Human-animal relationship in water buffalo: quality of stockpeople interactions and their effect on dairy and meat production

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1. Introduction

For domestic bovines—including water buffaloes (Bubalus bubalis)—raised as meat or dairy livestock, human-animal relationships are essential to ensure reproductive and productive success. A negative interaction decreases profit in dairy production, causing losses of high value meat cuts and increasing the risk of accidents for both caretakers and buffaloes. It may also lead to the negative emotional states such as fear towards humans and aggression towards conspecifics (des Roches et al. 2016; Guerrero-Lagarreta et al. 2020; Mota-Rojas et al. 2021a; Napolitano et al. 2022).

Human-animal relationships (HAR) for livestock refer to any interaction between the stockperson and the animals. It can be either positive, negative, or neutral, depending on quantity and quality of the relationship (Napolitano et al. 2019), the attitude towards the animal, and the emotional outcome that it might represent for the animals (Hemsworth et al. 2000; American Veterinary Medical Association 2023). For example, in buffaloes, a negative HAR arises when stockpeople shout, slap, and forcefully handle the animals, causing behavioral alterations such as fearfulness, restlessness, stepping and kicking (Napolitano et al. 2019; Mincu et al. 2022). Likewise, when buffaloes are used as draught animals they are exposed to mishandling with the use of heavy loads and physical tools that may cause pain and lesions, sores, fatigue, dehydration, and metabolic disorders. (Hoffmann et al. 1989; Minka and Ayo 2007; Makki 2014; Hu et al. 2020; Mota-Rojas et al. 2021a). In contrast, a positive HAR might result when handlers have knowledge about the species temperament and behavior (e.g., they are slower when compared to Bos taurus cattle), which may help handling buffaloes accordingly (Lawrence and Pearson 2002).

Buffaloes are used as double purpose species, for the simultaneous production of meat and dairy. According to their productive purpose, HAR can differ. In the case of dairy buffaloes, is considered that almost 50% of the time is spent in the milking process (Guler et al. 2009; Borghe et al. 2013). Proper care and attention from the stockpeople or caretakers during milking minimizes losses and improves parameters associated with udder health to maintain an adequate and constant milk ejection and adequate emptying of the cistern and alveolar gland (des Roches et al. 2016; Mota-Rojas et al. 2020a). Inadequate emptying of the udder can cause inflammatory processes such as mastitis (with percentages ranging from 4.8 to 51.6%) (Sharma and Sindh 2007; Lakshmi et al. 2009; Fareed et al. 2016), decrease calf weight gain (in dual purpose units) (Ghezzi et al. 2022; Rodriguez-Gonzalez et al. 2022), and adverse effects on the lactation curve (Borghese et al. 2013; Boselli et al. 2020; Napolitano et al. 2022).
In contrast to dairy buffaloes that require daily interaction during milking, HARs in buffaloes destined to meat production are reduced. For beef buffaloes, handling procedures are limited to preventive medicine (e.g., vaccination, deworming, directed veterinary care), mobilization, and transport of the animals. In this sense, animal mobilization is recognized as a multifactorial stressor that might be diminished with the training, formation, attitude, and behavior of the stockpeople. During this stage, the implementation of technology and daily monitoring of livestock practices and handling farm routines might prevent negative consequences (Napolitano et al. 2020a).

Therefore, the objective of the present review is to discuss the importance of HAR for water buffaloes in dairy and beef production systems, and its impact on their productivity. HAR will be addressed by focusing on interactions with caretakers and stockpeople during milking, fattening, mobilization, and slaughtering, as well as other breeding and management factors that are directly related to the human presence in the production process and that might impact production success or failure.

2. Quality of stockpeople interactions and their impact on buffalo physiology, behavior, and production

In recent years, the interest in maintaining optimal animal welfare standards in livestock has led to the establishment of guidelines that ensure the physical and mental health of animals and animal-based food production chain (OMSA 2004; Rojas et al. 2005; Saltalamacchia et al. 2007; Veissier et al. 2011; Deemer and Lobao 2011; Napolitano et al. 2019). Within these guidelines, the quality and frequency of HAR has an impact within buffalo production in different contexts, as shown in Figure 1, such as feeding, transport, herding, handling, milking, or weighing, causing certain effects on the emotional and cognitive states of buffaloes (Waiblinger et al. 2002; Rusheen and Passillé 2010; Napolitano et al. 2019; Mersmann et al. 2022).

