REVIEW ARTICLE

Main critical factors affecting the welfare of beef cattle and veal calves raised under intensive rearing systems in Italy: a review

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ABSTRACT

This review describes the principal causes of poor welfare in beef cattle and veal calves raised in intensive husbandry systems in Italy. Nowadays there are no specific regulations in force for beef cattle welfare. However, a document produced in 2001 by the Scientific Committee on Animal Health and Animal Welfare of the European Commission on Health and Consumer Protection identified the main causes of inadequate welfare levels in the different cattle rearing systems in Europe. In Italy and in the Po Valley in particular, the beef cattle farms are mainly finishing units characterised by animals kept at high density in multiple pens and fed high starch diets. Under these rearing conditions the limited space allowance is one of the most important issues impairing animal welfare. Other risk factors for poor welfare related to the housing structures are type of floor, space at the manger, number of water dispensers and lack of specific moving and handling facilities. Microclimatic conditions can be critical especially during the summer season when cattle can experience heat stress. The feeding plan adopted in the Italian beef farms may be another factor negatively affecting the welfare of these animals due to the low content of long fibre roughage which increases the risk of metabolic acidosis. In the veal calf rearing systems there has been a mandatory introduction of the new system of production according to the European Council Directives 91/629/EEC and 97/2/EC. Farms had to adopt group housing and to provide calves with an increasing amount of fibrous feed in addition to the all-liquid diet. Despite this specific legislation, several risk factors for calves' welfare can still be identified. Some of them are related to the housing system (type of floor, air quality, feed and water supply equipment and lack of loading facilities) and some others to the feeding plan (type and amount of roughage, quality of milk replacers). Recent studies have shown that the welfare of veal calves and beef cattle can be severely affected by the quality of the stockmanship and particularly by negative human-animal interaction.

Key words: Beef cattle, Veal calves, Animal welfare, Intensive farming, Italy.

RIASSUNTO

PRINCIPALI PUNTI CRITICI PER IL BENESSERE DEI BOVINI DA CARNE E DEI VITELLI A CARNE BIANCA IN ALLEVAMENTO INTENSIVO IN ITALIA: UNA REVIEW

Il presente lavoro descrive le possibili cause di scarso benessere per vitelloni da carne e vitelli a carne bianca in allevamento intensivo in Italia. Per quanto riguarda il vitellone, attualmente non esiste ancora una specifica normativa in proposito. Tuttavia, un documento redatto nel 2001 dal Comitato Scientifico Veterinario "Salute e Benessere Animale" della Commissione Europea sulla Salute e Protezione del Consumatore ha identificato le principali cause che possono comprometterne il benessere nei principali sistemi di allevamento presenti in Europa. In Italia ed in particolare nella Pianura Padana, la produzione del vitellone da carne è caratterizzata dall'elevata densità di animali confinati in box multipli ed alimentati con una razione molto ricca in amido. Uno dei maggiori problemi per il benessere dei vitelloni allevati in modo intensivo è rappresentato dalla limitata disponibilità di spazio per capo, anche se non vanno trascurati, sempre per quanto riguarda le strutture, il tipo di pavimentazione, lo spazio in mangiatoia, il numero di abbeveratoi e la mancanza di apposite strutture per la movimentazione e la restrizione degli animali. Nell'area della Pianura Padana inoltre, soprattutto nel periodo estivo, non vanno sottovalutate le condizioni microclimatiche visto che gli animali sono spesso sottoposti a condizioni che inducono lo stress da caldo. Altre cause che possono influenzare in modo negativo lo stato di benessere dei vitelloni sono attribuibili all'alimentazione, che generalmente è carente in fibra lunga e può quindi aumentare il rischio di stati di acidosi subclinica. Nell'allevamento del vitello a carne bianca, l'entrata in vigore delle Direttive del Consiglio Europeo 91/629/CEE e 97/2/CE ha imposto agli allevatori di adottare la stabulazione di gruppo e di fornire ai vitelli una quantità crescente di alimento solido fibroso in aggiunta alla dieta lattea. Nonostante la vigente legislazione, numerosi fattori di rischio sono ancora identificabili negli allevamenti di tale categoria di bovini. Alcuni di questi parametri riguardano le strutture (tipo di pavimentazione, qualità dell'aria, sistemi di distribuzione della dieta e dell'acqua di bevanda e l'assenza di sistemi di rampe di carico), mentre altri sono legati al programma alimentare (tipo e quantità di alimento fibroso, qualità dei sostitutivi del latte). Recenti studi hanno dimostrato inoltre che i problemi di benessere sia del vitello a carne bianca che del vitellone sono imputabili anche alla scarsa professionalità degli operatori di stalla ed in particolare ad una interazione di tipo negativo tra uomo e animale.

