Topic 1
"Safety in agricultural building and livestock"

Oral Presentation

Ammonia and Greenhouse Gases Concentration in Relation to Daily Routine Operations in Laying Hens Houses

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Abstract
In livestock houses, ammonia, greenhouse gases and particulate matter represent the main pollutants that can adversely affect the health status of animals and men working in animal husbandries. All these pollutants can reach high concentrations during the routine management operations performed by farmers, for example, following the litter removal. The aim of this work was to study ammonia, and CO_2, CH_4 and N_2O concentration during daily routine cleaning like litter removal in different housing systems for layers, a battery system with pit under cages and a scraper to remove manure (BSP) and an aviary system house (ASH). Data were collected for the 60 % of the cycles during a whole year. The same happened for methane concentration (4.33 mg m^{-3} in the BSP house vs 3.06 mg m^{-3} in the ASH house). Nevertheless, in the ASH, during and after litter removal, the methane concentration reached the value of 16.49 mg m^{-3}. The remarkable variation of these pollutants concentration that usually took place in the ASH during routine daily cleaning highlights how this layers house, even if endorsed by EU rules on animal welfare and that will be widespread in Europe in future, cannot guarantee a healthy working environment for operators, taking also into account the cumulative effects of noxious compounds like dust and ammonia.

Keywords: layers houses, ammonia, greenhouse gases, cleaning operations

Introduction
Workers and animals in hens units are exposed to a wide range of airborne contaminants that cause respiratory irritation and sensitization (Katila et al., 1981). The most important gases generated by animal facilities are ammonia (NH_3), greenhouse gases (GHG) as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Philippe et al., 2007). Gaseous NH_3 is the predominant pollutant gas in poultry production operations, it can also adversely affect bird performance and welfare and men's health (Andreasen et al., 2000, Donham, 1991). Ammonia is generated by the microbial decomposition of uric acid in bird faeces, its emission is of environmental concern because it contributes to soil acidification and increased nitrogen deposition in ecosystems. Carbon dioxide is considerably produced by respiration and manure fermentation. However agriculture is also a CO_2 consumer through plant photosynthesis, this gas contribution to the greenhouse effect is less important than that of CH_4 and N_2O, whose warming potentials are, respectively, 21 and 310 times that of CO_2 (Intergovernmental Panel on Climate Change, 2007). Methane is generated from anaerobic bacterial decomposition of organic compounds present in feed and excreta and it is emitted both as by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms in the animal digestive tract (mainly in ruminants), and from the decomposition of manure under anaerobic conditions, increasing with the Volatile Solids content of the excreta. N_2O is emitted from manure as an intermediate product of nitrification/denitrification

processes under condition of low oxygen availability which normally convert ammonia into inert dinitrogen gas, also it contributes to the ozone shield destruction. Dust, or particulate matter, represents another important aerial contaminant in animal houses, since it can combine with inorganic compounds, gases, bacteria and viable endotoxins, that fixed on dust particles surface, can become potentially hazardous agents (Hartung, 2002).
The aim of this study was to evaluate the concentration of ammonia, greenhouse gases and dust (PM_{10}) in two types of laying hens houses, with a particular interest to the variation in pollutant concentrations occurring during daily routine operation.

Materials and methods

Farms location

The measurements were taken in two commercial laying hen units located in Northern Italy in the same farm. The monitored techniques were:

1. Battery system with pit under cages and a scraper to remove manure (BSP)
2. Aviary system house (ASH)

<u>Battery system with pit under cages and a scraper to remove manure (BSP).</u>
The house, with 11.000 hens lodged, is 14m wide x 70 m long. The house is ventilated by 4 fans of 1.16 m of diameter, positioned on one of the two longitudinal walls, the maximum ventilation rate is 42000 $m^3 h^{-1}$ for each fan.

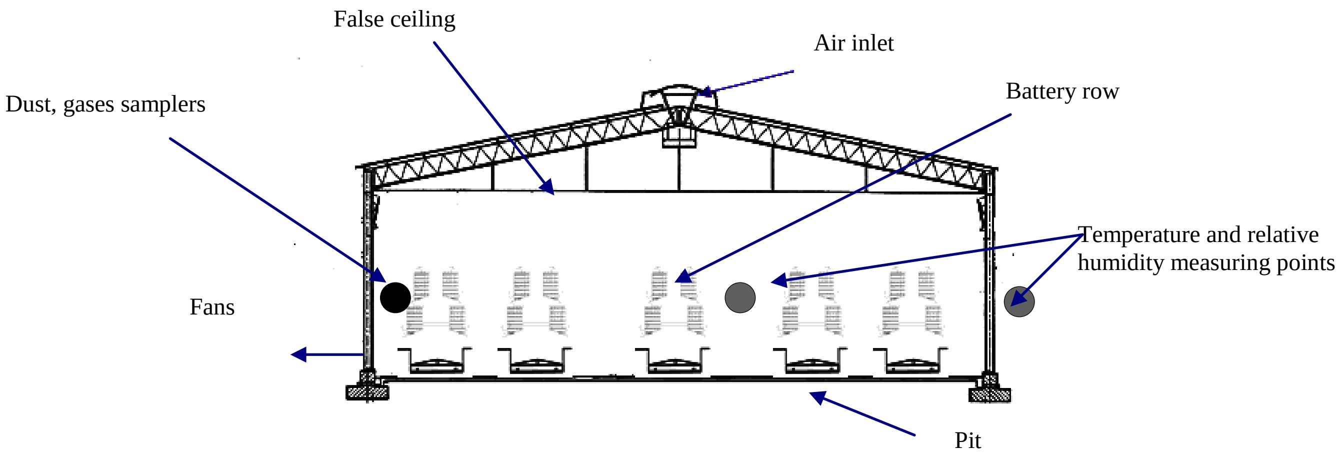

Figure 1. Cross section of the battery system house

The air is collected from the roof, insulated by polystyrene sheets, enters the house through a continuous longitudinal ridge chimney. The ventilation program is computer controlled and based on thermostatic regulation (the first group of fans are active for the minimum ventilation level, when temperature is higher than 15.4 °C, the second group switched on when temperature inside the barn was equal or greater than 22°C). Daily routine inspections and cleaning procedure were performed from 8.00 AM to 10.00 AM.
This conventional type of laying hens house in 2013 will be eliminated as a consequence of the application of European laws on Animal welfare.
<u>Aviary system house (ASH).</u>
The house, with 7500 hens lodged is 14m wide x 70 m long, is ventilated by 4 fans of 1.16 m of diameter, positioned on one of the two longitudinal walls, the maximum ventilation rate is 42000 $m^3 h^{-3}$ for each fan.

As in the previous housing system, the air is collected from the roof, insulated by polystyrene sheets, enters the house through a continuous longitudinal ridge chimney.

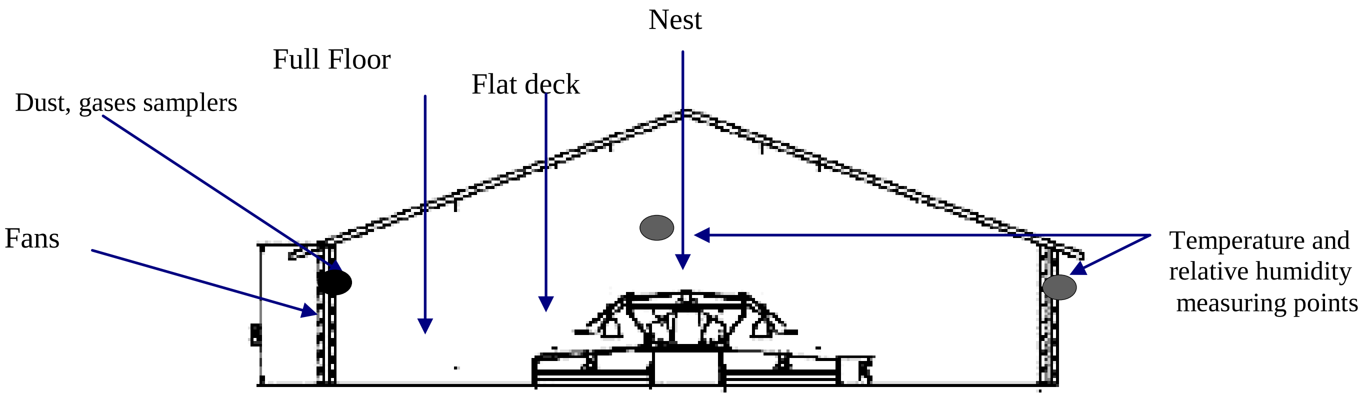

Figure 2. Cross section of the aviary system house

The ventilation strategy is computer controlled and based on thermostatic regulation (the first group of fans are active for the minimum ventilation level, when temperature is higher than 15.4 °C, the following groups are switched on when temperature inside the barn reaches 22°C). In this house hens are reared on the litter and flat decks at different levels. The nest for eggs deposition is located in the middle of the room. Daily routine inspections and cleaning procedure were performed from 10.00 AM to 12.00 AM.
This housing type is endorsed by EU rules on animal welfare.

Gases and dust concentration measuring equipment
NH_3, CO_2, CH_4 and N_2O concentrations were continuously measured in the exhaust ducts using an infrared photoacustic detector IPD (Brüel & Kjaer, Multi-gas Monitor Type 1302, Multipoint Sampler and Doser Type 1303) collecting data every 15 minutes.
In each of these facilities, the PM_{10} concentration was continuously monitored, with an acquisition interval time of one minute, using calibrated scatter light photometers (accuracy: ± 3 μg m^{-3}; EPAM 5000, HAZ-Dust; Environmental Devices Corporation, Plaistow, NH). Measurement were performed continuously, at least, for the 60 % of the period of the cycle, to include all the seasons of the year (Arogo et al., 2003). From the year of measurements, only data recorded in presence of no other activity than the usual daily routine, was kept for the study.

Ventilation rate and environmental parameters
The ventilation rate was monitored by recording the number of active fans, the air flow rate was measured for each fan in 9 different positions of its surface using a hot wire anemometer (BSV 105, LSI, Settala, Milano). Measurements were taken for each monitoring cycle (six times per year) for each ventilation step. The mean air flow rate was compared to the nominal ventilation rate to calculate the effective ventilation rate for each fan and the measurement error. The use of the hot wire anemometer allows an accuracy ranging from to 0.5 to 25 % in

checking the effective ventilation rate (Scholtens and Van 't Ooster 1994), in our study the measurement accuracy was calculated to be 5 %. The temperature and relative humidity were monitored constantly both inside and outside the houses, with dataloggers (Babuc M, LSI, Settala, Milano).

Results

Environmental parameters

In table 1, the results of the yearly monitoring in the three laying hens houses are shown, subdivided in the periods between November 2006 and May 2007 (I period), and June and November 2007 (II Period).

Table 1. Structural characteristics, environmental parameters and dust emission factors in the two laying hens houses

Building type		**BSP**		**ASH**	
	Monitoring period	**Period I**	**Period II**	**Period I**	**Period II**
Structural characteristics	Ventilation system	4 Exhaust fans in one of the two the longitudinal walls		4 Exhaust fans in one of the two the longitudinal walls	
	Number of animals	11.000		7500	
	Dropping removal system	Dip pit with a scraper to remove droppings		Litter, a belt in front of the nest removes droppings	
Inside Microclimate	Temperature °C;(min; max)	18.68 (11.24; 25.60)	19.31 (13.24; 27.32)	14.88 (9.72; 26.21)	21.42 (17.47; 26.53)
	Relative Humidity %, (min; max)	55 (24; 88)	56 (27; 86)	62 (28; 97)	46 (32; 58)
Outside Microclimate	Mean Temperature °C, (min; max)	12.41 (-1; 29)	19.34 (6.2; 32.3)	12.41 (-1; 29)	19.34 (6.2; 32.3)
	Relative Humidity %, (min;max)	66 (25; 99)	55 (25; 93)	66 (25; 99)	55 (25; 93)
Ventilation rate	Mean of the period $m^3 h^{-1}$	59481	65498	18892	72752

Legend:
Period I: November 2006 - May 2007, Period II: June 2007 - November 2007

Table 2. Pollutants concentrations in the two laying hens houses

	BSP						**ASH**				
Variable	**NH_3**	**N_20**	**CO2**	**CH_4**	**PM_{10}**	Variable	**NH_3**	**N_20**	**CO2**	**CH_4**	**PM_{10}**
Mean	3.88	1.53	2001	4.34	0.094	Mean	3.18	1.45	1920	3.07	0.215
Std.Dev	2.26	0.37	576	2.51	0.059	Std.Dev	1.49	0.53	885	32.22	0.262
Minimum	1.07	0.60	717	0.68	0.001	Minimum	0.47	0.00	678	0.65	0.001
Maximum	30.00	2.54	3160	34.70	0.844	Maximum	13.60	3.12	5360	34.00	11.837

Gases Concentration

As shown in Figure 3, in the two houses, ammonia concentration showed a similar trend during the day, with a minimum in both concentration at 3.00 PM, as expected, also for the increase in ventilation rate in the warmest part of the day.

During the morning, gaseous ammonia concentration raised in correspondence with increased animal activity and routine cleaning procedure. In the ASH house, mean value of ammonia concentration was lower in comparison with the BSP house, (3.88 mg m^{-3} vs 3.18 mg m^{-3}), in agreement with literature (Fabbri et al., 2007), also the maximum values registered during workers inspections from 10.00 AM to 12 AM was lower (30 mg m^{-3}vs 13.6 mg m^{-3}).

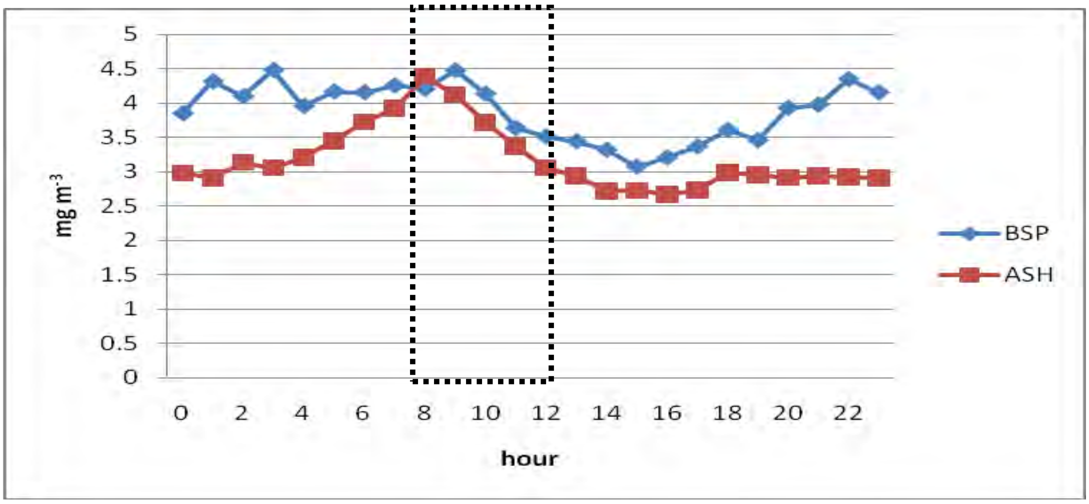

Figure 3. Daily ammonia concentration in the two hens houses

Yearly mean methane concentration, was 4.33 mg m^{-3} in the BSP house vs 3.06 mg m^{-3} recorded in the ASH house.
In the ASH house, from 10.00 to 12.00 AM, corresponding to workers inspection time, methane concentration reached a mean value of 16 mg m^{-3}.