![Figure 1](https://www.jabbnet.com)

Figure 1 Types of interactions during buffalo mobilization and their impact on the relationship between attitude and welfare. A. Use of sticks to stimulate buffalo mobility in handling chute must be avoided to prevent injuries in animals; B and C. Use of electric prods to facilitate buffalo entry into the vehicle are not considered an adequate technique to mobilize water buffaloes; D and F. Conversely human-animal interaction involving actions like talking or gentle touching and movements that do not involve the use of physical force on the buffalo might improve HAR.

To determine the valence of the HAR –positive, negative, or neutral–, some questionnaires can be used to assess the human intervention and attitudes towards livestock, as well as physiological and behavioral animal-based markers. Regarding questionnaires, these can help infer the attitude taken by stockpeople during animal handling, breeding, and animal housing. These evaluation methods have shown that stockpeople’s training, willpower, technical skills and knowledge, disposition, motivation, attitude, and job satisfaction affect on animal welfare and productive performance (Coleman and Hemsworth 2014). Moreover, the attitude of the stockpeople or caretakers can be influenced by their level of training, age and gender, which directly affects the welfare of the buffalo (Mota-Rojas et al. 2020a). Another factor that has been considered by Waiblinger et al. (2006) is the personality traits of the farmers/stockpeople. This includes aspects such as their self-confidence or their aggressiveness which can greatly impact the way they interact with the animals. An agreeable and stoic stockperson may be more openminded to believe that an animal is intelligent and can easily learn through patient handling. In contrast, impatient and easily hostile
caretakers tend to impulsively use aversive handling that induce fear in the animals, establishing a negative feedback cycle where the stockpersons job satisfaction, motivation, and attitude worsens as the animal fear increases while their productivity decreases.

Aside from the importance of selecting trained people to manage water buffaloes, monitoring the nature of the interaction will allow for evaluation and re-adjustments of current practices in production units. For example, shouting, clapping, forced usage of sticks, hands or electric prods can elicit a negative interaction where buffaloes might become fearful, distressed or aggressive, and diminishes their productive and behavioral performance (Arnold et al 2007; Acharya et al 2022). In contrast, visual, tactile, and auditory stimuli such as talking or gentle touching, the use of rattles and strokes, or tools to generate noise by banging on solid surfaces, and speaking at a medium noise level can lead to positive or neutral results (Mota-Rojas et al 2020a; Napolitano et al 2020a; Acharya et al 2022). In addition, positive reinforcements such as feeding have been shown to decrease plasma corticosterone concentrations in farm animals like hens, helping to stimulate positive physiological reactions in other farm animals such as the so-called “anti-stress effects” (Mota-Rojas et al 2020).

Most of the aforementioned negative HAR and its consequences in buffaloes are the result of stress, an unconscious response to a stimulus perceived as a threat to the well-being. Stress causes a set of behavioral, autonomic, metabolic, hormonal, immunological, and neuroendocrine changes and responses that are aimed at maintaining the homeostasis of the animal (Cruz-Monterrosa et al 2020b; Mota-Rojas et al 2020b; OMSA 2021; Hernández-Avalos et al 2021). The perception of a stressor by the central nervous system triggers the hypothalamic-pituitary-adrenal axis (HPA) and the sympathetic nervous system, causing the release of glucocorticoids –cortisol– and catecholamines –adrenaline, noradrenaline– (Kinlein et al 2015). Alteration in glucocorticoid concentrations have been reported when different types of HAR develop between animals and stockpeople. In dairy cows, fecal cortisol metabolites were lower when the contact between humans and cows was increased, as well as with keeping sick cows together with the healthy animals and by providing optimal resting space (Ebinghaus et al 2020). Similarly, in Gyr cows, positive HAR such as hand stimulation during milking and training of the cows to enter the parlor resulted in lower cortisol levels (ranging from $15.09 \pm 1.46$ to $16.23 \pm 1.11$ ng/mL). In this study, the animals also reduced the percentage of residual milk and improved the behavioral response of cows to milking (Ujita et al 2021). These studies show that the endocrine response of animals to stressors such as a negative HAR do not only affect their homeostasis but also have significant implications on their productive performance.