Parole chiave: *Bovini da carne, Vitelli a carne bianca, Benessere animale, Allevamento intensivo, Italia.*

Introduction

Animal welfare is negatively affected when normal biological functions are afflicted but even healthy, normally growing and reproducing animals may be in a poor state of welfare if they experience suffering and are reared in inadequate conditions (Mendl, 2001). Nowadays, it is common opinion that rearing systems with a high stocking rate are negatively related to the animal's well being since for the great majority of the urbanized world the perception of farm animal welfare is related to 'natural' behaviour in a 'natural' environment.

The basal needs of farm animals should be assured by allowing free access to adequate quantities of feed and fresh water, by providing a suitable rearing environment and by avoiding physical pain or suffering of any kind (Webster, 2001). Specific legislation on animal welfare by the European Union exists for several categories of farm animals. In the case of cattle, a regulation is in force for the protection of veal calves, imposing their group housing and the provision of a small amount of fibrous feeds in addition to the liquid diet (European Council Directive 91/629/EC and 97/2/EC). Instead, no explicit rules are in force for beef cattle and the only reference document is the report by the Scientific Committee on Animal Health

and Animal Welfare (SCAHAW, 2001) that made a detailed survey on the current rearing systems identifying several housing and management solutions to improve the health and care of these animals. Despite the large number of studies carried out on this topic, many causes of an inadequate level of welfare can still be found in beef cattle and veal calf farms and sustainable rearing systems have yet to be established (McGlone, 2001). The present review aims to describe the main causes of poor welfare that may be found in intensive beef cattle and veal calf farms in Italy.

Intensive beef cattle production in Italy

According to European statistics (OFIVAL, 2007), in the year 2005 Italy represented the third main contributor (11.4%) to the total cattle meat produced within the 25 EU Countries following France (22.5%) and Germany (15.3%). However, the self-supply obtained by calves born and raised for meat production in the country covered only little more than 30% of the national demand. Thirty percent of the national deficit was covered by importing fresh and frozen meat from animals raised and slaughtered abroad, mainly in France and Spain. The remaining 40% was provided by living young bulls and heifers that were imported to be finished in the Italian fattening units. In 2005, about 1 million heads were transferred to Italy from their native countries (Cozzi, 2007). France is the major supplier of these imported young cattle followed by Eastern European countries. The prime category of the imported beef cattle from France is the "*broutard*", young bulls and heifers 8-12 months old belonging to French pure beef breeds Charolais, Limosine, Blonde d'Aquitaine or their crosses with dual purpose breeds (SCAHAW, 2001). Polish Friesian and Simmental are the main breeds imported from Eastern Europe. Once at destination, cattle are fattened in specialized farms under intensive rearing conditions. Most of these fattening units are located in the Po Valley and they adopt the indoor loose housing of the animals in multiple pens. Fattening bulls and heifers are fed high concentrate diets which are provided as total mixed rations (TMR) in order to reduce the risk of the occurrence of rumen and metabolic acidosis. Maize is the main crop used for the formulation of these diets and it is included either as dried ground meal or as high moisture ear silage and whole plant silage.