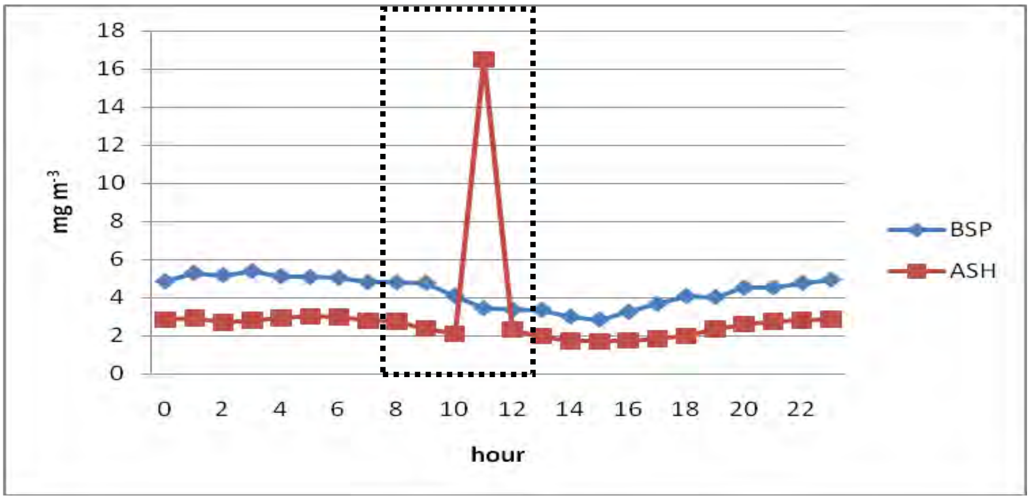

Figure 4. Daily methane concentration in the two hens houses

Yearly mean nitrous oxide concentration was lower than 1.53 mg m^{-3} in both hens houses, it reached a mean hourly value of 1.73 mg m^{-3} in both houses at around 8.00 AM and declined during the afternoon in a remarkable way in the ASH.

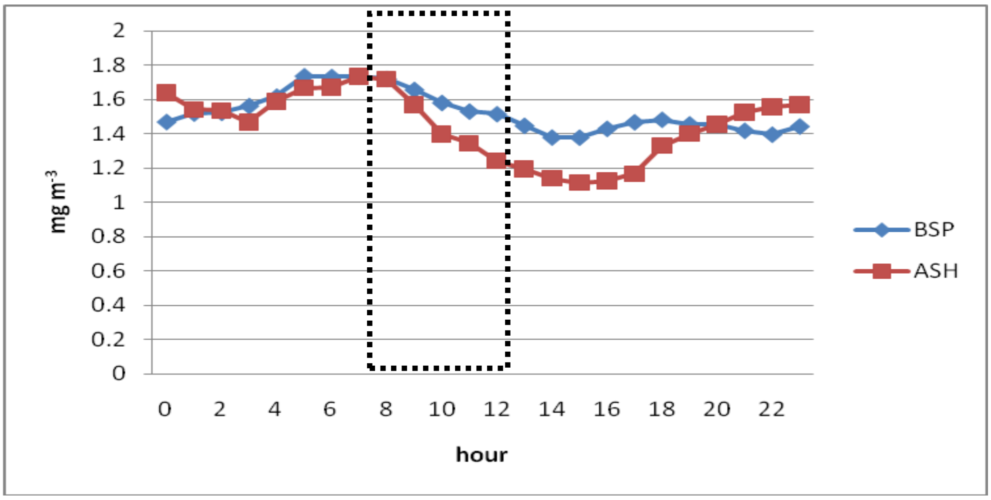

Figure 6. Daily nitrous oxide concentration in the two hens houses

Carbon dioxide showed a similar trend, with higher concentrations (around 2200 mg m^{-3}) in both houses during the first hours of the day, characterized by the beginning of animal activity and low ventilation rate.

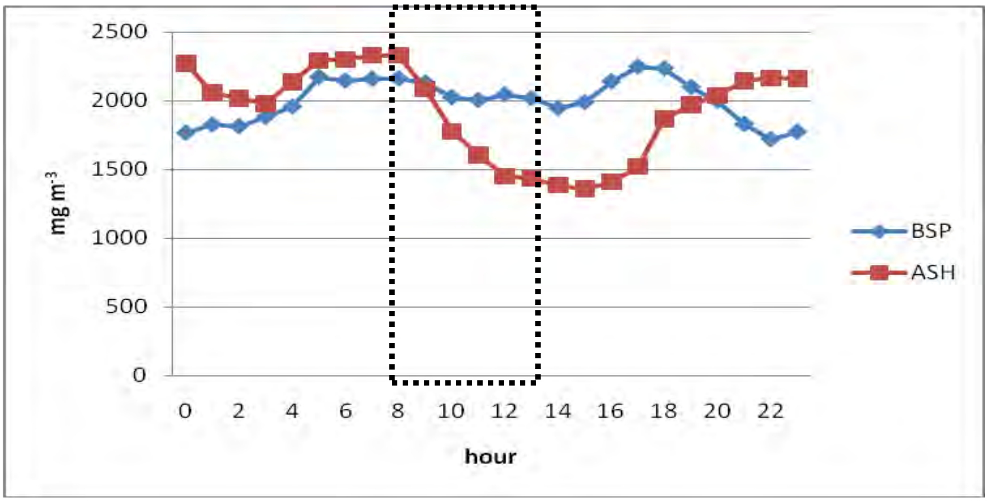

Figure 6. Daily carbon dioxide concentration in the two hens houses

Mean yearly PM_{10} concentration was remarkably higher in the ASH with 0.215 mg m^{-3} vs 0.094 mg m^{-3} for the traditional battery cages house, with appreciable peaks of dust concentration during the morning, together with the increased animal activity (Costa et al., 2009) and daily farmer operations.
Table 2, that reports mean, standard deviations, maximum and minimum values of pollutants, shows the high variability occurring during the 24 hours in both layers houses, an example of the trend of gases concentration in the ASH is reported in Figure 7.

This study evaluated the variation occurring in ammonia, GHG gases and dust concentration in a conventional housing system (BSP) that, in 2013 will be eliminated as a consequence of

the application of European laws on Animal welfare, and in a layers house (ASH) endorsed by EU rules on animal welfare and that will be widely spread in Europe in future.
Methane and dust concentrations, even if lower as mean values in the ASH house, reached very high concentrations during the working time of men, and so dust, as shown in a previous work (Costa et al., 2009).
In both houses, in the presence of farmers during routine daily operations a high concentration of pollutants occurs: epidemiological studies conducted in United States, Denmark and Canada demonstrated a greater prevalence of respiratory symptoms such as shortness of breath, chronic bronchitis, wheezing, and cough among workers and animals than in unexposed controls (Porterjoie et al., 2002; Katila et al., 1981).
ACGIH recommends a threshold limit value (TLV) of 25 mg m^{-3} a short-term exposure limit (STEL) and 17 mg m^{-3} on a timeweighted average (TWA) to avoid irritation of the eyes, nose and throat.
Ammonia, mainly generated by the enzymatic decomposition of urea from urine, at high concentration, can affect animal health and performance and is an important cofactor in the genesis of atrophic rhinitis and enzootic bronchopneumonia (Hamilton et al., 1996).
CIGR (1984) recommended a maximum ammonia concentration of 14 mg m^{-3} while Urbain et al. (1994) and Portejoie et al., (2002) indicated the ammonia threshold of 10 mg m^{-3} for irritations to the respiratory tract, while Gerber et al., (1991) indicated a human-related limit value of 5 mg m^{-3}.
Mean yearly methane concentration, although lower in the BSP house (3.06 mg m^{-3} vs 4.33 mg m^{-3}), in the ASH reached the mean value of 16.49 mg m^{-3} during routine cleaning operations and 34 mg m^{-3} during litter removal.

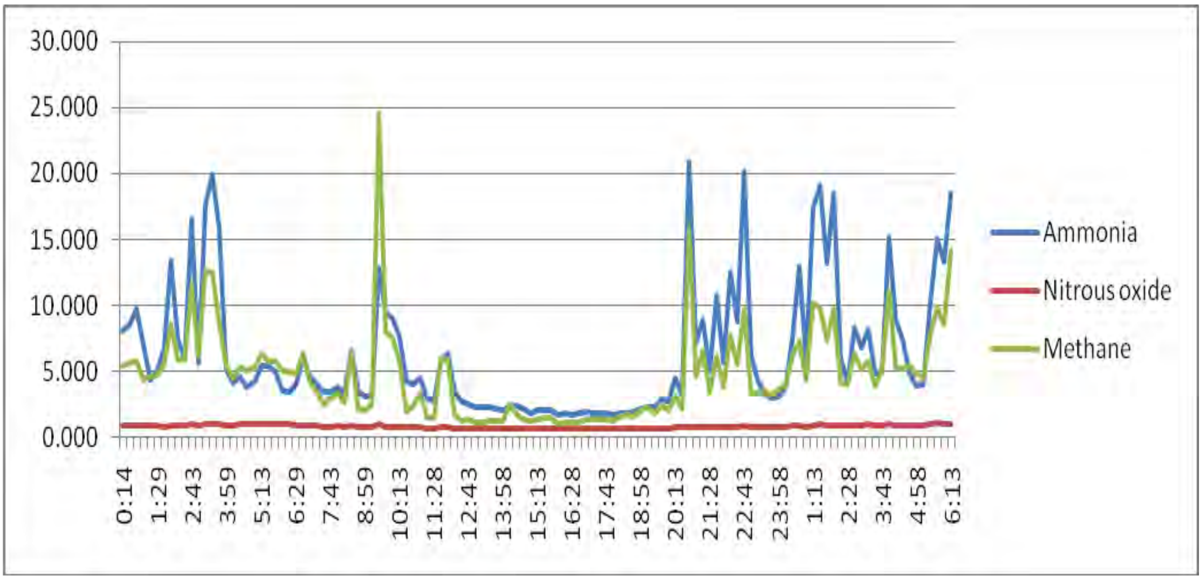

Figure 7. Example of gases concentration in the ASH during one day in July

In fact, for laying hens the CH_4 enteric fermentation emissions are expected to be negligible and the emission from manure management are connected with lack of oxygen in the stored manure.
Generally, methane could be taken as an indicator of good management practices adopted by the farmer, hence it is evident how the droppings removal procedure in this animal house

represent a risk for health and is not suitable for air quality inside and outside the animal building.

Conclusions

The remarkable variation of pollutants concentration that usually took place in the ASH during routine daily cleaning highlights how this layers house, even if endorsed by EU rules on animal welfare and that will be widespread in Europe in future, cannot guarantee a healthy working environment for operators, taking also into account the cumulative effects of noxious compounds like dust and ammonia.

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Industrialization of Dairy Operations: Ergonomic Implications

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Abstract

The industrialization of dairy production has led to increased occupational risk of musculoskeletal disorders among parlor workers. Questions arise regarding the effects of the work and the environment on the worker. The purpose of this project was to investigate musculoskeletal symptoms among large-herd dairy parlor workers, and asses ergonomic risk exposures involved with large-herd parlor milking operations. Musculoskeletal symptom surveys were adminstered to large-herd dairy parlor workers. In addition, full-shift direct measurements of exposures to muscle force and postures were taken involving the upper extremity and trunk. Preliminary results indicate 79% of large-herd dairy parlor workers experienced job-related pain in the previous 12-month period. Data also showed the highest percentages of reported job-related pain are in the feet, upper back, shoulders and wrist. Workers rated "continuing to work when injured or hurt" and "working in hot, cold, wet, humid conditions" as the two most problematic job-features associated with parlor milking. Full-shift electromyography results revealed mean peak loads of 57.8% of maximum voluntary contraction (MVC) of the flexor forearm musculature and 48.5% of MVC of the anterior deltoid. Full-shift exposure variation analysis results revealed 94% of myoelectric activity in both flexor forearm and anterior deltoid musculature was 1 second or less in duration, indicative of highly repetitive activities. Preliminary findings suggest large-herd parlor workers may be exposed to upper extremity risk factors (extreme posture, repetition, high muscle loads) associated with the development of musculoskeletal disorders.

Keywords: dairy, industrialization, ergonomics, parlor

Introduction

Over the past decade, the US dairy industry production profile has changed dramatically to more efficiently produce dairy products to meet higher consumer demands. From 1989 through 2009, the number of US milking operations decreased by 68%, while during the same period milk production increased by 32%. Increased US milk production in conjunction with a decreased number of milking operations has been driven by increased milking herd sizes. Small herd operations (<500 head) operations continue to diminish whereas large herd (500+ head) operations continue to rise (Douphrate, et al.,2009). In 1998, nearly 70% of milk produced in the US came from small herd operations. By 2009, over 60% of milk produced in the US came from large herd operations, and 31% came from operations of 2,000 head or more (NASS,2009). These changes have led to significant shifts in work tasks resulting in exposures to high repetition, forceful muscle exertions, a fast work pace, and a specialization of labor. The industrialization of dairy production has led to increased occupational risk of musculoskeletal disorders (MSDs) among parlor workers. Questions arise regarding the effects of the work and the environment on the worker, as well as the acceptable comfort and safety in the different milking systems, when considering the higher cow throughput rates and the greater size of the herds being milked. Work demands are increased in large-herd dairy operations due to large numbers of cows being milked per unit time compared to a small-herd operation. Modern large-herd milking systems may increase the physical workload and thus have an effect on the development of MSDs in the neck, shoulder, wrist and hand. More focused research should investigate milking practices and parlor designs as they relate to worker safety and health. Additional research is vital given the trend towards large industrial milking operations.(Douphrate, et al.,2009) The purpose of this multi-faceted project was to investigate musculoskeletal symptoms among large-herd dairy parlor workers, and asses ergonomic risk exposures involved with large-herd parlor milking operations.

Methods

Symptom Survey

An ongoing 4-year investigation involves the administration of symptom surveys to assess musculoskeletal symptoms among large-herd dairy parlor workers. A modified Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka, et al.,1987) was administered to parlor workers on dairies with milking herd sizes of 500 head or more. In addition to the standardized NMQ items, additional questions addressed dairy parlor work environment factors. The questionnaire was administered on-site by a bilingual dairy veterinarian through a structured interview to insure high response rates, completeness and accuracy.

Muscle Force Exposure

Surface electromyography (EMG) was used to assess force used by the forearm flexors and extensor muscles during the performance of milking tasks. Myoelectric activity was recorded unilaterally from the flexor digitorum superficialis (flexor forearm) extensor digitorum (extensor forearm), anterior deltoid (upper arm flexor), and upper trapezius (shoulder stabilizer and elevator). The EMG electrodes were positioned on the skin above the muscles according to standard placement procedures (Zipp,1982). Electrodes were bipolar, differentially preamplified with a gain of 1000, and bandpass filter the input EMG signals (bandwidth 20 Hz – 460 Hz) to minimize motion artifacts and high frequency noise. Electrodes were dry (i.e., do not require electrode gel), reusable, and produced negligible noise ($\leq 5\ \mu V$). In addition, a reference electrode was positioned over the clavicle on the opposite side of the body from which the EMG electrodes are placed. Postural data was collected from each worker for an entire workshift and was then downloaded for analysis. A Spanish speaking dairy veterinarian was present during data collection for translation support.

Posture Exposure

Investigators used a self-recording inclinometer for the assessment of postural tilt (shoulder elevation and trunk inclination). The device utilized was a datalogger with 2 Mb of built-in memory called the Virtual Corset (MicroStrain, Inc; Williston, VT) which non-invasively and continuously collected postural exposures in two dimensions. The pager sized Virtual Corset was mounted to the posterior aspect of each upper arm, mid-way between the shoulder and elbow. A third was mounted to the posterior trunk at the level of the eighth thoracic spinous process. Postural data was collected from each worker for an entire workshift and was then downloaded for analysis. A Spanish speaking dairy veterinarian was present during data collection for translation support.