In addition, the housing and management conditions are aspects that require attention and monitoring since they are associated with the success or failure of the production unit and the quality of the HAR. Particularly, water buffalo is a species that, regardless of its productive purpose, require specific components such as swampy (Barboza 2011; Bertoni et al 2020) and natural shading areas (Barboza-Jiménez and Barboza 2011; Khongdee et al 2013), or the use of fans and nebulizers to avoid heat stress (Das et al 1999; Bertoni et al 2019; Mota-Rojas et al 2020c, 2021c; Napolitano et al 2020b). Nonetheless, the requirement of the facilities, as well as the quantity of HAR, depends on the purpose, whether dairy or meat buffaloes.

3. Human-animal relationship during milking

On a global scale, buffalo milk represents 13% of the total milk production. Buffalo milk stands out for its physicochemical and nutritional characteristics and better performance during the production of dairy products due to its high total solids content (Ocampo et al 2016; Uzun et al 2018; Mota-Rojas et al 2019; Li et al 2020). The quality of this is influenced by facilities, handling, animal welfare, breed, parity number, diet type, and HAR (Garau et al 2021).

In this regard, Saltalamacchia et al (2007) investigated the relationship between human and water buffalo behavior on 17 dairy farms in Italy. The authors evaluated the number of positive, neutral, and negative interactions according to the number of steps and kicks from the entrance to the milking parlor to the registration of the milking teat cups when the stockperson was within half a meter of each animal. Results showed that enhancing positive interaction with buffaloes was negatively correlated with stepping and kicking ($r=-0.63$). Similarly, studies by des Roches et al (2016) mention that the fear of Holstein and Montbéliarde cows towards people is due to negative behaviors shown by caretakers, affecting the milking process and representing potential disturbances during the calving period. When considering the main calving location, fewer cows let themselves be touched when the place of calving was in the barn or when farmers cleaned the deep bedding after calving. In addition, farmers with more negative behavioral attitudes had a lower proportion of cows that let themselves be touched (8.9%). It was also mentioned in an investigation by Hemsworth (2007) that restlessness is another negative consequence that can occur during milking due to inappropriate and careless stockpeople behaviors like hastily moving the cows from pasture to milking and loud vocalizations from the stockpeople. Another study by Napolitano et al (2019) stated that restlessness during milking can further be caused by the quality of the HAR and by other factors such as lameness, the presence of arthropods, or poor milking machine maintenance.

The intensification and introduction of mechanical milking in buffalo livestock production has exposed both stockpeople and dairy buffaloes to an environment with potential stressors. For example, inadequate machinery maintenance, bad practices, and hasty calf separation can result in delayed milk ejection and/or incomplete emptying of the udder and alveolar compartment (Mota-Rojas et al
2022; Napolitano et al 2022). Moreover, other factors involved could be the lack of proper visual, auditory and tactile stimulation during the milking process, excessive noise, changes in the milking routine that impact the laterality of the female and the concentration of odors in the milking parlor (Thomas et al 2004, 2005; Borghese et al 2007; Insel 2010; Panksepp et al 2011; Polikarpus 2013; Polikarpus et al 2014; Faraz et al 2020). In addition, the presence of aversive operators during the milking process generates an increase in heart rate, blood cortisol, and residual milk (De Rosa et al 2007; Saltalamacchia et al 2007).

Positive HAR in the milking parlor, together with good husbandry practices are not only beneficial for the welfare of buffaloes, but also are related to the udder health and prevention of other inflammatory process (Patbandha et al 2015; Gabr et al 2017; Rahman et al 2019).