Environmental resources and cattle welfare

From an animal welfare perspective, the loose housing in groups adopted in the Italian fattening units must be considered an acceptable solution because it allows locomotion (Kempkens and Boxberger, 1987) and the development of social behaviours among pen-mates. Feed intake has also shown to be increased when cattle are loose housed in comparison to the permanent tethering (Ingvartsen and Andersen, 1993). However, in many farms, the pen size is insufficient due to overcrowding and, therefore, the space allowance is one of the most critical factors negatively affecting beef cattle welfare. According to Ingvartsen and Andersen (1993), a limited space allowance results in low feed intake and daily gain worsening the feed conversion ratio of the animals. Aggressive behaviours have shown to increase when fattening bulls are housed with an insufficient space allowance. In this housing condition, there is also a reduction of the time spent resting, eating and ruminating, particularly by the subordinate animals which cope with more difficulty with the dominant pen-mates (Gottardo *et al.*, 2003; Bouissou and Boissy, 2005).

Even cattle health is worsened by an insufficient space allowance which was considered the main cause of lesions, such as trauma on bones and joints, osteoarthropathies, prepuce injury and tail tip necrosis observed in fattening cattle (Groth, 1985). Beranger (1986) reported mortality around 1% when space allowance was 3 m^2/head while it more than doubled when space was less than 2.5 m^2/head. On the contrary Sundrum and Rubelowski (2001) found a low correlation between the incidence of early losses and either space allowance or floor quality indicating that many other aspects were relevant besides pen design criteria. Based on several studies, SCAHAW (2001) has suggested at least 3 m^2/head as tolerable space allowance for bulls weighing 500 kg, to be increased by 0.5 m^2/head for every additional 100 kg of live weight.

Another issue to be considered as a critical point for the welfare of beef cattle is the pen floor type and quality. A suitable housing system should assure to the animal the possibility to move and lay or stand freely on a floor that is not slippery (Veissier *et al.*, 1999). Inadequate floor conditions, besides changing animals' normal laying/standing and walking behaviours, often cause injuries. The predominant type of floor in the Italian intensive beef cattle farms is the fully slatted type, because it does not require any bedding material and it has a lower labour cost to remove slurry. Littered pens are adopted for the fattening of bulls slaughtered at heavy live weights. Fully slatted floors compared to deep litter systems, have been shown to impair bulls' behaviour by increasing abnormal positions both when standing and lying (Wierenga, 1987), and by enhancing the frequency of leg and foot injuries (Murphy *et al.*, 1987), tail tip necrosis and early losses, especially when it is associated with a limited space allowance (Ingvartsen and Andersen, 1993; Metzner *et al.*, 1994; Schrader *et al.*, 2001). However, a recent study carried out by Gottardo *et al.* (2003) in an Italian beef cattle farm reported satisfactory health status and similar values for several blood indicators of chronic stress between bulls housed on fully slatted floors and animals on straw bedded floors with the same space allowance (3 m^2/head). Straw bedding allowed bulls to better perform their natural social behaviour during feeding time by increasing eating frequency and the simultaneous presence of more bulls at the manger.

Cleanliness can be used as an indirect measure of cattle welfare since it has been shown to worsen either in animals suffering from gastrointestinal disorders or in the case of poor quality farm stockmanship. In the study by Gottardo *et al.* (2003), bulls on deep litter were always dirtier than those on slats due to an insufficient frequency of its renewal. Therefore, in case of short supply of bedding materials the slatted floor system has proved to be an effective compromise to the deep bedding (Kelly and Webster, 1989). Furthermore, when using the deep bedding system, the adoption of sloped floors should be avoided since it has shown a high incidence of lameness (ITEB, 1983; Cozzi *et al.*, 2005).