Results

Symptom Survey

To date, a total of 403 surveys have been administered to large-herd parlor workers representing 30 dairies in six western US states. Preliminary results indicate 79% of large-herd dairy parlor workers experienced job-related pain in the previous 12-month period. However, only 6.7% reported having a pain that prevented the performance of milking tasks in the previous 12 months, and only 7.1% report seeing a physician to address their job-related pain in the previous 12 months. These findings suggest an underreporting of job-related injuries among large-herd parlor workers. Preliminary data also showed the highest percentages of reported job-related pain are in the feet, upper back, shoulders and wrist. Teat stimulation and cluster attachment are the two most difficult milking tasks. Researchers investigated specific job features associated with the development of job-related pain or injury by asking parlor workers to evaluate the most difficult job features associated with parlor milking on a 0-10 Likert scale. Workers rated "continuing to work when injured or hurt" and "working in hot, cold, wet, humid conditions" as the two most problematic job-features associated with parlor milking.

Muscle Force and Posture Exposures

Full-shift EMG Amplitude Probability Distribution Function (APDF) results revealed mean peak loads of 57.8% of Maximum Voluntary Contraction (MVC) of the flexor forearm musculature and 48.5% of MVC of the anterior deltoid. Full-shift Exposure Variation Analysis (EVA) results revealed 94% of myoelectric activity in both flexor forearm and anterior deltoid musculature was 1 second or less in duration, indicative of highly repetitive activities. Based on studies of muscular endurance during constrained static and dynamic work, Jonsson (1982) recommends muscle contraction force peak loads should not exceed 50% of MVC to reduce risk for muscular injury. Full-shift shoulder posture EVA revealed nearly 40% of the workshift involved the shoulder being elevated greater than 45 degrees. Silverstein (2008) reported upper arm flexion $\geq$ 45 degrees $\geq$ 15% of time combined with forceful exertions or forceful pinch to be a significant risk factor for development of rotator cuff syndrome.

Conclusions

The industrialization of dairy production in the US has led to increased occupational risk of the development of musculoskeletal disorders among large-herd parlor workers. Preliminary findings from the current studies suggest large-herd parlor workers may be exposed to upper extremity risk factors (extreme posture, repetition, high muscle loads) associated with the development of musculoskeletal disorders. Continued ergonomic research is needed to further quantify these exposures to facilitate the development of cost-effective ergonomic intervention strategies.

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Livestock Handling Injuries in the United States

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Abstract
Studies have demonstrated that nonfatal injury rates are elevated on farms with animals, especially beef and dairy farms. Additionally, in the U.S. livestock-related injuries account for the highest rate of lost work days. Few studies have addressed specifically animal-related injuries on farms. The objectives of this study were to analyze U.S. workers' compensation data to determine the costs, consequences and contributing factors associated with livestock-handling injuries. Methods: Workers' compensation injury claims data from the State of Colorado in the United States were used to analyze livestock-handling injuries. A ten-year (1997-2006) claim history was used for analysis. Results: A total of 1,114 livestock-handling claims were analyzed. Riding horseback, sorting/penning cattle and livestock-handling equipment represented higher proportions of livestock-handling injuries among cattle/livestock raisers and cattle dealers. Among dairy farms, 31.1% were caused by livestock. Among all injury causes that were classified as high cost (≥$5,000 USD), livestock -handling injuries represented the highest proportion in all three sectors. Livestock-handling injuries also represented the highest percentage of high severity injury claims. Milking parlor tasks represented nearly 50% of injuries among dairy workers. More specifically, 21% involved the worker being kicked while performing a milking task and 10% involved the worker attaching a milking unit to a cow's udder when he/she was kicked. In addition, 8% of claims indicated the worker was stepped on while performing a milking task.

Keywords: livestock handling, dairy, injury costs

Introduction
Because of the increasing mechanization of farms over the past half century, and the high fatality rate associated with injuries due to machinery and tractors (Cole et al., 2006; Carlson et al., 2005; Bernhart and Langley, 1999; Lee et al., 1996; Etherton et al., 1991; Hopkins, 1989; McKnight and Hetzel, 1985), most studies of agricultural injuries have focused on those related to interactions with machinery or tractors. Animal-related injuries are also an important occupational hazard in agriculture. Animals may bite, kick, scratch, trample, crush, gore, buck or throw, or drag the livestock-handler. Studies demonstrated non-fatal injury rates are elevated on operations with livestock, especially beef and dairy cattle (Nordstrom et al., 1995; Zhou and Roseman, 1994; Brison and Pickett, 1992; Pratt et al., 1992). Researchers have reported that up to 33% of injuries on the farm are caused by animals (Sprince et al., 2003; Lewis et al., 1998; Layde et al., 1995; Nordstrom et al., 1995; Pickett et al., 1995; Zhou and Roseman, 1994; Brison and Pickett, 1992; Pratt et al., 1992; Myers, 1990; Hoskin et al., 1988) and livestock-related injuries account for the highest rate of lost work days (Thu et al.,

1997). The purpose of this study was to determine the costs, consequences and contributing factors associated with workers' compensation (WC) livestock-handling injury claims among dairy farm, cattle/livestock, and cattle dealer workers in the U.S. State of Colorado.

Methods

Colorado's largest WC insurer, provided the data used in this study. Colorado statute requires any business with one or more employees to maintain a policy of workers' compensation insurance. According to the Colorado Workers' Compensation Act, injured workers must make a written report to the employer within four days of the injury event. Within the next 10 days the employer must submit a First Report of Injury to the WC provider. According to the 2002 Census of Agriculture (NASS, 2002), there were 31,369 farms in Colorado.

Workers' compensation benefits include payment for medical expenses, wage-replacement, permanent impairment or disfigurement, and death benefits. Medical benefits include payment for all expenses associated with physician visits, hospital treatments, rehabilitation, diagnostic testing, and prescription medications. Wage-replacement benefits (indemnity) include payment for lost wages, up to two-thirds of the injured worker's normal hourly wage earnings. An injured worker is eligible for indemnity benefits after three lost days of work due to injury.

A ten-year claim history of injuries occurring from the period January 1, 1997 through December 31, 2006 was analyzed. All 12-month policies were included in the dataset, including those that did and did not have reported injuries. All injury claims were closed. Claims data represented Colorado dairy farm, cattle dealer, and cattle/livestock raising occupations. The claim dataset included details concerning each injury: the nature of injury; body part(s) affected; source of injury; cause of injury; demographic characteristics of the employee (age, gender, work experience); policy holder payroll; risk classification code; medical expense; indemnity paid (if any); days of paid indemnity; and a narrative description of the injury event. Claims data were taken from the First Report of Injury for each injury claim. The First Report of Injury may be completed by the injured worker or by the foreman, supervisor, or business owner.

Agricultural work was defined in the study as agricultural production, including crops, livestock, and animal specialties, and agricultural services. A livestock-handling injury claim was defined as any unintentional work-related injury resulting from the performance of any livestock-handling related job task. Only claims accepted by the WC provider were analyzed. Injury severity was based on data provided for each injury claim; therefore no minimum level of injury severity was required for inclusion in the analysis.

Results

A total of 4,421 injury claims, representing 8,493 12-month policies were included in this study. The data set included 605 dairy farm policies, 7,083 cattle/livestock raiser policies and 805 cattle dealer policies in the 10-year sample period. The 2002 U.S. Census of Agriculture was referenced to provide an indication of the number of farms represented in the three class codes. According to the 2002 Census of Agriculture, 130 dairy farm, 306 cattle feedlot, and 2,386 beef cattle farm operators reported hired labor expense (NASS, 2002). The injury claim dataset included 67 dairy farm, 149 cattle dealer, and 730 cattle raising operation distinct policies for the same year.

The number of claims included 988 from dairy farms, 2,168 from cattle/livestock raisers, and 1,265 from cattle dealers. A total of 1,114 livestock handling claims were identified. Average annual claim incidence rates (injury claims per 100 workers) were highest for cattle dealers (10.3), followed by dairy farms (9.4) and cattle/livestock raisers (8.4). Livestock-handling claim rates were highest among all injury causes in all three sectors (2.9 for dairy farms, 2.7 for cattle dealers, and 1.8 for cattle/livestock raisers).

Livestock-Handling Injury Characteristics

Livestock was responsible for the highest percentage of claims in all sectors. Of total claims among dairy farms, 31.1% were caused by livestock. Livestock was responsible for 21.7 % and 26.6% of claims among cattle/livestock raisers and cattle dealers respectively. Falls or slips and strains represented the second and third highest proportion of injury causes among all three sectors. Contusions and injuries to the wrist, hand and fingers represented the highest percentages of injuries in all three sectors.

The average age of livestock-handling injury claimants among dairy farm workers was 32.2 years (range 18 to 67 years), and the average employment duration at the time of injury claim was 2.4 years. The majority of livestock-handling claims were made by males (88%), and by employees on farms employing 11 or more workers (87%). Ninety-eight percent of total dairy employment was represented by farms that employed 11 or more full-time equivalents. Workers between 25 and 34 years of age were 29% more likely to report a livestock-handling injury claim than all other injuries, and workers between 45 and 54 years of age were 58% less likely to report a livestock-handling claim than all other injuries.

The average age of livestock-handling claims among cattle/livestock raisers was 36.3 years (range 17 to 77 years), and the average employment duration at the time of injury claim was 2.5 years (range 0 months to 40.9 years). Female workers reported 44% more livestock-handling injury claims than all other injury causes. Workers between 25 and 34 years of age were 29% more likely to report a livestock-handling injury claim than all other injuries, and workers between 55 and 64 years of age were 45% less likely to report a livestock-handling claim than all other injuries.

The average age of livestock-handling injury claims among cattle dealers was 38.6 years (range 16 to 78 years), and the average employment duration at the time of injury claim was 3.4 years (range 0 months to 61.9 years). The majority of livestock-handling claims were made by males (92%), and by employees on farms employing 11 or more employees (67%). Ninety-six percent of cattle dealer total employment was represented by farms that employed 11 or more full-time equivalents. Workers employed by small operations reported 39% more livestock-handling claims than all other injury causes.

Claim Cost and Severity

One measure of injury severity is if the injury claim involved paid lost time (indemnity). Approximately 85% of dairy farm injury claims involved medical expenses only, while 71% and 75% of injury claims involved medical expenses only among cattle/livestock raisers and cattle dealers, respectively. Cattle/livestock raisers had the highest median paid days off work, followed by cattle dealers and dairy farm workers. On a per claim basis, median medical and indemnity costs per injury were lowest for dairy farm workers, and highest for cattle/livestock raisers. Median total (medical plus indemnity) cost per injury was lowest for dairy farm workers, and highest for cattle/livestock raisers.

Injuries were stratified by total cost (<$5,000 USD versus ≥$5,000 USD) and injury cause. Among all injury causes that were classified as high cost (≥$5,000 USD), livestock -handling injuries represented the highest proportion in all three sectors. Nearly 30% of dairy farm high cost injuries were livestock-handling related, while 23.7% and 27.3% injury claims were related to livestock-handling among cattle/livestock raisers and cattle dealers, respectively.

Injuries were also stratified by severity (<28 days of paid disability versus ≥28 days of paid disability), and injury cause. Livestock-handling injuries represented the highest percentage of high severity injury claims in all three sectors.

Contributing Factors

Narrative injury event descriptions were analyzed to further understand additional factors contributing to livestock-handling injuries. Of the 307 total livestock-handling injury claims among dairy farm workers, all event descriptions contained at least one identifiable factor. On average, event descriptions contained 3.2 contributing factors. Forty-eight percent of livestock-handling claims involved a milking task. More specifically, 21.2% of claims involved the worker being kicked while performing a milking task and 10.1% of claims involved the claimant being kicked while attaching a milking unit. In addition, 8.1% of claims involved the worker being stepped on while performing a milking task.

Thirty-eight percent of the claims among cattle/livestock raisers involved the worker riding a horse. Numerous work tasks were identified at the time of injury such as branding, ear tagging, horse training, calf birthing, hoof trimming, and vaccinating. More than 50% of descriptions mentioned a horse being responsible for worker injury. Nearly 20% of descriptions indicated the worker was injured when he/she was bucked or thrown off a horse and 15% of the event descriptions mentioned the worker was injured when the horse they were riding fell.

Twenty-seven percent of claims among cattle dealers involved horseback riding. Twelve percent of claims involved sorting/pinning cattle while on horseback. Nearly 12% of claims involved the worker being bucked or thrown off a horse. Pushing cattle, vaccinating, loading cattle into a trailer, processing cattle, birthing, and trimming hooves were among the more frequently mentioned job tasks. Nearly 38% of claims indicated a cow or calf was responsible for the worker's injury. Livestock-handling claims indicated various cow actions led to worker injury such as the cow kicked, stepped on, pushed, charged, or had run over the worker. Nearly 17% of claims mentioned a corral gate being involved in the injury event, and 9% of claims involved a cow kicking a gate into the worker. Five percent of claims involved a cow chute.

Conclusions

These data from one U.S. state WC provider provide unique descriptive information specific to dairy farms, cattle/livestock raisers, and cattle dealers in the state of Colorado that would not be found in national injury databases. Workers' compensation data has been used for analysis of work-related injuries and illnesses in previous studies (Douphrate et al., 2006; Hofmann et al., 2006; Villarejo, 1998; Cooper and Rothstein, 1995). Unlike previous studies of WC claims among agricultural workers, the present analysis focused on livestock-handling operations. This focus allowed for the investigation of workplace hazards that were specific to the livestock industry which may differ from the risk factors in other agricultural operations. The present study is the first to utilize WC data to specifically investigate agricultural livestock-handling injuries.

Nearly 50% of dairy farm livestock-handling injuries took place in the milking parlor. More focused research should investigate milking practices and parlor designs as they relate to worker safety and health. Additional dairy-related injury research is vital given the trend towards large industrial milking operations. Large-herd and "mega-herd" dairy operations will present new and challenging opportunities for developing effective safety interventions. Among cattle/livestock raisers and cattle dealers, livestock-handling injury prevention efforts should be directed at livestock-handling facility and equipment design. Livestock equipment and facilities should be designed to minimize worker exposures to livestock. All workers in agriculture who handle livestock should be knowledgeable of livestock-behavior and proper handling techniques. The present study determined that livestock-handling work injuries are a significant problem, more costly, and result in more time off work than other agricultural injury causes. Increased attention should be focused on livestock-handling injuries via continued research and safety intervention development.

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Sow's *Streptococcus suis* Deafness and Piglets Crushing Rate

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Abstract
Infections caused by Streptococcus suis are considered a global issue in the swine industry since they are associated with septicemia, meningitis, endocarditis and arthritis. Moreover, it is a zoonosis that afflicts people in close contact with infected pigs or pork-derived products. In this research, we aim to study the presence of S. Suis, type 2, as a possible cause of deafness, in farrowing sows, in relation to piglets crushing which is a major pre weaning mortality problem. From the analysis of sow's reactions to specific sounds we studied if deafness influences piglets early crushing and by counting the number of piglets crushed and investigating the presence of S. suis infection we search for a correlation towards this problem.From the deafness test 78 sows (30%) were classified as non-reactive and sampled for bacteriology. These sows had a 0.65 avreage-crushed piglets per nest while reactive ones had 0.38 ($P<0.05$). There appears to be a cross correlation between infection of S. suis, hypacusia and neonatal crushing. Our results show how infections of the inner ear can be a problem for the productivity in intensive pig farms. It is interesting to underline the high number of deaf animals that crush on piglets (30%) confirming the importance of auditive recognition of nests. Prophylaxis with vaccines or antibiotic treatment against S. suis type 2 seem to be a valuable help in avoiding chronic forms of hypacusia and meningitis and pre-weaning mortality rate.