3.1. Milk ejection and udder health

From a neuroendocrine perspective, milk ejection requires sensory stimulation that can be provided by the presence of the calf during hand milking (Borghese et al 2007). Udder stimulation by the calf activates mechanoreceptors present in the teats that transmit the signal to lumbar nerves for the stimulation of the supraoptic and paraventricular nucleus of the hypothalamus. The consequent oxytocin release to the bloodstream acts on udder myoepithelial cells causing their contraction and releasing milk (Crowley and Armstrong 1992; Bruckmaier 2005; Akhtar et al 2012; Faraz et al 2020; Kamikawa and Seko 2020; Rodríguez-González et al 2022). For water buffaloes, tactile stimulation is highly important because the proportion of milk stored at the alveolar level (92-95%) is higher than the cisternal level (5-8%)(Bidarimath and Aggarwal 2007; Cavallina et al 2008; Bertoni et al 2020a). Nonetheless, in machine milking, udder stimulation by the calf is uncommon, but the milker performs activities such as teat cleaning, preparation, and disinfection to initiate milk ejection (Thomas et al 2004) (Figure 2).

![Figure 2](image-url)  
**Figure 2** Relation between milk ejection and a positive human-animal-relationship. By performing daily routines such as teat disinfection and udder massage, tactile stimulation activates mechanoreceptors located in the udder. Its activation triggers the oxytocin release pathway mediated by the MPOA, SON, and PVN. Oxytocin acts on myoepithelial cells of the mammary gland to produce milk and its consequent ejection. During milking, it is important to promote positive interactions between buffaloes and the stockpeople. Interactions as improving the milking parlor. MPOA: medial preoptic area of the hypothalamus; PVN: paraventricular nucleus; SON: supraoptic nucleus.

By understanding the importance of sensory stimulation during milking, the impact of HARs during milking is also comprehensible, not only considering the interaction but also regarding the parlor design. In this sense, Napolitano et al (Napolitano et al 2019) evaluated negative, neutral, and positive interactions between stockpeople and dairy buffaloes from 27 Italian farms. In 14 farms there were herringbone parlors and 13 tandem parlors. In tandem parlors up to 15% were regarded as negative HAR, while only the 2.56% of negative HAR were reported in herring-bone parlors. Thus, these results could be due to the individual handling that buffaloes require in tandem parlors that enable them to exit and enter each stall. Contrarily, to minimize the likelihood of developing negative interactions herring-bone parlors employ group handling. Also, milk production may decrease due to inadequate designs that could promote heat stress with the consequent vasoconstriction of vessels supplying the mammary gland.
(Shamshul and Yusof 2023). As stated by Napolitano et al (2019), the type of parlor can also influence the number of animals injected with oxytocin to improve productivity during milking. These authors found that herring-bone parlors are less likely to require oxytocin injections because the animals are handled in groups instead of individually while in tandem parlors, individual handling is more common and, therefore, the likelihood to have negative interactions between stockpeople and animals is increased.

An improper stimulation can also affect udder health due to an incomplete emptying of milk in the mammary gland. In addition, interrupted milk ejection causes air entry which not only increases the chances of bacteria entering into the teat canal, which could increase the prevalence of mastitis (Moore-Foster et al 2019). In the case of water buffalo, increased avoidance distance, low touch tolerance, and flight behavior can hinder the milking process. However, trained stockpeople could understand and address such aspects to improve milking in buffaloes (Ivemeyer et al 2018).

Therefore, it is important to ensure positive HAR with stockpeople because clinical and subclinical mastitis is one of the most commonly observed challenges in the milk sector, due to the economic impact on production units, treatment costs and, in some cases, early replacement of females (Hussain et al 2013; Mota-Rojas et al 2019).

3.2. Tactile and auditory stimulation as a strategy to promote a positive HAR during milking.

Manual stimulation during milking is necessary for oxytocin secretion into the bloodstream and activation of myoepithelial cells within the mammary gland (Napolitano et al 2022). It is mentioned that stimulation for about 30, 60, and 90 seconds (Bruckmaier and Wellnitz 2008) or up to 2 minutes is required due to the location of the highest proportion of milk in the udder (alveolar cistern) (Olmos-Hernández et al 2020). These stimuli can be provided by pre-milking teat massage and teat disinfection, in addition to the tactile stimulation provided by the calf that positively stimulates milk ejection latency (Espinosa et al 2011).