The space at the manger may be another critical factor for beef cattle welfare because, if restricted, it can negatively affect the feeding time by increasing competition and stress among pen-mates (Longenbach *et al.*, 1999). Reducing the number of feeding places to less than 1 per animal also decreases their performances (Ingvartsen and Andersen, 1993). The SCAHAW report (2001) suggests a feeding trough space allowance ranging from 0.6 to 0.7 m/head for fattening cattle weighing 500 kg in loose housing systems. However, Gottardo *et al.* (2004) proved that this parameter becomes less relevant when bulls are truly fed *ad libitum* while

the indication should be followed if the diet is rationed (Faulkner and Berger, 2003). Besides the allowance of space, mangers have to be designed in a way that all the animals can easily and comfortably achieve the distributed feed (Veissier *et al.*, 1999).

Beef cattle should be provided with clean fresh water in order to fully meet their water requirements (Webster, 2001). Cattle water consumption depends on the dry matter content and composition of the diet as well as on the environmental temperature and humidity (Philips, 1993; NRC, 2000). In the literature, there are no specific indications about the number or the size of the water dispensers to be installed in multiple pens for beef cattle. However, it is rational to recommend that they should increase according to the number of animals kept within the same pen. According to NRC (2000), the water intake of finishing bulls (450 kg of live-weight) increases from 48 up to 78 l/d when temperatures rise from 21.1 to 32.2 °C. Therefore, additional drinking points should be provided during the hot season to fulfil the greater demand for water by beef cattle exposed to heat stress. A recent survey, carried out by Mazzenga *et al.* (2006) in 20 Italian intensive beef cattle farms showed that in none of them there was the inclusion of additional water dispensers during the hot season. The quality of drinking water should also be considered but no specific reference values for its temperature, chemical and organoleptic characteristics are available. However, there is a common opinion among practitioners that they should not be very different from drinking water standards for humans.

Critical summer weather conditions have also been shown to have a negative effect on animal welfare by increasing body temperature and reducing feed intake (Lefcourt and Adams, 1996). According to the SCAHAW report (2001), temperatures above 27 °C at a relative humidity >80% or above 30°C at lower moisture negatively impact cattle welfare. Under intensive rearing systems, the effect of the hot climate on the beef cattle response can be exacerbated by the heat increment induced by feeding diets rich in concentrates (Mader, 2003). The Temperature Humidity Index (THI) proposed by Armstrong (1994) could be an effective tool in assessing the potential stressful conditions for beef cattle. A value of THI greater than 74 is considered the minimum threshold of heat stress for beef cattle (Davis *et al.*, 2003; Holt *et al.*, 2004) and this climate condition can be frequently experienced by cattle raised in the Po Valley (Mazzenga *et al.*, 2006). Farm design criteria should therefore consider solutions capable of allowing animals to better cope with these stressful conditions including appropriate ventilation and cooling systems. A good ventilation system should also provide good air quality by lowering the concentration of noxious gases. Levels of NH_3 above 20 ppm and above 5000 ppm for CO_2 are considered harmful for both animals and farmers (SCAHAW, 2001). In this regard, direct measures of both gases in a sample of Italian beef farms during summer and winter showed that their concentrations were far below the risk threshold (Mazzenga *et al*., 2006).

Housing structures should avoid crossbars used to prevent mounting. Such bars negatively impact welfare because they are adverse to the animals' freedom to express normal behaviours (Webster, 2001). Another critical factor for the Italian beef farms is the almost complete absence of moving and loading facilities for cattle (Nanni Costa *et al.*, 2001). This fact has negative implications for both animal welfare and meat quality. Moving and handling cattle without dedicated alleys, loading ramps and restraint structures makes animals nervous and less cooperative, thereby increasing the

stockmen's risk of being injured (Grandin, 1997; Gustafsson, 1997). The use of electric prods to speed up the moving and loading operations does not help and it should be avoided since it negatively affects cattle welfare and, at the time of the slaughter, it enhances the risk of a severe carcass depreciation due to bruising or to the occurrence of dark cutting beef (SCAHAW, 2002).