Keywords: hypacusia, S. suis, crushing

Introduction

Infections caused by Streptococcus suis are considered a global issue in the swine industry since they are associated with septicemia, meningitis, endocarditis and arthritis. Moreover, it is a zoonosis that afflicts people in close contact with infected pigs or pork-derived products. From the 35 capsular serotypes currently known, the 2 is considered as the most virulent and frequently isolated in both swine and humans causing causing severe disease outbreaks in swine herds (Wisselink et al., 2000). Different experimental models have been used to elucidate the infection but central parts of the pathogenesis still remain unclear (Gottschalk &Segura, 2000). In spontaneous infection, S. suis is generally believed to invade via the upper respiratory tract (Gottschalk & Segura, 2000) and in contrast to pigs with pulmonary lesions, S. suis was often the only bacterial pathogen isolated from pigs with neurologic lesions (Reams et al., 1994; Palmer, 1993). It is uncertain whether meningoencephalitis in pigs infected with S. suis results from nasal exposure (extension from the cribiform plate) or from septicemia (Clifton-Hadley et al., 1984) and here we aim to investigate whether the infection lead to a certain degree of hypacusia and may influence also pre weaning mortality rate by piglet crushing. This latter parameter describes the financial incoming of a pig farm; it is calculated on the number of weaned piglets per sow, per year and stands for productivity and ranges from 5 to 20%. It can increase with the elderly of sows, the numerousness of the nest, inadequate farming environmental conditions, ipofertility, embryonic death, dystocia, neonatal pathologies and piglets crushing (Edwards & Malkin, 1986; Fraser et al., 1990).

Crushing especially is a majour complicance accounting for up to 45% of all piglet deaths (Edwards, 2002). Litter and environmental factors (Weary et al., 1996a; Cronin et al., 1998; Weary et al., 1996b) can contribute to some extent to increase crushing but also the sow's maternal behaviour after farrowing has several implications. This attitude it is linked to sows' experience, hereditariness and hormonal factors. Sows are phylogenetically preset to not crush on piglets while laying down: they explore the ground with the muzzle and move piglets with legs or head but in intensive farm breeding systems the single crates and the pressed selection for productivity may have partly prevent this maternal attitude. Another important issue is the responsiveness of a sow to (the sound of) a piglet being crushed which takes into account sows' overall experience (Thodberg et al., 2002; Grandinson et al., 2003). It has been ascertained that a sow better reacts to piglet's screams more that to the tactile effect while a crushing is happening (Hutson et al., 1991) and this reaction is even higher during the first days after delivery when the crushing hazard is higher. Individual reactivity of sows to piglets shrills has been studied confirming that the more they' re reactive to those sounds the less crush on piglets. The focus of this research is to measure sows's crushing of newborns during their first days after nesting investigating whether deafness may influence a less reactivity to piglets screams stimuli. In particular we studied if Streptococco Suis, type 2 could be a cause of sensory hypacusia, involving the inner ear, so that this lack of hearing will increase the chance of crushing. Trough the analysis of sow's reactions to specific sounds we studied the role of deafness as a cause of early crushing, the correlation between deafness and presence of infection and number of died piglets by crushing per sow. To prove deafness also bacteriological analysis has been done. The importance of this work stands in amplify the knowledge concerning neonatal mortality causes helping the prevention of neonatal death which would result in improvement in piglet survival

Material and Methods

1. Deafness tests and crushing monitoring

Data were recorded in the farrowing compartment of a swine full cycle breeding farm.
The sows were lodged in horizontally ordered farrowing crates (2.74 X 1.75 m) according to the expected farrowing date. Underfloor heating and lamps for piglets and were provided .The piglet nest area was located laterally the sow. The sows were fed once a day untill farrowing and twice from the second postpartum day. During the whole study time, no medications were administered. To test deafness, 256 sows were checked in 3 different farrowing rooms in three different periods of the year (April, June and September 2006). The animals were 7 different commercial strains from Italian Landrace X Large White X Duroc boar. Triangle sensitivity tests were performed in moments of the days in which no food was distributed and no routine farm checks from farm personnel were done, avoiding extra disturbance noises. To evaluate animals' reactivity to acoustic stimuli, an operator used to play an acute sound from a musical triangle standing behind the animals in crates. At that moment, a second operator measured the triangle sound intensity by using a sound level meters (Assicontrol ASC-010). Sow behavior was observed and classified as: reaction standing up, reaction moving, reaction vocalizing, ignoring, no reaction. The first three classes where than more generally grouped as "positive reaction" while the last two as "negative reaction". All the data collected in this part of the research were put together in a table containing all information coming both from the single sows farming files and from the data collected during our tests: the farrowing room, sow code, number of the farrowing crate, dB level played near the animal during the triangle test, sow reactivity and number of crushed piglets (table 1). The number of crushed piglets in

all sows during the research were daily collected from farm personnel and noted in sows' personal files.

Table 1: Example of data collected from 12 sows during the study, full table available for the whole research consisted of data from 265 sows).

Sow Code	Nr crate	Reactivity (Y/N)	dB	Nr crushed piglets
4688	11	Y	89	
4411	9	Y	89	3
4109	7	Y	95	
4412	5	NO	95	2
3767	3	Y	91	
4402	1	Y	85	
4633	2	NO	89	2
4507	4	NO	93	2
4634	6	Y	92	1
4421	8	Y	94	
3725	10	NO	96	1
4530	12	Y	97	
…	…	…	…	…

2. Microbiologic test:
After triangle test and evaluation of sow's reactions a bacteriological analysis aimed to verify the presence of Streptococcus Suis type 2 in those animals classified as non reactive (table1). In vivo nasal swabs and post mortem isolation of the bacterial, from the inner ear were done. 78 Nasal swabs were collected in the sows three days after delivery to check the presence of the bacterial in the upper respiratory airways in this particular peripartum stressful moment. For microbial identification, a commercial kit based on agglutination methods was used. Following slaughter, 17 sows were necropsied and gross lesions were recorded. Tissues for microscopy, as well as swabs for microbiological culturing were collected from ears and tympanic bulla. From each animal, samples were taken from gross lesions as well as a standard of 8 tissues for histopathology and 8 tissues for microbiological culture, which was done aerobically at 37°C on 5% bovine blood agar.
Morphologically suspect colonies were subcultured and identified biochemically and serologically using standard methods. For histopathology, fixation in 4% neutral buffered formaldehyde, decalcification of relevant tissues, as well as processing of HE stained sections were performed and the presence of S. suis antigen was examined by immunohystochemistry using a previously published protocol from Madsen and collaborators (2001).

3. Statistic analysis
Variance analysis (Proc GLM, SAS, 2008) has been performed considering all those variables recorded during the research both from the single sows farming files and from the data collected during our tests. The model used is:

$$\mathbf{y}_{ijk} = \boldsymbol{\mu} + \mathbf{T}_i + \mathbf{L}_j + \mathbf{S}_k + \mathbf{V}_z + \mathbf{e}_{ijkz}$$

where:
y= number of crushed piglets or dead during lactation,
μ= general mean,

T_i = effect of i_{th} test effect (i = 1,..3),
L_j = genetic effect (j=1,…7),
S_k = animal effect (k = 1,..256),
V_z =number of delivery effect (z=1,…9),
e_{ijkl} specific random effect of each observation.

Results

From the deafness test and the data collected from single sows files we drawn information regarding the reactivity of the females to sound, the level of sound played and the number of piglets crushed after delivery. This is reported in table 1. The score of the sow's maximum response to the triangle sound appeared to be a crucial moment of observation because there were different behaviors from a simple movement of the ears looking for the sound, grunts, sitting up or standing up; sometimes they didn't just react to the stimulus. For this reason, we decided to group the reactions in two exclusive classes: reactive and non reactive (table 2) to sound.

Table 2: The data coming from the deafness test show the percentage of animals reacting or non-reacting to sound stimuli. During the three different days of tests, on average, the 30% of sows has been evaluated as hypoacusic since did not react to the stimuli.

Day	*N° sows tested*	*Positive reaction*	*Negative reaction*	*% positive*	*% negative*
29/04	88	69	19	78,4	21,6
13/06	84	59	25	70,2	29,7
27/09	84	50	34	59,5	40,5
Tot.	256	178	78	69,5	30,5

Seventy eight non reactive sows were found from the triangle test and they have been observed for the number of crushed piglets and microbiologic analysis.
The number of dead piglets observed during the trial was 119 of which 77 came from non-reactive sows and 42 to reactive ones.
These data were submitted to GLM procedure to evaluate deafness data (reactions and dB) together with productive parameters (weaned piglets per sow), a correlation between deafness and number of crushed piglets was found, on the other hand also the correlation between normal animals and number of dead by crushing is significant (table 3).

Table 3: Statistic analysis of the relation between deafness and piglet crushing

	Average crushed piglets per sow	**P**
Reactive	0.38 on litter	<.05
Non-Reactive	0.65 on litter	

The analysis showed that the animal and the genetic effects did not influence the number of crushed piglets; thus those parameters were dropped from the model. A productive parameter directly correlate with the increase of crushing is parity (P<0.01), as shown in table 4: at the first delivery there were 0.8 crushed piglets/sow, a lower number of deaths was observed at second delivery while the phenomenon increases from the third delivery further on (table 4, figure 1).

Table 4: Relation between parity and number of crushed piglets (GLM)

Parity	Nr crushed piglets	SEM	P
1	0.8	0.21	<.001
2	0.6	0.21	<.05
3	1.33	0.23	<.0001
4	1.21	0.24	<.0001
5	1.35	0.27	<.0001
6	2.04	0.30	<.0001
7	1.6	0.4	<.0001
8	1.57	0.55	<.05
9	2.44	0.77	<.05

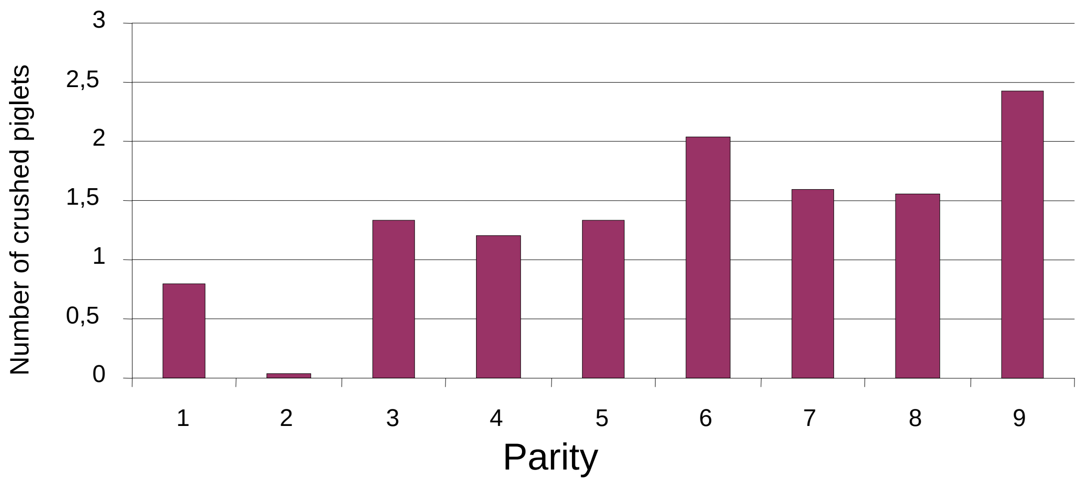

Figure 1: Parity and number of crushed piglets

The microbiologic results from the nasal swabs were negative to Streptococcus suis. This result anyway isn't indicative since sows in peripartum are treated with large spectrum antibiotics. On the other side the microbiologic analysis of the tympanic bulla from the head of slaughtered animals were positive to the bacterial. The animals tested for bacteriology showed 96% positivity against S.suis while the sows of the control group showed a lower percentage of 41%. Swabs from the inner ear have been done at slaughter day, the hystopathological analysis of the brain, middle and inner hear animals also showed microscopic lesions due to meningitis.

Conclusions

In this research it has been found that the 30 % of sows out of 256 animals observed were deaf and that there was a relation between deafness and crushing. Another important consideration raised is related to parity since the average of crushing resulted related to this parameter: high percentages of dead piglets by crushing has been observed, this is due to a partial development of the maternal attitude in young mothers (Lensink et al., 2008). At second delivery there is a halving of the percentage of crushing in comparison with the previous delivery. From the 3rd delivery, the reaction to piglet screams decrease and number of crushed piglets slightly increase probably because of bacteriological agents that develop chronic infections of the inner ear causing deafness or hypacusia. On the other side, younger animals may suffer less from deafness due to streptococci infections since they are less exposed to chronic infections and lesions. There appears to be a cross correlation between infection of Streptococcus suis, hypacusia and neonatal crushing. Our results evidence that a chronic infection of the inner ear can be a problem for productivity in a intensive pig farm, it is interesting to underline the high number of deaf animals which crush on piglets confirming the finding of Hutson, 1991, who stated that for sows physical contact is less important than auditive recognition of nests. Streptococcus suis type 2 diagnosis and antibiotic treatment against seem to be a valuable help in avoiding chronic forms of hypacusia and meningitis. This must be considered a form of prevention of newborn mortality and of zoonosis among workers in close contact with swine livestock. Improving Streptococcus diagnosis and therapy may reduce production costs that are also due to higher number of pre weaning mortality (64.7%).

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Measurement of Dust Exposure During Straw Distribution in Piggery

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Abstract

Straw handling in pig barn is one of the most troublesomely manual tasks due to the dust exposure. This paper presents the measurement results on dust exposure for straw distribution in piggery. The work included the measurements of working time requirement and airborne dust exposure at pig barns in Sweden. The measurements were carried out by a personal particulate monitor mounted on farmers during working on distribution of various bedding materials at different pig barns. Endotoxins and microorganisms contained in the dust were analyzed from the personal sampling in the breathing zone. The working tasks that were investigated at daily manual straw handling were: a) mucking out by scraper in pigpen, b) loading straw into handcart in storeroom, c) moving straw between the storeroom and pigpen, d) distributing straw and littering down in pig pen, etc. The results show that the concentrations of endotoxins in the pig farms investigated exceed an exposure risk limit for inflammation of respiratory tract. An extremely high content (>5700 ng/m^3) of endotoxin in airborne dusts was measured with a farmer when he was manually littering oats straw in one of the pig farms, and an automatic dry feeding was in process. The results of microbiologic analysis also show that airborne dusts contain an amount of bacterium and mould fungus. In order to reduce the health risk for the farmers, some approaches on improvement for such working environments were discussed.

Keywords: airborne dust, endotoxin, farmer, healthrisk, working environment

Introduction

The swine building is a dusty working environment, and the daily straw distribution is one of the most hazardous working tasks for the farmers. Swine confinement workers suffer a higher prevalence of respiratory symptoms, such as cough, phlegm, chest tightness, and wheezing, rather than the rest of the population. (Cormier, et al., 1990; Larsson, 2001; Larsson, et al., 2002; Banhazi, et al., 2008; Sundblad, et al., 2009). This is because the organic dust in swine confinements contains a lot of microorganisms, bacteria and bacterial products, such as endotoxins. Inhalation of organic dust in swine house can induce acute airway inflammation and increase bronchial responsiveness, resulting in a rise to diseases of the respiratory tracts and lungs. (Rylander, 1986; Larsson 1990; Malmberg m.fl., 1987; Kirkhorn & Garry, 2000; Viet m.fl., 2001; Müller-Suur, 2002; Spurzem m.fl., 2002). Endotoxin is believed to be a responsible agent for the majority of acute dust exposure related to the respirator problems (Clark, et al., 1983; Shiefer & Hancock, 1984; Creasia et al., 1987; Donham, et al., 1989; Creasia et al., 1990; Pitt, 1994; Douwes et al., 1997; Wang, 1997; Skaug et al., 2000; Larsson, 2001).