In addition to this type of stimulation, the use of mechanical brushes has been proposed as another option to improve productive parameters and adequate milk ejection. The use of mechanical brushes has been related with a positive behavioral response, increased feed consumption and productive performance (Figure 3) (Newby et al 2013). In this regard, Keeling et al (2016) evaluated the effect of mechanical rotating brushes on 23 Holstein and 49 Swedish Red dairy cattle for 9 weeks. The instauration of brushes increased roughage intake, milk yield (+1.52 kg), and dry matter intake (+0.67 kg). These results were associated with high concentrations of oxytocin, leading to an increase in milk ejection latency, decreasing the frequency of occurrence of clinic mastitis in multiparous cows and increasing feed intake (Figure 3).

![Figure 3](image-url) Effects of tactile stimulation before milking. Tactile stimulation, whether by hand or with mechanical brushes, activates low-threshold mechanoreceptors located in the skin. These receptors transmit non-noxious tactile signaling to cerebral structures such as de VTA, NAc, and SON. Dopaminergic neurons located in the NAc participate in the behavioral and physiological benefits of tactile enrichment, by reducing anxiety and promoting relaxation. On the other hand, oxytocinergic neurons in the SON participate in the milk ejection process by acting on the alveolar tissue of the mammary gland. NAc: nucleus accumbens; SON: supraoptic nucleus; VTA: ventral tegmental area.
Another strategy to promote positive HAR and welfare of dairy livestock is through auditory enrichment. In humans, listening to music has been associated with analgesic and anxiolytic properties. In animals, studies assessing the effect of music on the productive performance of animals have shown effects on animal physiology and behavior that reduce anxiety and aggression through the elimination of unpleasant noises (Alworth and Buerkle 2013; Dhungana et al 2018). Besides, during milking, auditory stimulation might improve behavior and allow for a complete emptying of the udder (Uetake et al 1997; Ciborowska et al 2021).

An example of these studies includes Abuzead and Khalil (2007), who evaluated 48 dairy buffaloes divided into control or no music (n=16), slow music (n=16) and fast music (n=16) groups. After one month of evaluation, buffaloes exposed to slow and fast music showed behavioral postures associated with interest in the sound (e.g., pointed ears towards the sound source), and showed a more relaxed behavior and absence of rumination. Additionally, milk latency period increased, meaning that nervous buffalo cows that are difficult to handle might benefit from music. This type of response is associated to the use of auditory enrichment in dairy animals which imitates their normal pulse rate and increases the release of inhibitory neurotransmitters (e.g., gamma amino butyric acid). It also promotes the secretion of the growth hormone that has a regulatory role during lactation, increasing milk production, stabilizing serotonin levels, and reducing stress. The endocrine and behavioral effects of music are schematized in Figure 4 (Ma and Wang 2020).

**Figure 4** Physiological effects of auditory enrichment in livestock. Exposure to different types of music in water buffaloes and dairy cattle has been shown to activate cerebral structures such as the VTA, Amyg, NAc, PFC, PVN, and SON. The activation of these regions decreases noradrenaline concentration and promotes a stress-free state. The participation of the limbic system and dopamine release has effects on the physiological parameters of bovines (e.g., reduced blood pressure, heart rate, respiratory rate, and abnormal behaviors). Oxytocin released by the SON also enhances milk yield. However, this reaction highly depends on the period of exposure, genre of music, and sound waves. ACTH: adrenocorticotropic hormone; Amyg: Amygdala; dB: decibels; NAc: nucleus accumbens; PFC: prefrontal cortex; SON: supraoptic nucleus; VTA: ventral tegmental area (Alworth and Buerkle 2013).