Feeding plan and cattle welfare

A satisfactory feeding plan should deliver to all the pen-mates the right quantity of a diet made with good quality ingredients. Therefore, the ration should be formulated to fully meet the nutritional requirements of the animals according to their breed, bodyweight and daily gain (INRA, 1988; NRC, 2000). In this regard, a survey carried out by Gottardo *et al.*, (2002a) on 17 intensive Italian beef cattle farms observed unsatisfactory feeding conditions for most of them. Energy and protein concentrations of the TMR were frequently above the target needed according to the cattle requirements. This represents a stress factor because a large amount of readily fermentable organic matter decreases ruminal pH and may lead to subclinical or clinical acidosis (Fiems *et al.*, 1999). Cattle fed high amounts of concentrates also have an increased risk of developing liver abscesses (Ingvartsen and Andersen, 1993) and laminitis (De Campeneere *et al.*, 2002). Another critical point observed in the same survey was the insufficient amount of diet distributed, since in many fattening units there was no feed residue at the manger before the provision of the new TMR the next day (Gottardo *et al.*, 2002a). This feeding condition may not assure the maximum intake to all the penmates and therefore it could increase the negative interactions among them resulting in a likely inhomogeneous growth between dominant and subordinate bulls.

Periodic chemical analyses should guarantee the quality of the feed ingredients of the diet but this good management practice has been shown to be implemented only by a limited number of Italian beef farmers (Gottardo and Cozzi, 2005). Particular attention should be addressed towards the storage of the wet feedstuffs such as the ensiled forage and grains in order to keep them unaltered and toxin-free.

The particle size of the TMR is another important parameter which can affect ingestive behaviour and rumination in beef cattle (Cozzi and Gottardo, 2005). Cozzi *et al.* (2008), in a large study on the feeding situation of finishing beef cattle in Italy recently showed that diets have a high percentage of fine particles (<8mm) which has a limited capacity to promote chewing (Mertens, 1997). On many farms, a significant loss of long particles (>13mm) occurs during the TMR preparation due to the damage of the long particles of maize silage. Therefore, more careful handling of this roughage could reduce its damage and the consequent loss of long particles, which at the moment imposes the inclusion of straw or other long fibre roughages in the TMR for rumination purpose.

Quality of the stockmanship

The main critical factor for beef cattle welfare to be considered when discussing the quality of the stockmanship is the human-animal interaction. A positive attitude of the stockperson in handling and taking care of the animals seems to improve cattle welfare. Specific training of farm crews should therefore be encouraged (Boivin *et al.*, 2003). Under intensive rearing systems, where a single stockperson is in charge of a large number of animals, the opportunity to build positive relationships between humans and animals is limited by the fact

that contacts are not frequent and they are usually associated with frightening practices for cattle such as in the case of medical treatments, prophylaxis or grouping etc. (Waiblinger *et al.*, 2006).

Knowledge of the ethologic patterns and social behaviour of cattle could be useful for the stockman in order to establish a trustful relation with its animals. Therefore, beef farmers should avoid regrouping the animals during the fattening period in order to keep the hierarchy unaltered and especially to maintain the dominant-subordinate relationships established within each pen (Boivin *et al.*, 2003; Bouissou and Boissy, 2005; Mounier *et al.*, 2006). On the contrary, good management practice should advise the quick transfer of sick, lame or recumbent bulls to an appropriate infirmary pen since their early separation from their healthy pen-mates avoids further stress and injuries from dominant aggressive animals.

Tail docking and other forms of surgical mutilation have been shown to cause fear, pain and distress in beef cattle (Mellor and Stafford, 1999) and therefore they should be avoided. Proper management decisions, such as the provision of a suitable feeding plan combined with adequate flooring and space allowance, have been shown to be effective preventive measures in reducing the incidence of tip necrosis and avoiding tail docking (Metzner *et al.*, 1994).