The Provisions of the Swedish Work Environment Authority on Occupational Exposure Limit values (OEL, AFS 2005:17) give a level limit value for total organic dust content (5 mg/m^3 in air during one working day). This limit value refers to the maximum acceptable concentration of dust from organic substances, and it does not allow for specially hazardous components of biological origin. Components of the biological origin include, for instance, endotoxins, bacteria, mite excrement and fungal spores, as well as severely allergenic substances like particles from animal hair, epithelium and bacterial spores. The special limit values for such hazardous components are still lacking. The hygienic quality of straw has an important bearing on the work environment, especially mouldy straw that encloses a lot of endotoxins and microorganisms (Gustafsson and von Wachenfelt, 1993; Larsson, K. and Ihrsén S., 1996).

As a dose response, the dust concentration and the exposure duration both are important factors. A higher concentration and longer exposure duration to the dusts increase the health risk of likelihood. The duration of the OEL values for total organic dust content in air at 5 mg/m^3 is for exposure during one whole working day of eight hours (AFS 2005:17). There is also an occupation exposure limit value for exposure during a reference period of 15 minutes (short-term value, AFS 2005:17). The short-term values are used for swift-acting or otherwise especially dangerous substances. In fact, the farmers usually are exposed to much higher concentration of organic dust during daily ditrubution of strew for a shorter duration in swin house. However, the information regarding whether there is a health risk on the respiratory system for this kind of daily work on strew handling is still missing.

The aim of this paper was to investigate the exposure to organic airborne dust when farmer handle strew in swine barns.

Methods

The work included the measurements of working time requirement and airborne dust exposure at ten large pig barns in Sweden. Exposure to dusts was investigated by measuring the concentration of airborne dust as well as by analyzing endotoxins and microorganisms sampled from the personal sampling in the breathing zone (Figure 1). To obtain a representative overview of real time exposure to organic dust, the measurements were performed with each farmer during a really working shift in a pig barn when he/she operated the tasks.

Figure 1. Instrument used for the personal sampling (a portable air pump that was connected with two sampling filters and the DataRAM).

The real-time concentration of airborne dust was monitored with personal sampling by an instrument named personal pDataRAM (Thermo Electron Corporation, 2005). A model pDR-1000AN of the pDataRAM performed the measurement fraction of the airborne dust (particle size range: 0,1 to 10 µm; concentration range: 0,001 to 400 mg/m^3). The data were collected in every 5th second, and the stored data were downloaded to a personal computer for the data management and analysis. The results related to air volume were expressed as milligrams per cubic meter (mg/m^3) for the concentration of airborne dust.

The contents of endotoxins and microorganisms in the airborne dust sampled during the operation were verified by chemical analyses. A portable air pump that was connected with two sampling filters was used for the personal sampling in the breathing zone (Figure 1). After each measurement, the sampled filters were immediately left to the laboratory of Pegasus Lab for the analyses. The results related to air volume were expressed as nanograms per cubic meter (ng/m^3) for the endotoxins and that given as spores/m^3 for the microorganisms.

The working tasks investigated at manual straw hantering were: mucking out by scraper in pigpen, loading straw into handcart in storeroom, moving straw between the storeroom and pigpen, distributing straw and littering in pigpen, etc. (Figure 2). In each investigation, the performance of the tasks and the working duration were observed and recorded. In addition, the type of straw used, and climate (air temperature and relative huminitity) were recorded during the measurement.

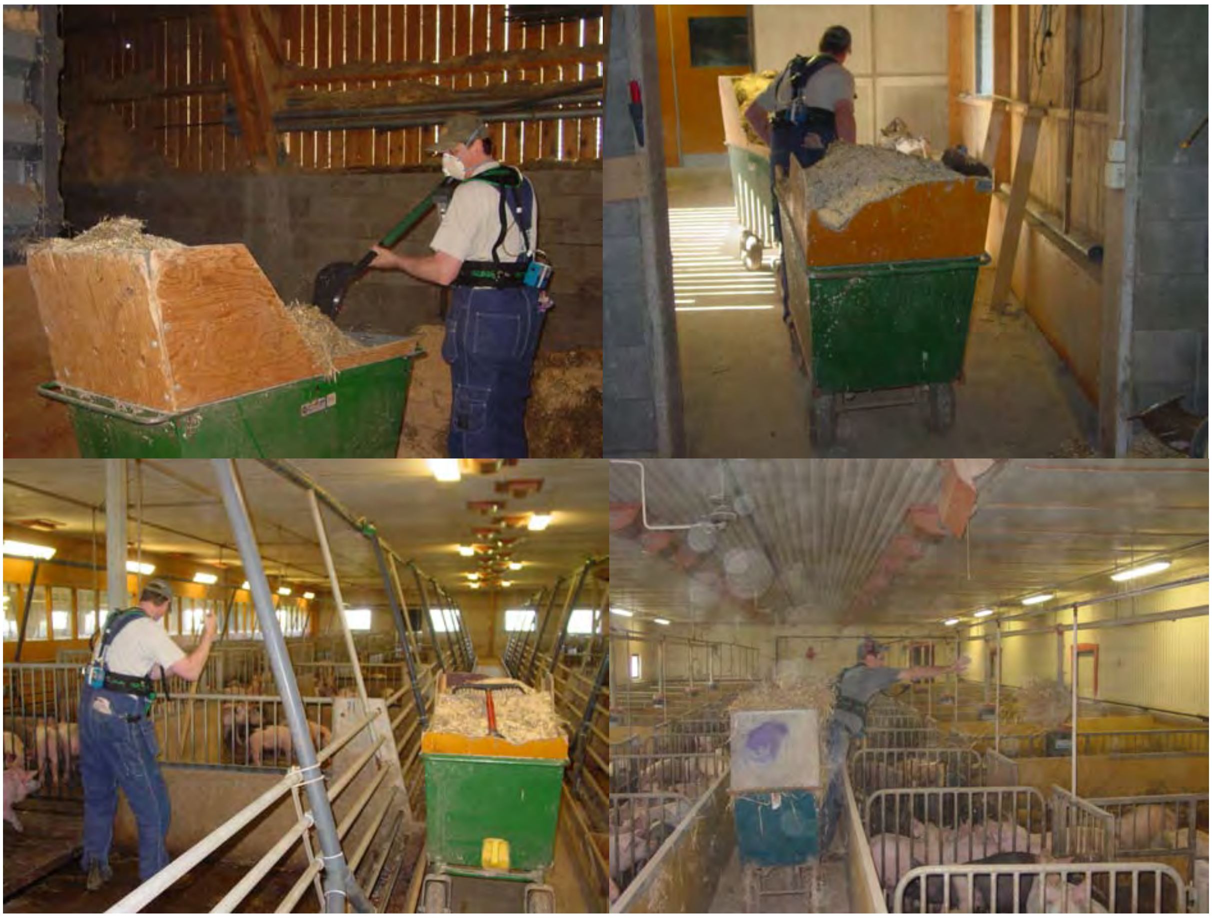

Figure 2. The working tasks investigated.

Results and discussion

The general information about the swine farms studied is described in Table 1. The duration of each measurement varies much among the farms due to differnt sizes of the swine barns.

Table 1. General information for the measurement conditions.

Study nr	Straw sort	Air temperature (ºC)		Relative humidity (%)		Measuring duration (minut)	Barns' size for number of pig
		Indoor	Outdoor	Indoor	Outdoor		
1	Wheat straw & Shavings	18-20	17,2	63-65	54,8	130[1)]	9*360
2	Wheat straw	19-21	16	57-58	62	129	2*(240+370)
3	Wheat straw	18-20	8	61-63	-	47	4*120
4	Wheat straw & Shavings	21-26	23	70-77	68	31[2)]	5*300
5	Wheat straw & Shavings	26-28	-	68-70	-	56	2*400 1*360
6	Barley straw & Shavings	16-21	2	56-75	60	81	3*330
7	Wheat straw[3)]	15-17	7	82-89	96	40	2*140 2*210
8	Oats straw	19	15	56-57	44,4	32	240+280
9	Barley straw	13-15	12	50-70	41	57	9*300
10	Wheat straw	14-16	14	45-66	28	46	2*240+140

[1)]: A break for 44 minutes in the building was included; the real working duration was 86 minutes.
[2)]: Worked for only distribution and litter of straw without mucking out during measurement.
[3)]: The straws have been stored for 2-3 years.

Dust concentration

Figures 3 - 5 show the examples on the variations of dust concentration measured by the pDR-1000AN with three of the participators during operating the tasks under different working conditions as described above. Clearly, the dust concentration varied both at various activities and in different pig barns. The airborne dusty concentration was higher than the health risk for OEL value of 5 mg/m^3 when the farmers loaded streaw into the handcart and moved it to pigpens as well as distrabuted and littered down strews at two differnt swine farms (Figures 3 and 4).

In addition, Figure 3 shows that the airborne dust measured for mucking out was lower than that for distrabuting and littering strews operated by a famer in the same swine building.

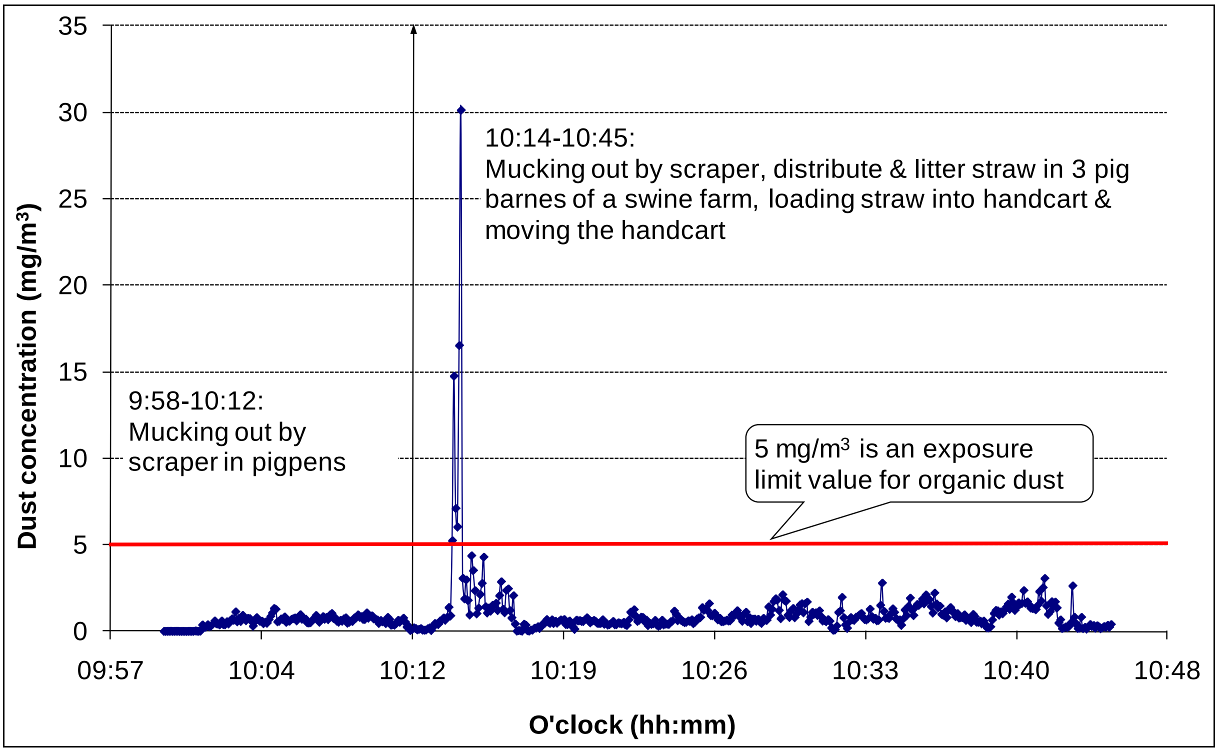

Figure 3. The dusty concentration versus working time measured with farmer by the pDR-1000AN.

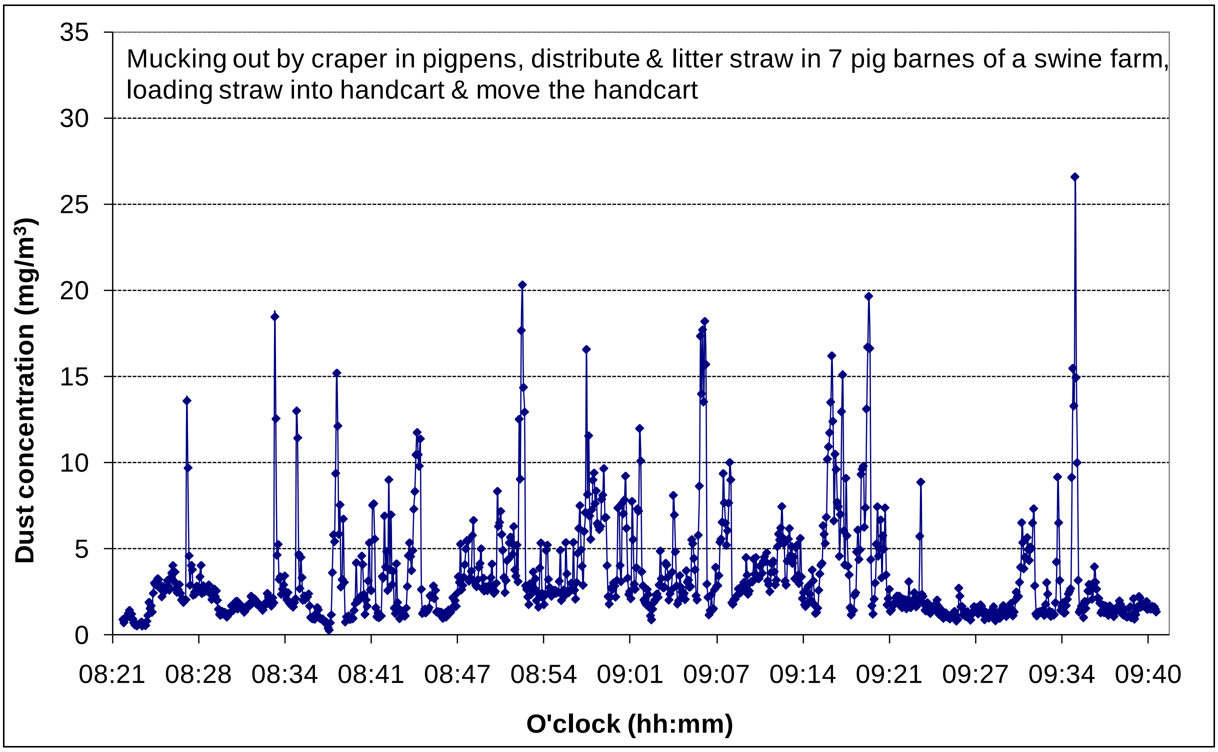

Figure 4. The dusty concentration versus working time measured with farmer by the pDR-1000AN.