In contrast to the aforementioned, a study conducted on 24 Jersey cows (10 primiparous and 14 multiparous) showed no benefits in terms of productive and behavioral parameters after one week of exposure to music. The authors reported that music significantly reduced milk production in primiparous cows (3.45 vs. 2.78 liters per day), while a greater willingness to feed and ruminate was observed in the non-music periods. Multiparous cows had higher milk yields, reduced feeding, and rumination, and had a higher proportion of standing behavior. Nonetheless, no significant effects were recorded after music exposure, meaning that longer exposure periods, type of music, parity number and even housing environment need to be considered when evaluating the effect of auditory stimulus in ruminants (Shamshul and Yusof 2023).
4. Human-animal relationship and its effect during meat production

Another purpose for water buffalo is meat production, with notable characteristics such as a lower concentration of lipids with respect to beef (57% less) (Naveena and Kiran 2014), a lower presence of saturated fat and cholesterol (9% less), and 10% higher mineral and protein content (Domaradzki et al 2016; Guerrero-Legarreta et al 2020).

The meat process involves stages such as breeding, growing, and finishing, as well as mobilization (Šímová et al 2016; Ghoneim et al 2018). These events are considered stressful due to sudden changes in their social or physical environment and HAR (Kober et al 2014; Alarcón-Royo et al 2021; José-Pérez et al 2022). Fear, described as an undesirable emotional state of suffering, is another factor to consider in both animal and stockpeople. Fear towards humans can lead to acute and chronic stress in animals, inducing immunosuppression and other health problems that affect the quality of the product (meat or milk).

Whereas in humans, it has been associated to poor attitudes that may affect the commitment to the surveillance and attendance of animal welfare and production problems (Hemsworth 2003).

In meat-producing animals, the quality of HAR not only determines the presence of fear in buffaloes, but also has an impact on meat quality (Mota-Rojas et al 2020a). Daily weight gains and final meat yields depend to a great extent on proper routine practices, handling, and training by the operator.

4.1. Effect of human practices during mobilization

In particular, the mobilization of water buffalo, regardless of its objective (e.g., breeding, exhibiting, fattening, and slaughter) (José-Pérez et al 2022), includes activities such as loading, unloading, resting, stunning, and slaughtering. These processes can cause fear, epithelial tissue or muscle injuries (Chandra and Das 2001a; José-Pérez et al 2022; Rodríguez-González et al 2022), as well as pain and stress when farmers do not have the necessary training and supervision to ensure animal welfare (Grandin 2014). In addition, during these stages buffaloes are exposed to noise, overcrowding, excessive handling during herding and weighing, as well as changes in hierarchical structures and trailer microclimate (Marai and Haeeb 2010; Alam et al 2010a; Strappini et al 2012; Gallo and Huertas 2016; Bethancourt-García et al 2019; Valkova et al 2021).

Šímová et al (2016) indicate that adverse effects due to transport and negative HAR can be reduced when animals are habituated to transport and management by trained caretakers (Mota-Rojas et al 2021b).

One of the main problems during loading and unloading of water buffaloes is the use of herding methods and tools that can cause pain, such as sticks, shouting, kinks of tails and electric prods (Strappini et al 2012). For example, in Mexico it has been reported that electric prods are the most used (56.8%), followed by shouting (20.3%) and others (10.9%), with the justification of being necessary so that animals do not die during their journey (Valadez-Noriega et al 2018). The use of such tools can generate injuries, as reported by Alam et al (Alam et al 2010b), who found that 99% of buffaloes presented a 52% increase in skin lesions generated during mobilization, mainly in areas such as the buttock (61.9%), hips (48.4%) and abdomen (47.3%) (Alam et al 2010b; José-Pérez et al 2022). Among the main factors mentioned that were associated with this was aversive handling by handlers during loading and unloading. This is similar to what was observed by Chandra and Das (2001b), who described that the frequency and prevalence of bruises in water buffalo carcasses is due to impulsive and excessive use of sticks.

During transportation, driving techniques, sudden changes in speed and braking (Broom 2019), as well as inadequate loading density, long transport without considering resting times to provide water and feed, if necessary, may affect animal welfare. In addition, the lack of consideration for the presence of horns and the combination of animals from different origins and sizes could also affect animals welfare (Strappini et al 2012; Lemcke 2015; Valkova et al 2021; José-Pérez et al 2022).