A good level of stockmanship quality should also include the protection of the animals against endo- and ecto-parasites and rodents, as well as the frequent cleaning of housing structures, mangers and waterers. Nowadays, official methods are available for the assessment of cattle body cleanliness (MAFF, 1998) and this measure, in addition to being an important trait for the evaluation of beef cattle welfare, could represent an effective tool in judging the quality of stockmanship.

Veal calf production in Italy

The veal calves reared and slaughtered in Italy cover about 70% of the total national demand for veal meat (Cozzi, 2007). The remaining 30% is satisfied by imported veal meat from Holland and France. The Italian production is based on the rearing of male calves from dairy breed, either domestic or imported from Poland, France and Germany. Prior to 2004 the traditional rearing system was characterized by the indoor housing of the calves in individual crates with about 1 m^2 of space allowance and by the provision of an all-liquid diet. The pale colour of the meat was the result of a low iron feeding plan along with the use of wooden facilities (Andrighetto *et al.*, 1999). This rearing system was similar to those adopted by the two other main European producers of veal meat: Holland and France. Isolation, reduced space allowance and the lack of solid feeds were considered the main critical issues of this rearing system negatively affecting calves behaviour, welfare and health (Broom, 1991; Le Neidre, 1993). These negative factors led to the draft of specific European Council Directives (91/629/EEC and 97/2/EC) with the mandatory introduction of the group housing and the provision of fibre feeds in addition to the liquid diet.

Today, 90% of Italian farms raise veal calves in small groups housed within closed barns in pens with wooden or concrete fully slatted floors. In these pens, the milk replacer is administered individually in buckets or in a common trough, while solid feeds are provided using the same trough or a separate manger. The use of automatic feeding systems for large groups of calves is less frequent and it is adopted only by 10% of the Italian fattening units. Despite these changes adopted in the production system, several risk factors for the inadequate level of welfare in calves can still be identified

at the farm level in Italy, as well as in the other European Countries.

Environmental resources and calf welfare

There is no doubt about the improvement in calves welfare resulting from group housing since animals now have the opportunity to move freely and perform social behaviours such as playing and grooming (Verga *et al.*, 2000; Babu *et al.*, 2004). Moreover, calves in groups reduced the frequencies of abnormal behaviours, such as tongue-playing, which are indicators of social deprivation, coping stress or nutritional and environmental deficiency (Andrighetto *et al.*, 1999). Calves responded positively to this improved environment since their growth performance did not worsen as a result of the increased energy expenditure required for locomotion (Andrighetto *et al.*, 1999; Xiccato *et al.*, 2002). However, there is still some concern about the space allowance given to each calf by the regulation in force (1.5 m^2/head for calves up to 150 kg of live weigh, 1.7 m^2 per animal weighing from 150 to 220 kg and at least 1.8 m^2 per each animal above this weight). From an ethological point of view, space should be sufficient to allow grooming, turning around and comfortable resting with two or more limbs stretched out by all the pen-mates (Broom, 1991). Nowadays, there is a lack of scientific information about this issue as stated by EFSA (2006) in a recent scientific report. It has been recently demonstrated that the access to an outdoor pen improved growth performance of veal calves during winter in comparison to animals kept indoors. However this positive effect was not observed in the summer (Morel and Schick, 2004).

Regarding the type of floor, wooden slats offer better thermal comfort than concrete slats during the cold season, but they must not be slippery, too hard or splintery to change the locomotion behaviours of the animals or cause lesions. Consistent with more adult cattle, there are opinions that the inclusion of a resting area with permanent bedding could improve veal calf welfare. However, no specific scientific indications are available about the size of this area and the type of bedding material to be used.