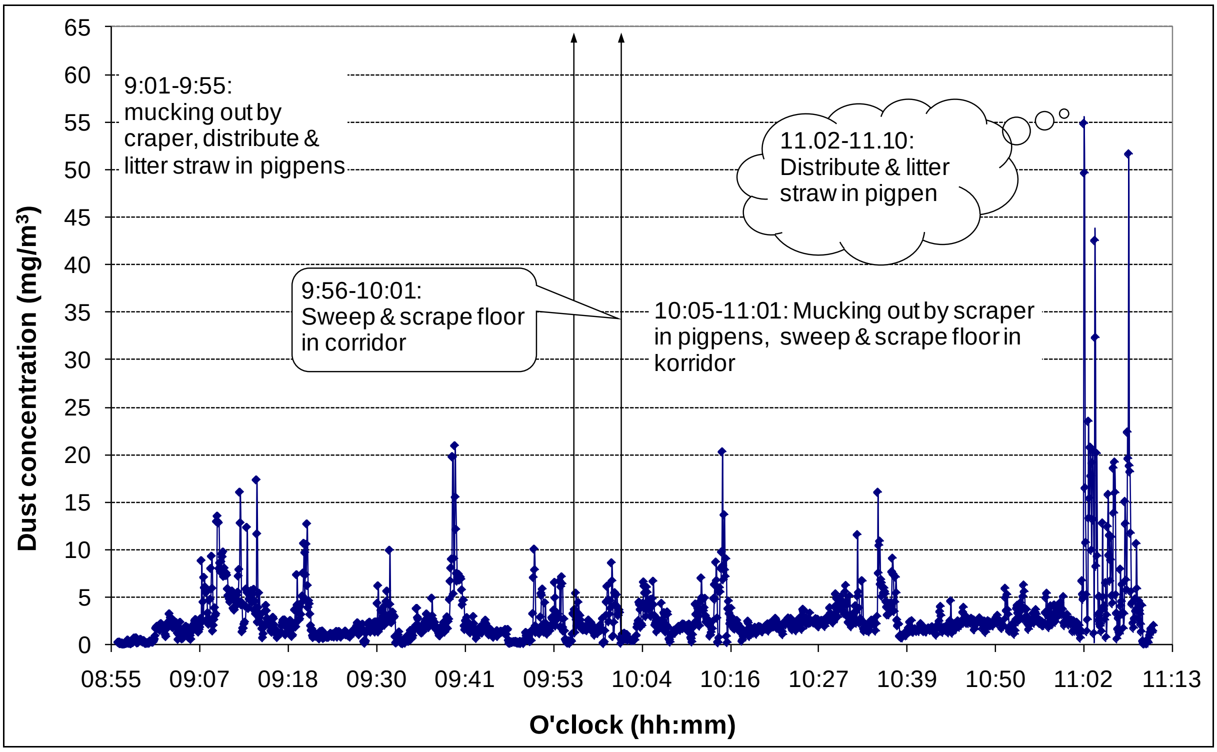

Figure 5. The dusty concentration versus working time during measured with farmer by the pDR-1000AN.

An extremely high concentration of airborne dust of 55 mg/m^3 was explored when distrabuting and littering strews in a swine building (Figure 5). Large quantities of organic dust were formed and released into air when chopped straw were distributed and littered in pigpens. In such a dusty working condition, the technical measures against the airborne dust concentration are thus needed. The farmers' exposure to such a harmful dust would be reduced via technical measures, for instance, introduction of an automatic equipment for straw distribution instead of daily manual straw handling in swine barns.

Endotoxin and microorganisms

Table 2 gives the results of concentration of endotoxins and microorganisms that were analyzed from the airborne dust with the personal samplings. Clearly, the all concentration values of the edotoxins exceed a risk level of 10 ng/m^3, which is a risk limit for inflammation of respiratory tract (Douwex, et al., 1997; Wesén 2009). According to Douwes, et al. (1997) and Wessén (2009), there was a risk for toxic pneumonia (fever reaction and irritation of respiratory tract) when a person was exposed to the endotoxin amount level at 200 ng/m^3 in air. It can be seen that eight of the ten values of endotoxin in the airborne dust measured with the farmers overstepped 218 ng/m^3. As known, organic dust in swine confinement buildings usually contains bacteria and endotoxins, as well as epithelium from the swine.

An extremely high content (>5700 ng/m3) of endotoxin in airborne dust was measured with a farmer when he was manually littering barley's straw in one of the pig farms. Noticed that during this measurement an automatic dry feeding was in proceed in this swine building. Large quantities of the organic dust could occur during the feeding, due to the dust generated both by dry feeding and by increased activity of the swine.

The analysis of microorganisms shown in Table 2 (Lager, 2009 and Wesén 2009) indicates that the airborne dust for the cases nr 3, 4, 6, 7, 8, 9 and 10 contained a large amount of bacteria (aureobasidium, streptomyces, trichoderma) and mould fungus (e.g. aspergillus spp, penicillium spp, jäst). It was observed that the quality of wheat straws used in the case nr 7 was not good as the straws have been stored for more that 2-3 years. The old straw could generate mould and toxic dust. The hygienic quailty of straws has a very important bearing on the airbrone dust. Handling of mouldy straw should be avoided as far ad possible. All bacteria and mould fungus belong to microorganisms in the airborne dust that are invisible to the naked eye, generating toxic dust in air. Also, the results show that the airborne dust contained a large amount of toxic producer (alternarium, eurotium, fusarium, trichoderma and wallemia), causing the high concentration of the endotoxin. Therefore, the technical and organisational measures to reduce the airborne concentration of these hazardous substances should be conducted.
If the technical measures cannot be taken or are insufficient, suitable personal protective equipment shall be used as a last resort. However, only three of the ten farmers who participated in the study used the respiratory protective device. The farmers should thus be informed of what kind of the risk exists when he/she exposed to organic dust, in which dusty condition the protective device must be used and how the risk could be reduced as well.

Table 2. Concentrations of total airbone endotoxin and microorganism in pig barns

Case nr	Endotoxin (ng/m^3)	Microorganism (spore /m^3)		Risk for respirator problem's organisms	Toxic producer
		Bacterium	Fungi		
1	***217,92****	1,6*10^6	2,7*10^5	Alternarium,	Aureobasidium, Streptomyces
2	***415,77***	6,1*10^6	1,5*10^6	Wallemia	Streptomyces
3	***492,98***	***1,5*10^7***	4,4*10^6	Trichoderma, Eurotium	***Streptomyces, Trichoderma***
4	75,46	***2,2*10^7***	4,0*10^5		***Streptomyces***
5	77,46	9,6*10^6	3,5*10^5	Fusarium	
6	***795,41***	***5,1*10^7***	5,8*10^6	Trichoderma	***Aureobasidium, Trichoderma***
7	***1314,52***	***1,4*10^8***	9,4*10^6		***Streptomyces***
8	***5769,74***	***4,3*10^7***	2,5*10^6	Fusarium	
9	***1238,39***	***3,1*10^7***	8*10^6		
10	***407,38***	***6,3*10^7***	2,1*10^6	Eurotium	Aspergillus niger, ***Streptomyces***

*: the contents of endotoxin and microorganisms as well as labels of the toxic producer shown by ***Italic boldface*** exceed the health risk limits.

It is recognized that farmers are often exposed to many potentially hazardous substances related to their work such as mineral and organic dust containing endotoxin, bacteria, allergens, fungi (e.g. straw dust, mouldy hay, animals), chemicals (e.g. fertilizers, pesticides, disinfectants), and gases (from animal manure pits, exhaust of machines) as well (AFS 2005:01; AFS 2008:17; Baekbo, 1990; JTI, 1990; Radon, et al., 2002; Rylander R., et al., 1989; Michel, et al., 1992).

The dust exposure is related to the exposure time when workers operate in a dusty environment. The reduction of the exposure duration in such a dusty working environment will thus have a direct effect on health. According to the Swedish regulation (AFS 2005:17), for one substance has different limit values, such as level limit value and short-term value. The reference period of the exposure should be eight hours for the level limit value (8-hours OEL). Additional investigation of dust exposure during working with different operations over one whole working day is therefore a necessity. For the short-term value, it has been defined as a recommended value consisting of a time-weighted average for exposure during a reference period of 15 minutes (STEL-15m). The short-term values are intended to protect workers during a short exposure to dangerous substances. These exposure limits cover risks from microorganisms such as viruses, bacteria, parasites, and fungi. Exposure to microorganisms is particularly relevant for farmers who work with swine in piggery. In Swedish regulation of AFS 2005:17, the STEL-15m value for organic dust in air has not yet been established. Further studies of exposure to the dust related to daily straw handling in swine barns for 15 minutes are thus essential to contribute the database on STEL-15m values for dangerous substances. This is because some substances have a STEL-15m value that should not be exceeded at any time to ensure protection against both acute effects, such as throat irritation, and chronic, long-term effects.

Conclusions

High concentrations of airborne dust occurred when the farmers operated tasks in swine barns, particularly for loading streaw into the handcart and transporting it to pigpens as well as distrabuting and littering down strews in pigpens.

All of the farmers investigated were exposed to high concentrations of endotoxins, which exceeded an exposure health risk level for inflammation of respiratory tract.

An extremely high concentration of endotoxin in airborne dusts was measured with a farmer when he was manually littering oats straw in pigpens together with the increased activity of swine while dry feeding was automatically in progress.

The airborne dust measured in most of the swine barns contained a large amount of bacteria and mould fungus. Preventively technical and organisational measures to reduce the airborne concentration of these hazardous substances should be conducted in the swine barns.

Further investigations of exposure to the airborne dusts related to daily work in swine barns for the reference period of both for 8 hours and for 15 minutes are essential.

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Research on Ergonomics in Animal Production in Sweden

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Abstract

Ergonomics in animal production involves not only the working environment legislation, but also the human welfare legislation. As an example: in the car manufacturing industry you can handle a car in an optimal way to create ergonomical good solutions for the worker. This is not possible when you are working with animals. Swedish research on ergonomics in animal production are trying in collaboration with farmers and the industry to develop and evaluate ergonomical solutions which benefits production as well as animal and human welfare. Active research involves milk production, pig production, poultry production, as well as work with horses and the involvement of children in agriculture.

Keywords: ergonomics, animal production, milking, horses, pigs, children, Sweden

Introduction

Research on ergonomics in agriculture is active in Sweden, with a focus on ergonomics and animal production. A recent PhD dissertation presented studies on the employee perspectives on ergonomics in milk- and pig- production (Kolstrup, 2008, Kolstrup et al 2006, 2008). Among her findings it was concluded that the livestock workers assessed their psychosocial work environment and mental health as good, although the quality of leadership, feedback and social support was experienced as being slightly poorer on dairy farms compared to pig farms. No psychosocial risk factors were identified for musculoskeletal disorders (MSD). Dairy farm workers working with healthy cows had poorer physical and mental health than those working with less healthy dairy cows. The livestock workers were contented with their psychosocial work environment; however, they reported high frequencies of MSD. The prevalence of MSD seemed to be associated with the physical rather than the psychosocial work environment.

The above mentioned thesis and a number of studies are performed by a research group at the Agricultural University in Alnarp (in the very south of Sweden) with a focus on ergonomics, injury prevention and leadership in agriculture, with a special focus on animal production.

Milk production

Several studies over the years have involved epidemiological, clinical and ergonomic studies in different types of milking parlours, technical and housing solutions (Lundqvist 1988, Lundqvist et al 1997, 2003, Pinzke 2003, Pinzke et al 2003, Stål et al 1997, 2003, 2004). A number of the studies have been adopted by the industry which means better products for the end users.

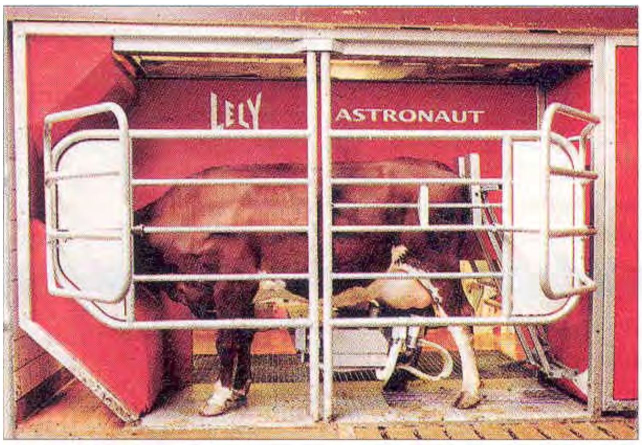

Figure 1. Ergonomics in milking is an essential part of the working conditions. All milking solutions have their positive and negative factors – still there is no perfect solution.

Working with horses

There are also a number of ongoing studies in Sweden involving ergonomics during work with horses, one is focusing on riding instructors (Löfqvist et al , 2009), and another one on hand held tools for manual work operations.

Figure 2. Working with horses involves a number of ergonomic challenges.

Pig and poultry production

Ergonomic studies on work with pigs has been quite rare until recent year, but now a number of studies has shown the frequency of musculoskeletal disorders together with in-depth studies of different manual work operations (Gustafsson & Lundqvist 2003, Stål & Englund 2005, Kolstrup 2008).

The changes of the animal welfare legislation which banned small cages for poultry production led to a number of scientific studies of ergonomics and injuries in alternative housing systems (Lundqvist, 1995, 1997).

Figure 3. Working with pigs still involves a lot of manual lifting and handling

Guidelines for farm children on animal farms

Another Swedish initiative have been the development of guidelines for children and adolescents on farms (Alwall Svennefelt, & Lundqvist, 2006) giving the family directions on what work operations could be suitable for children to be involved in and what considerations needs to be taken, such as age, strength, body postures and other issues of importance.

Figure 4. Guidelines have been developed for farm families in order to find the right work operations for their children with a special focus on ergonomics and safety on animal farms

Discussion and conclusions

Ergonomics is a key issue for the future of animal production. Improving ergonomical working conditions often also leads to a reduction of injuries. Working conditions on farms which includes safety, a good leadership and well designed ergonomical solutions makes the farm an attractive work place which makes it easier to find and keep skilled employees.

The interest for ergonomics in agriculture goes international and the International Asssociation of Ergonomics (IEA) has an agricultural section (http://www.iea.cc/). Also the European Union supports more and more efforts in order to improve ergonomics in agriculture. A joint project in this field has just been reported "Musculoskeletal problems in Agriculture" and has a home page with useful information (http://www.agri-ergonomics.eu/). Further collaboration and wider networks are needed on the road to good ergonomics in agriculture – on all farms!

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Exposure of Workers to Electromagnetic Fields (EMF) Inside the Olive Mills: Preliminary Evaluations During the Oil Production [1]

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Abstract
In this note the experimental results of an analysis of the electromagnetic fields present in the productive area of new built oil-mill, placed in Bari district, considered representative of the majority of such a kind of the workshops in the Apulia region, are reported. Introductory study's purpose has been evidently to evaluate the exposure level of the workers during an oil production activity, inside a typology of transformation systems much spread on the Apulian territory that, even though with seasonal character, gives occupation to a big number of operators.
Results of the tests highlight that inside the considered oil-mill there are not electromagnetic pollution risks for the operators during the period of maximum use of its productive capacities.