During stunning, previous events such as resting, lairage, animals of different origin, and anatomical characteristics (e.g., with or without horns) influence the response of animals to HAR. In addition, insufficient lighting, unmaintained guillotine doors that may generate injuries inside the drawer modules, or the incorrect use of stunning devices also affects this step (Mota-Rojas et al 2021b; Abubakar et al 2021). In this sense, the maintenance of stunning devices such as captive bolt penetration guns require operators to be trained to use these methods and recognize significant differences between species. For example, water buffaloes have thicker bone plates and deeper frontal sinuses than cattle, so it is recommended to use tools designed for buffaloes or to choose an appropriate impact site to generate deep un consciousness and insensibility (Gregory et al 2009; Mota-Rojas et al 2021b, d; Temple et al 2023; Molnar-Fernández et al 2023).

Regarding the impact on meat quality, under normal conditions, after stunning and anoxia, muscles maintain a continuous ATP synthesis and utilization to maintain cell homeostasis (Matarneh et al 2017). Anoxia leads to an increase in the rate of ATP hydrolysis and anaerobic muscle glycogen utilization until the ATP utilization rate is greater than that of generation, causing loss of muscle contractility and protein denaturation (a process lasting 1 to 12 hours) (Ouali et al 2006; Ortega and Ariza 2012; Díaz-Luis et al 2020). This metabolic change causes breakdown of glucose to lactic acid, decreasing pH and thereby improving physicochemical and microbiological characteristics such as color, texture, water retention capacity and water activity (Cruz-Monterrosa et al 2020; Gonzalez-Rivas et al 2020; Guerrero-Legarreta et al 2020; Joele et al 2017; Turan et al
2021). This transformation chain from muscle to meat is highly affected by any stressor during or before slaughter. Therefore, promoting positive HAR and adequate stunning methods is essential for buffalo meat producers.

To optimize buffalo transportation and slaughtering process, regulation and supervision of current laws and guidelines regarding water buffaloes is important. Likewise, training the personnel and understanding the impact that a negative HAR can cause in water buffalo is needed.

5. Future directions

Although the use of music to improve the behavioral and productive response of animals has yielded conflicting results further information on the type of music, its frequency and the period required to observe a change is still an area for additional research. (Ciborowska et al. 2021).

Another possible line of research could focus on analyzing the milking parlor design type and its impact on positive, neutral, and negative interactions for practical application in stockpeople selection and planning (Napolitano et al. 2019). Furthermore, using “cognitive-behavioral modification techniques” to improve the attitudes and behavior of stockpeople towards the animals in their care, as described by Hemsworth and Coleman (1998), could be an alternative. These techniques involve conveying knowledge and skills, changing previously established habits, attitudes, and beliefs, and even preparing the stockpeople to handle future negative reactions towards this change from other people. However, due to stockpeople having long-standing attitudes and beliefs it is a complicated issue that still needs to be developed over time (Hemsworth 2003).

On the other hand, when mentioning meat production in water buffalo, additional information is required to understand the effect that a negative HAR can cause during mobilization, stunning, and slaughtering. Moreover, different types of enrichment or positive stimulation during these critical periods has not yet investigated in buffaloes to determine its effect on physiological, productive, and emotional parameters.

6. Final considerations

Water buffaloes, being a double-purpose species, are exposed to different HAR through their productive stage. It has been documented that dairy buffaloes have abnormal and aggressive behavior towards the stockperson when the animals are rough handled with shouts and physical tools. This does not only have behavioral and emotional consequences by causing chronic stress in the animals, but also decreases milk yields. In the case of beef buffaloes, factors such as handling during mobilization and slaughtering is a critical event where negative HAR such as the use of electric prods or beatings causes physical injuries and fearful reactions. Additionally, the quality of both meat and dairy products is highly affected by HAR interactions.

Due to these observations, directed and continuous training is necessary in buffalo farming according to the productive purpose. In addition, the implementation of strategies that promote positive HAR, such as the use of mechanical brushes or music with slow sounds and adequate facilities, could be tools that improve and ensure positive HAR in water buffalo.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare that there is no conflict of interest with this work.

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