The number of animals per pen may be another critical point for calf welfare because of the greater antagonistic behaviours observed in overcrowded pens. The correct choice for this parameter should be based on the pen size but mainly on the feed supply system. In fact, when animals are bucket-fed pen size seems to lose importance if an adequate space is provided to all the pen-mates (Gottardo *et al.*, 2005). On the contrary, in the automatic teat-based milking systems, in addition to the space per calf, there must be an adequate ratio between the number of teats and the number of pen-mates. Commercially available computerized calf feeders are typically set with one teat serving more than 20 calves. Results by Von Keyserlingk *et al.* (2004) have shown that this practice may cause increased competition among calves, reducing feeding time and milk intake. Consistent with these findings, calves fed by computer-controlled milk feeders showed more frequent aggression and displacement around the feeding station, as well as a high occurrence of cross-sucking (Jensen, 2003).

Depending on its size, the pen design should also consider the presence of one or more drinking points since calves have been shown to consume a considerable amount of water in addition to the milk replacer diet (Ruis Heutinck and Van Reenen, 2000). Gottardo *et al.* (2002b) observed that drinking water did not cover a shortage in calves' water requirement, but it acted more like an environmental enrichment preventing

the arousal of nonnutritive oral behaviours. The provision of drinking water is particularly advisable now that calves are fed small amounts of solid feeds for welfare purposes, especially during the warm season.

Air temperature and humidity should be appropriate to give calves suitable thermal comfort. For this reason, dedicated cooling systems are necessary especially during summer in the hot and humid climate of northern Italy, where the majority of the veal farms are located. Air quality is noteworthy for epidemiologic issues; indeed the presence of draught is related to a lower incidence of calves suffering from infectious diseases (Lungborg *et al.*, 2005). Draught is useful as well in maintaining the air ammonia levels below the maximum critical threshold of 20 ppm in these housing systems where the liquid manure accumulates underneath the pen floor. Results by Lungborg *et al.* (2005) have shown that the dangerous air ammonia concentration for calves is much lower since values below 6 ppm were associated with an increased risk for respiratory diseases. However, air speed should not exceed 0.2 m/s because calves exposed to high-speed draughts showed a higher risk for respiratory sounds (Lungborg *et al.*, 2005).

Like beef cattle farms, calf fattening units in Italy generally lack dedicated moving and loading facilities leading to similar consequences for animal health and welfare, carcass and meat quality and stockmen safety.

Blood haemoglobin level

Low iron dietary supply is a prerequisite for the production of veal calves and blood haemoglobin is used to predict the meat colour since it is highly correlated with muscle myoglobin. In order to assure an adequate paleness of the meat and to guarantee acceptable calf health, the threshold of acceptance for this blood parameter was set at a minimum of 4.5 mmol/l (European Council Directive 91/629/EEC and 97/2/EC). The locomotion allowed by group housing has been shown to stimulate erythro-poiesis (Reece and Hotchkiss, 1987; Andrighetto *et al.*, 1999). Increased haemoglobin levels have been measured with the provision of some solid feeds like cereal-straw pellets or dried beet pulps (Morisse *et al.*, 1999; Cozzi *et al.*, 2002a) and with the administration of milk replacers in which milk powder was substituted with vegetable sources (Andrighetto *et al.*, 1996). All these results explain the reluctance of many producers to the introduction of the EU regulations since the market is still paying premium prices for whiter meat. Veal calf production is therefore a clear example of the need for parallel consumer education in order to allow a winning introduction of welfare friendly rearing systems for farm animals.