Keyword: electromagnetic fields, olive mills, risk analyses, worker health

Introduction
The riskiness connected to the diffusion in the environment of the electromagnetic fields (EMF) has emerged in the last decades as their use has got always more intense in the civil applications; it's useful to remember that most technological applications use alternating tensions and currents that, therefore, produce alternate electrical and magnetic fields (Bevitori, 2007).
Under the sanitary point of view, in fact, an individual dipped in an electromagnetic field interacts with it creating a physical coupling between his biological system and the field, which evidently produce a deviation from the conditions of electrical balance at molecular level (Chatteron *et al.*, 1992).
The field frequency and the dielectric features of biological tissues affect the physical mechanisms of coupling between electromagnetic fields and biological organisms, therefore the maximum limits are expressed as a function of the frequency (Widermann *et al.*, 2005).
Within the low frequency electromagnetic fields (0 ÷ 10 kHz), a person's exposure is directly bound to the values of a few electrical characteristics which establish themselves as an effect of such fields, inside the human body: such characteristics, internal or primary, are essentially the *intensity of the electrical field* and above all the *internal current density*, defined as the current which passes through a unitary section perpendicular to its direction in a conductive volume such as the human body or a part of it (Rubin *et al.*, 2005).
These characteristics are of difficult measurement in the real exposure conditions and therefore, the check of the exposure of a person to the electrical and magnetic fields is led measuring the so-called outside or derived characteristics, that is the effective values of the inductive electrical and magnetic fields in absence of the exposed body. After evaluated the

[1] *Each of the authors contributed in equal parts to this work.*

exposure conditions and the relative characteristic of the electromagnetic field, by mean of dosimetric models from the derived characteristics are evaluated the primary ones (D'Amore, 2003).
The Italian law in force regarding the workers' safety (Italian law decree and subsequent supplements n. 81, 2008) also counts among the various risks for the health of the workers the ones connected to the exposure to electromagnetic fields (0 Hz ÷ 300 GHz) during the job. These regulations regard the protection from the risks for the health and the workers' safety due to the well-known short term harmful effects in the human body deriving from the induced current circulation and energy absorption and from contact currents. In the law decree 81/2008 are defined: a) the limit values of exposure to the electromagnetic fields, based directly on verified effects on the health and on biological considerations, whose respect ensures the protection against all the well-known short term harmful effects for the health; b) the action values, directly measurable and whose observance assures the respect of the pertaining limit values of exposure, which determines the obligation to adopt one or more of the specified protection strategies.
In the agro industrial sector generally and in the olive oil production sector, with special reference to the manufacturing that happen in the oil-mills, the prevailing electromagnetic fields are the one at extremely low frequency (ELF, 30 ÷ 300 Hz), because they are due to the presence of electrical distribution lines and electrical motors working both at the 50 Hz industrial frequency.
In this note the experimental results of an analysis of the electromagnetic fields present in the productive area of new built oil-mill, placed in Bari district, considered representative of the majority of such a kind of the workshops in the Apulia region, are reported.
Introductory study's purpose has been evidently to evaluate the exposure level of the workers during an oil production activity, inside a typology of transformation systems much spread on the Apulian territory in relation to electromagnetic fields generated by the machineries used for the extractive purposes.

Materials and methods
The considered oil-mill, located in Corato (BA) countryside, has a typical lay-out of many productive realities of the northern Apulia, as they integrate deferring continuous cycle productive lines are present, in fact, 2 lines with stone mill (line 1 and line 2) and 1 line with metal crusher (line 3) (Figure 1).
Under the organization point of view, the oil-mill is family driven and during the oil production period, the oil-mill works 24 hours a day; in such conditions, the workers follow the production in 8 hours turns each.
The evaluation of the level of exposure to the electromagnetic fields has carried out first of all analysing both the spatial arrangement of the electrical machines inside the oil-mill, and the relative working cycles taking care to the workers individuals' duties, with their recurring working paths and the standing points.
Referring to what above reported during the extractive activity and during each working turn, with 3 operative lines simultaneously used, the working cycles of the various machines are not very different in terms of use, in terms of special arrangement of the utensils, in terms of electrical current absorptions and in terms of workers' operations and paths.
On the basis of this checking, it has established to carry out just one explorative measurement or "spot" of the field in 15 point at the working area: near electrical engines used by the operating machineries (stone mill, malaxer machines, decanter, vertical centrifuges) of the 3 above-mentioned extractive lines and near general electrical panelboard (Figure 1), with the

aim of evaluating the trend of the electromagnetic field and identify any critical points at higher intensity level on which investigate, later, with measurements sampled for all the duration of the working turn.

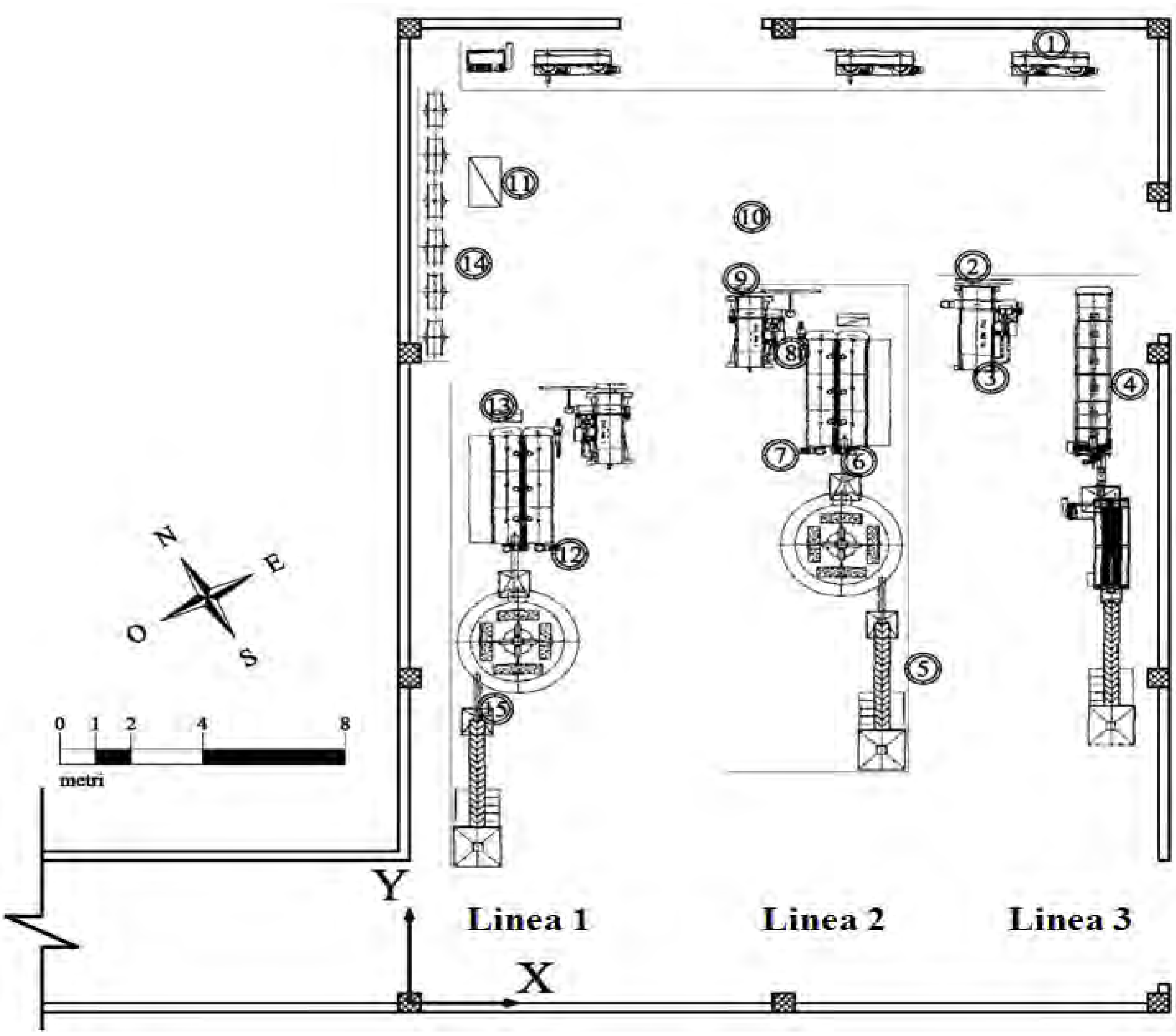

Figure 1. Studied oil-mill lay-out with indication of electromagnetic field measurement points.

Referring to extraction line 3 (Figure 1) the measurement points were: 1-back side of vertical centrifuge; 2-near decanter out; 3-near decanter in; 4-near malaxer machine out.
Referring to extraction line 2 (Figure 1) the measurement points were: 5-near leaf remover out; 6-near right side of malaxer machine in; 7- near left side of malaxer machine in; 8-between malaxer machine out and decanter in; 9-decanter side; 10-decanter out.
Referring to general electrical panelboard (Figure 1): 11-in front of it.
Referring to extraction line 1 (Figure 1): 12-near malaxer machine in; 13- near malaxer machine out; 14-near decanter out; 15-near leaf remover out
Measurements have been executed in all the points at a constant height by the floor of 1.50 m, which corresponds to the mean height of workers' thorax, and at a mean distance from each machinery of about 0.50 m.

Furthermore with this type of investigation it has been gathered information regarding to the frequency of the biggest spectrum line and the field distribution spectrum.
The evaluation of the electromagnetic fields has been executed on the basis of the Italian technical regulation in force (CEI 211-6, 2001); it's also useful to remember that the measure of low frequency electrical and magnetic fields has to be carried out in the so-called area of reactive near field, that's to say at distances from the sources lower than the λ wave length that, in the considered case of 50 Hz industrial frequency, is 6000 km.
As it is well known, in the reactive near field area no correlation between electrical and magnetic field exists: the first depends on the tensions present in the system or in the equipment which produces such fields, the second depends on the currents in them circulating, being tensions and currents completely independent. Therefore the complete characterization expects in any case the measure of both components: electrical field and magnetic field.
The system of measure of electrical and magnetic fields for low frequency used for the tests, was formed by an analyser PMM mod. EHP-50C, standing on a tripod mod. TR-02A, and from the gauge PMM mod. 8053A.
This instrumentation, in compliance with Italian Ministerial Decree 381 of 10/09/1998 and with Italian DPCM 08/7/2003 and whose main technical features are summarized in Table 1, it's extremely versatile and allows many measurement possibility with continuous monitoring also of many days.

Table 1. Main technical specification of the adopted instrumentation

	Electric field	Magnetic field
Frequency range	5 Hz – 100 kHz	
Level range	0.01 V/m -100 kV/m	1 nT – 10 nT
Overload	200 kV/m @ 50 Hz	20 T @ 50 Hz
Dynamic	>140 dB	

For each of the above mentioned measure points has been detected the orthogonal components x,y,z of the electrical and magnetic field for the 5÷100 Hz frequency spectrum, with a scan of 0.25 Hz,.
Figure 2, shows the position of the measure instrumentation near the leaf remover out (1 in Figure 2) and near the malaxer machine in (2 in Figure 2) that are both part of the extractive line 2.

Results and discussion
In Figure 3 are reported the effective values of electrical field E_{RMS} in each measurement point, obtained considering the components along the axies and the whole examined 5 ÷ 100 Hz frequency spectrum. In particular the value of electrical field at the generic E_i frequency is evaluated by mean of the following relation:

$$E_i = \sqrt{\left(E_{xi}^2 + E_{yi}^2 + E_{zi}^2\right)}$$

where E_{xi}, E_{yi}, E_{zi} are the components in the three x, y, z directions; the effective value of the electrical field E_{RMS} considering all the frequencies measured by the measurement instrumentation in the 5-100 Hz range in given by:

$$E_{RMS} = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} E_i^2}$$

All the E_{RMS} values are considerably lower than the action values reported in the actual job safety laws and graphically reported in Figure 4, which determine the obligation to adopt one or more of the specified protection strategies.

Figure 2. Measure instrumentation positioning at leaf remover out (1) and at malaxer machine in (2).

Peak values of electrical filed E_{peak} obtained in the various measurement points have been all obtained at of the frequency of 50Hz and have been in any case lower than the correspondents effective values E_{RMS}; it's useful to remember that the electrical field is function of the tension, assumed to be constant inside the oil-mill, as the lighting equipment was fed with a single-phase tension (220 V) and the engines of the operator machines were fed with three-phase tension (380 V) or single-phase tension (220V).

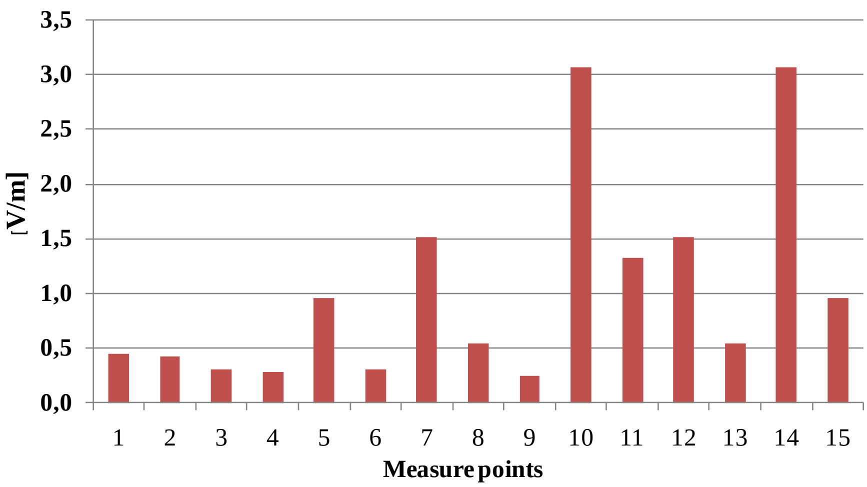

Figure 3. Effective values of electrical field E_{RMS} obtained in each measurement point

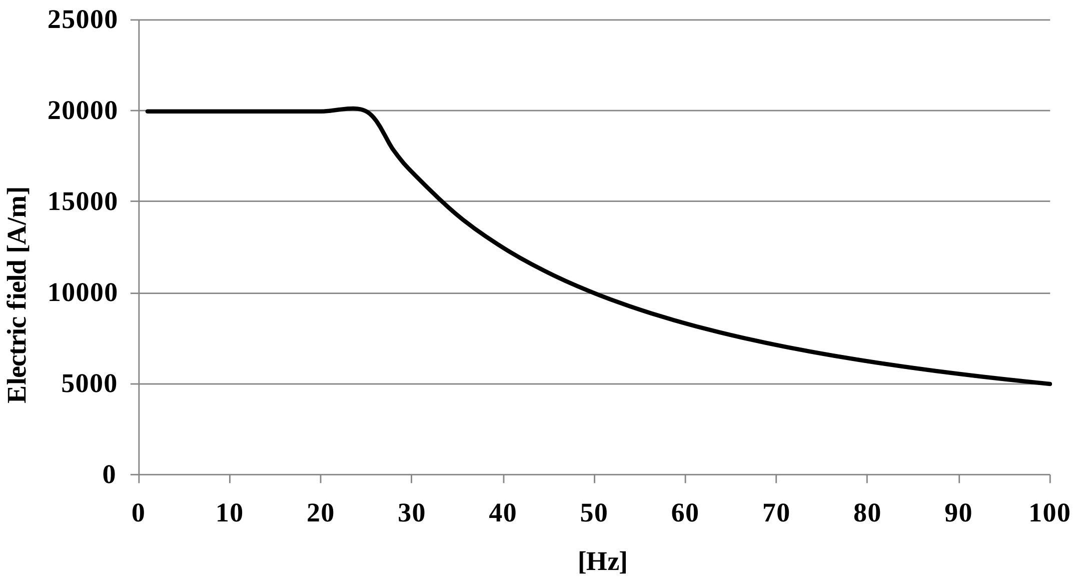

Figure 4. Effective action values of electrical field E_{RMS}.

In Figure 5 are reported the effective values of magnetic induction field B_{RMS} (also called magnetic flux density) in each measurement point, obtained considering the components along the axies and the whole examined 5 ÷ 100 Hz frequency spectrum. In particular the value of magnetic induction field at the generic B_i frequency is evaluated by mean of the following relation:

$$B_i = \sqrt{\left(B_{xi}^2 + B_{yi}^2 + B_{zi}^2\right)}$$

where B_{xi}, B_{yi}, B_{zi} are the components in the three x, y, z directions; the effective value of the magnetic induction field B_{RMS} considering all the frequencies measured by the measurement instrumentation in the 5-100 Hz range in given by:

$$B_{RMS} = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} B_i^2}$$

All the B_{RMS} values are considerably lower than the action values reported in the actual job safety laws and graphically reported in Figure 6.
Peak values of magnetic induction filed B_{peak} obtained in the various measurement points have been in any case lower than the correspondents effective values B_{RMS}; it's useful to remember, besides, that the magnetic induction field is strictly related to the entity of circulating currents at the measurement instant. Having made the measurements in a period during which the oil-mill was in full activity and so with all the electrical users in a steady-state, it is plausible to think that these values are maximums ones to be considered in relation to the oil-mill full operation state.
It's important, otherwise, remember that, according to the theory of the multipole development, the trend of the magnetic field decreases in a hyperbolic way; therefore, at a

distance from the machine of few meters, the magnetic induction field assumes values comparable with the underlying ones.

