely **voluntary and confidential**, and no personal information will be requested during the questionnaire.

- This questionnaire is only intended for the dairy farm team.

- The study aims to relate animal welfare with its reproductive performance and consequent milk production, also addressing the possible impact that team satisfaction may have on these parameters.

- The following is an adaptation of the questionnaire used in the study carried out by Phillip Durst in 2018, under the topic of *"Evaluation by employee management on large US dairy farms".* Therefore, I do not hold any rights to the questions presented.

- The questionnaire consists of multiple and short answer questions. The questions are inserted in themes such as workplace environment, attitudes, relationship with the supervisor, happiness in the workplace and dairy sector recognition.

If at any time you have any questions regarding the questionnaire do not hesitate to contact me via email (joao[redacted]

Thank you very much for your collaboration

Part 1. Please answer the following questions ticking the option that **most fits to you.**

1. Age

☐ 18-25 ☐ 36-45 ☐ >55
☐ 26-35 ☐ 46-55

2. Sex

☐ M ☐ F

3. Educational qualifications

☐ Elementary school
☐ Middle School
☐ High School
☐ Graduation
☐ Master's degree
☐ PhD

4. Type of contract

☐ Full time ☐ Fixed contract
☐ Part-time ☐ Other
☐ Service provider

5. How long have you worked for the dairy industry?

☐ < 1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

6. Salary
   a. Fixed salary

☐ <630 € ☐ 1000-1250 €
☐ 630-750 € ☐ >1250 €
☐ 750-1000 € ☐ Variable

   b. Variable salary

☐ Travelling allowance
☐ Food allowance
☐ Housing
☐ Health insurance

7. How long have you worked for this farm?

☐ < 1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

8. Are you an employee who is also a member of the owner's family?

☐ Yes ☐ No

9. What is your primary responsibility?

____

10. How long have you had this responsibility for?

☐ < 1 year ☐ 6-10 years
☐ 1-5 years ☐ >10 years

11. How long you see yourself at this position?

☐ <1 year ☐ >10 years
☐ 1-5 years ☐ Until retirement
☐ 6-10 years

Part 2. Answer the following questions ticking **yes** or **no**

	Yes	**No**
Q1. Do you feel you have the tools and equipment you need to do your job right?		
Q2. Would you recommend this workplace to others?		
Q3. Do you feel you know what's expected from you?		
Q4. Do you feel happy in your workplace?		
Q5. Is it clear who your supervisor is and who you need to go to when you have a problem?		
Q6. If you have a problem and need help do you talk to your supervisor about it?		
Q7. Is your training provided by your supervisor or by an external source?		
Q8. Does your salary match your responsibility?		
Q9. Would you say you are irreplaceable to the ongoing operation?		
Q10. Do you feel that the dairy sector is properly recognized?		
Q11. Do you think society recognizes the importance of the dairy farming sector?		
Q12. Do you feel supported by those who regulate the dairy industry?		

Part 3. Answer the following questions ticking from **1 (Never),** to **5 (Always).**

	1	**2**	**3**	**4**	**5**
Q13. How many times a week do you feel happy in your workplace?					
Q14. Do you feel fulfilled at your work?					
Q15. Do you usually feel bored at your workplace?					
Q16. Do you usually feel frustrated at your workplace?					
Q17. Do you feel motivated by yourself to do your best job?					
Q18. Do you feel consumed by your work, compromising your private life?					
Q19. How often do you receive feedback (good or bad) about your work from your supervisor?					
Q20. In the last 15 days how often have you received recognition and praise for good work?					
Q21. How often do you receive training to improve your skills?					

Q22. How well are the rules and regulations of the operation enforced adequately and fairly across all employees?					

Part 4. Answer the following questions ticking from **1 to 5 according to each classification score.**

	Not necessary				Essential
	1	**2**	**3**	**4**	**5**
Q23. How necessary is your work to reach the farm goals?					

	Individualist				We are a team
	1	**2**	**3**	**4**	**5**
Q24. How would you rate the teamwork within the group?					

	Not satisfied				Satisfied
	1	**2**	**3**	**4**	**5**
Q25. How satisfied are you working at this farm?					
Q26. Rate how open and honest communication is with your supervisor (and employer) and across the dairy operation.					
Q27. Rate your relationship to your supervisor.					

	Indifirent				Continuous
	1	**2**	**3**	**4**	**5**
Q28. How would you rate *your* interest in learning?					
Q29. How would you rate *your* commitment to the farm's success?					

	Dependent				Independent
	1	**2**	**3**	**4**	**5**
Q30. To what degree do you feel that you are given independence to do your job?					

	Static				Dynamic
	1	**2**	**3**	**4**	**5**
Q31. Please rate your employer on working to improve the operation.					

	Blames me				We improve together
	1	**2**	**3**	**4**	**5**
Q32. When you fail, how does your employer react?					

	Not explicit				Explicit
	1	**2**	**3**	**4**	**5**
Q33. Do you feel that the farm goals are communicated effectively to employees?					