Solid feed provision

In order to fulfil the physiological and behavioural demands of the calf European Council Directive 97/2/EC dictates that calves must be provided with increasing amounts of fibrous feed from 50 g/head/d at 8 weeks of age to 250 g/head/d at 20 weeks, in addition to the regular liquid diet. Several studies have indeed demonstrated that the addition of a roughage source to the traditional liquid diet reduced abnormal oral behaviours (Vessier *et al.*, 1998; Morisse *et al.*, 1999; Mattiello *et al.*, 2002; Di Giancamillo *et al.*, 2003), promoted normal development of the rumen and its papillae (Morisse *et al.*, 1999, 2000) and increased rumen motility and therefore it was likely the reason for the reduced number of hair balls (Morisse *et al.*, 2000; Cozzi *et al.*, 2002b). However the quality of the fibrous sources must have

adequate roughness and particle size. Fibrous feeds that are too rough may increase the incidence of lesions in the walls of the abomasums or if not adequately grounded they can worsen abomasal erosions, ulcers and scars (Cozzi *et al.*, 2002b, Mattiello *et al.*, 2002). On the contrary, an inappropriate length of the roughage may have a limited capacity to stimulate rumination (Morisse *et al.*, 2000). Considering the fore-stomach development, supplementing concentrates differing in carbohydrate composition to veal calves increased the empty rumen weight but it enhanced the incidence of coalescing rumen papillae (Suárez *et al.*, 2006).

The quality of the liquid diet should be controlled by a periodic chemical analysis of the milk replacer and by a regular on-farm check of the temperature at the time of its administration. This latter practice has been shown to reduce the risk of occurrence of diarrhoea (Lungborg *et al.*, 2005).

Human-animal interaction and management

Scientific evidence has proved that veal calves benefit from a positive attitude of the stockman (Boivin *et al.*, 2003). The disease level was lower in calf fattening units where the farmer behaved sympathetically towards the calves and had a positive attitude towards the importance of cleaning (Lensink *et al.*, 2001b). Calves receiving positive human contact during the rearing period were less fearful when approached by known or unknown people (Lensink *et al.*, 2000) and during handling and transport (Lensink *et al.*, 2001a).

Continuous fear causes stress and it is negatively related to welfare (Raussi *et al.*, 2003). Animals should be used to humane presence, vocal interactions, physical contact and they should be rewarded by feeding (Waiblinger *et al.*, 2006). The establishment of positive human-calf interaction is likely to render less stressful invasive routine practices such as blood collection for haemoglobin control.

Farm management decisions can affect calf welfare, as in the case of the choice of the feed supply system for small groups. In comparison to the trough, bucket-feeding assures the individual control of milk intake for all the pen-mates. However, this system is more time consuming and labour intensive for the stockman. On the contrary, trough feeding amplifies drinking competition at meal times leading to the exacerbation of the dominant-subordinate relations. Repeated regrouping is therefore necessary to limit the inhomogeneous growth of the entire batch. Unlike more adult cattle (Raussi *et al.*, 2005), a study by Veissier *et al.* (2001) observed that this practice did not impair calves' health and growth. However, the same authors suggested carefully applying this finding to commercial farms in which rearing conditions are different from those adopted in their research.

As is the case on beef farms, good management of the calf fattening units should pay attention to the cleanliness of animals as well as of housing and feeding facilities, in order to protect calves from parasites and rodents.

Conclusions

Italy still has a prominent position in the European scenario of beef cattle and veal calf production. But the maintenance of a significant domestic production requires the identification and adoption of effective solutions capable of overcoming the present critical factors for the welfare of these animals. At least for beef cattle farms, these solutions should be tailor made to the existing systems of production, which are not always similar to those of other European countries.

Therefore, Italian beef producers should build a strong partnership with the scientific community in order to support future improvements with robust scientific knowledge, which is required today by the official institutions.

The present review has discussed several cattle welfare limiting issues related to the farm environment and facilities that will mostly be solved by future advances in farm technology and engineering. A more difficult step will be the achievement of significant improvement in the skills of stockmen as respects the adoption of welfare friendly farm practices.

The success of any further improvement in farm animal welfare is, however, strongly dependent on two factors. First of all, farmers must consider the adoption of welfare friendly practices as an opportunity to increase their net income. Secondly, proper consumer education towards the purchase of welfare friendly beef and veal meat appears the strongest tool to drive the entire productive chain to the welfare target.

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