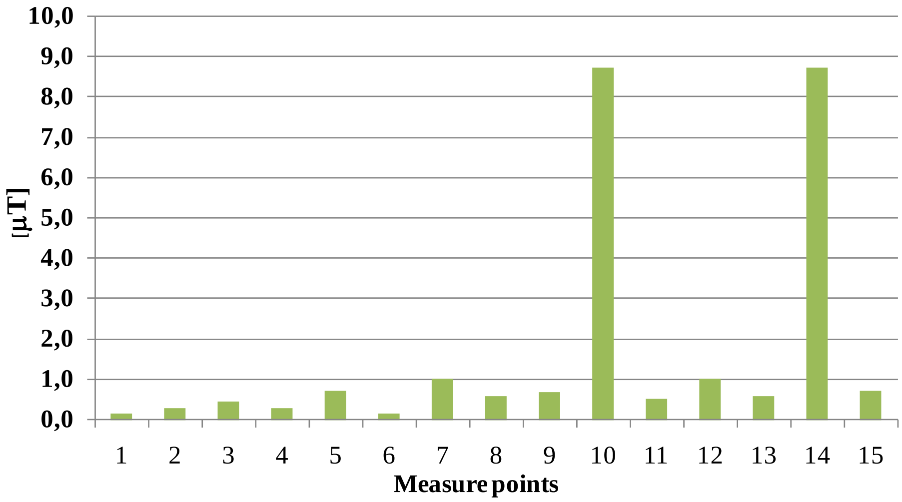

Figure 5. Effective values of magnetic induction field B_{RMS} obtained in each measurement point

Since have not been discovered critical points at high level of intensity both of electrical and magnetic induction field, next or higher than the correspondents action level, no further measurements sampled for all the duration of the working time were carried out.
This measurement typology would have been elaborated with statistical criteria (average, standard deviation, cumulative frequency curve, bends of frequency distribution etc), to highlight the field trend in the time and to provide an estimate both of the exposure levels and of the cumulative quantity in the time of development of the working activity or of the stay in the place of exposure to the field.
It would have been useful to execute also an explorative measurement campaign in the above-mentioned points with all or only some of the operator machines turned off so as to have a comparison with the underlying levels and verify, taking into consideration also the overlap effect, the contribution to the field distribution due by the single sources. However it was not possible to do that as the switching off of some or all the machines simultaneously would have interrupted the extractive production with repercussions on the quality of the final product.

Conclusions

Results of the carried out tests, also considering the limits of this introductory study, highlight that inside the analysed oil-mill, in the period of maximum use of its productive capacities, there are not risks for the operators bound to their exposure to electrical and magnetic low frequency fields.
It is useful to say that the electrical field only turns out significant if there are machines, conductors or, in general, users requiring high voltage; therefore, if equipments directly connected to mid or high voltage are excluded, particular interest arises the electrical field produced by the electroducts and, so, found in open field.
The magnetic induction field produced, instead, by most electrical users, with the exclusion of electroducts, has a low copulation with man and turns out in a close area around the source.

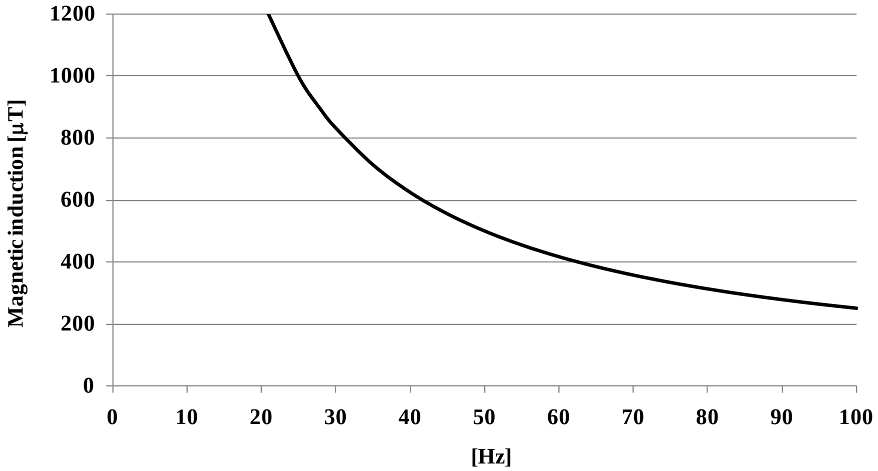

Figure 6. Effective action values of magnetic induction field B_{RMS}.

The investigation methodology tuned for this study, based on current Italian technical and legislative law indications is rather complex but can be used to make further studies regarding the electromagnetic field pollution in other agro-food sectors.

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Hand and Wrist Disorders Among U.S. Poultry Processing Workers

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Abstract
It is not uncommon for food processing workers to have complaints of musculoskeletal disorders such as carpal tunnel syndrome (CTS) within a short period of being hired. It is often difficult to determine if such conditions are caused by the new work or are pre-existing conditions. The purpose of this study was to determine the prevalence of abnormal median nerve conduction and CTS among newly hired poultry processing workers. Hand symptom surveys assessing numbness, tingling, pain, and burning were administered. Nerve conduction studies of the median and ulnar nerves across the wrist were performed bilaterally on all new employees. Median mononeuropathy was defined as a peak median-ulnar latency difference of 0.6 ms or greater. The surveillance case definition for CTS included symptoms and nerve conduction studies indicating a median mononeuropathy across the carpal canal. Over a three-year period 2,387 newly hired poultry processing workers were evaluated. The prevalence of median mononeuropathy among men was and 12% and 9% in the right and left hands, respectively. And among women the prevalence of median mononeuropathy was and 20% and 17% in the right and left hands, respectively. Among the job applicants, 6 women and 9 men that had a median mononeuropathy indicated that they had symptoms consistent with CTS. Many workers at the time of hire appear to have objective evidence of abnormal median nerve conduction within the carpal canal. Few newly hired workers report characteristic CTS symptoms, including those with median mononeuropathy. Workers at the time of hire may not be forthcoming with regard to symptoms that indicate existing pathology.

Keywords: carpal tunnel syndrome, median mononeuropathy, food processing

Introduction
In terms of lost and restricted work days, surgery, rehabilitation, and retraining, one of the most costly disorders proposed to be associated with repeated trauma in the upper extremity is carpal tunnel syndrome (NCCI, 1991). If CTS is related to an employee's job, the employer in the United States often bares the burden of the costs through worker's compensation. These costs are in addition to the pain and suffering associated with the employees disability if the syndrome progresses to an advanced stage.
Nathan and Keniston (1993) suggested that in some industrial settings the duration of time between employment and the onset of CTS was too short to develop CTS as a result of occupational factors. Thus, pre-existing occupational or current non-occupational factors may have been causally associated with the development of CTS. Investigators have also reported major discrepancies between subjective CTS symptoms and the results of nerve conduction studies (Nathan and Keniston, 1993, Werner et al., 2001).

Because the diagnosis of CTS is based primarily on subjective reports of symptoms and subjective responses to clinical tests (provocative tests, vibration perception, current perception) sincere responses are required for an accurate diagnosis. Fearing employer reprisals, there is the potential for applicants with symptomology to deny or not be forthcoming with symptoms of pre-existing conditions like CTS or low back disorders. Employers may therefore be hiring workers with pre-existing medical conditions such as CTS and in some instances placing them in jobs that exacerbate their condition. Additionally, the employer is required to provide compensation to the employee if the condition is considered to be work-related.
The most widely accepted objective tests supporting or assessing the median neuropathy associated with CTS are electrophysiologic studies (Jablecki, 2002; Kimura, 1989; Remple et al, 1992; Stevens, 1987). Thus, at the time of employment, it may be beneficial to conduct CTS evaluations with nerve conduction studies to assess the integrity of the median nerve segment within the carpal tunnel. Nerve conduction tests at the time of hire may provide a baseline to assess dose-response relationships in longitudinal studies of risk factors for CTS. The purpose of this clinical investigation was to determine the prevalence of median nerve slowing across the carpal tunnel in applicants for industrial jobs.

Methods
Nerve conduction studies (NCS) were performed on both hands as part of a health assessment to applicants for jobs involved with poultry processing operations. Testing was performed following a conditional offer of employment but prior to the applicants job assignment at one of several processing areas in facility. All new applicants during a 3-year period were tested.
Each applicant completed a self-administered questionnaire (Rosecrance et al., 2002a) at the time of the health assessment. The questionnaire focused on hand symptoms that are commonly associated with CTS. Hand symptoms were coded as present if they were not caused by acute injury and had been present within the last two weeks. For surveillance purposes, an employee had symptoms consistent with CTS if they included numbness, tingling, pain/burning, or brachaligia paraesthesia nocturna localized to an anatomical area which included the median nerve distribution of the hand.
Nerve conduction studies were performed on both hands of each employee. Nerve conduction measurements were recorded with a Cadwell Sierra Wedge nerve conduction machine (Cadwell Labs, Kennewick, Washington). Mixed nerve latencies were determined over an 8 cm palmar segment for the median and ulnar nerves. Supramaximal stimulation was performed in the palm with a hand held bipolar stimulator. For sensory latencies, the recording electrode was eight centimeters proximal to the cathode of the bipolar stimulator. Median nerve latencies were measured with the active recording electrode placed over the median nerve two centimeters proximal to the distal wrist crease. The ulnar latency was measured with the active recording electrode placed two centimeters proximal to the distal wrist crease over the ulnar nerve. Sensory latency (peak latency) was determined as the time interval between onset of the stimulation artifact and the peak of the negative response. When median sensory responses were not obtained because of conduction blocks, median motor latencies were recorded. Median motor latencies were obtained by supramaximal stimulation of the median nerve 8 cm proximal to the abductor pollicis brevis. Motor latency was determined as the time between stimulation artifact and onset of the motor response. The choice of electrophysiologic NCS performed in this study was based on the practice parameters set forth by the American Association of Electrodiagnostic Medicine (Jablecki et al., 2002) and methods outlined by Anton and associates, (2002) and Roecrance and associates, (2002b).

Nerve conduction studies were performed by occupational health nurses trained and experienced in conducting the studies. Skin temperature was measured using a surface thermistor probe. Temperature was measured in the mid-palm and recorded prior to testing. Nerve conduction testing was performed in a warm room with the ambient temperature maintained between 21 and 23 degrees Celsius.

The primary electrophysiological measurement used to determine the prevalence of median nerve slowing was a comparison of the median nerve sensory latency to the ipsilateral ulnar nerve sensory latency. Thus, the median-ulnar latency difference in the right and left hands was used to determine the prevalence of median nerve slowing. The median ulnar latency difference was calculated by subtracting the ulnar sensory latency from the median sensory latency. Median nerve slowing was defined as a median ulnar latency difference of 0.5 ms or greater. This was chosen as a surveillance, rather than a diagnostic definition of median nerve slowing. A 0.6 ms difference was established because it represents a very conservative criterion for determining median nerve slowing within the carpal tunnel (Redmond and Rivner, 1988; Rosecrance et al., 2002). If a median sensory latency was not obtained because of a sensory conduction block, a median motor latency greater than 4.4 ms was used as the criteria for median nerve slowing.

Because the primary criteria for median nerve slowing was a comparison of the median and ulnar nerves, temperature correction was not performed on the latency values. The ulnar nerve served as an internal control for the median response. The median ulnar latency difference values were tested against a normal distribution with a mean and variance equal to the sample mean and variance.

Results

Over a three-year period 2,387 newly hired poultry processing workers (1695 men, 692 women) were evaluated. The average age was 32.0 years (SD, 11.3) and 33.1years SD, 9.9) for the men and women workers, respectively. Participation rate was 100% since the nerve conduction screening was part of the new hire process. Some applicants were excluded from the participating due to positive results to drug testing. Mean body mass index was 28 for men and 31 for women. The prevalence of median mononeuropathy among men was and 12% and 9% in the right and left hands, respectively. And among women the prevalence of median mononeuropathy was 20% and 17% in the right and left hands, respectively. Among the job applicants, only 6 (4.8%) women and 9 (4.8%) men that had a median mononeuropathy in either hand indicated that they had symptoms consistent with CTS in that hand.

Conclusions

Slowed median nerve conduction across the carpal tunnel in incumbent workers is reported to range between 3 and 49 percent (Bingham et al., 1996; Chaing et al., 1990; Franzblau et al., 1993; Nathan and Keniston, 1993; Nathan et al., 1988; Schottland et al., 1991; Werner et al., 2001). By definition, carpal tunnel syndrome is a condition primarily based upon neurological signs and symptoms and confirmed with nerve conduction studies. Median nerve conduction abnormalities within the carpal tunnel without symptoms do not necessarily constitute carpal tunnel syndrome. However, carpal tunnel syndrome in the face of normal electrodiagnostic findings has been reported and treated surgically (Grundberg, 1983).

While abnormal nerve conduction findings in the absence of symptoms do not represent clinical disease, prolonged latencies are objective evidence of segmental demyelination, axonal stenosis, or conduction block of large diameter axons (Kimura, 1989). Many of the

asymptomatic workers with abnormal nerve conduction tests in the present study may represent pre-symptomatic or asymptomatic neuropathy similar to the type of sub-clinical entrapment neuropathy described by Neary et al., (1975). Based upon our experience, asymptomatic workers with the most severe median nerve slowing are more likely to develop CTS with continued exposure to CTS risk factors (whether personal characteristics, occupational factors, or a combination).
Performing nerve conduction studies on applicants after a conditional offer of employment raises some important occupational issues. If the applicant with a positive NCS is eventually hired, will evidence of median neuropathy during application for employment be used by an employer to contest future CTS compensation claims? Additionally, if the applicant with a positive test is hired, placed in a job requiring repetitive hand intensive tasks, and develops CTS, can the employer be held liable for exposing an employee with significant median neuropathy to workplace hazards associated with CTS?
We conclude that a large percentage of applicants for food processing jobs have pre-existing median neuropathy within the carpal tunnel. It is quite likely that many employees diagnosed with carpal tunnel syndrome had the condition or its silent sub-clinical neuropathy before they began their employment. It is not known, however, whether their previous job tasks, recreational activities, personal characteristics, or a combination of these factors led to their condition. It is likely that CTS is a disease with multiple causality and that determining a single causative agent may be futile.

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Topic 1
"Safety in agricultural building and livestock"

Poster Presentation

Safety Characteristics of Bridleways

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Abstract
Bridleways can technically be defined as routes practicable for horses, generally on excavated paths, through interesting places under a landscape, cultural and gastronomic profile. Unfortunately however, many of these pathways don't hold in due account safety characteristics for the safeguard of the binomial horse-rider. The purpose of this job instead is to individuate the possible dangers which the binomial horse-rider can go toward and to define all those actions that can eliminate or reduce the possible risks without penalizing the technical and functional characteristics of the pathway.

Keywords*:* horse, safety, bridleway

Introduction

Technically a bridleway can be defined as an itinerary which can be followed on horseback, generally on a prepared trail, through attractive countryside and areas of gastronomic cultural or other importance. Unfortunately many of these trails do not meet the essential levels of safety for both horses and riders.

Thus what should be a relaxing ride can become a high risk activity if it is carried out on unprepared roads or mule tracks. The horses, even when they are well trained and well mannered, are also much more energetic and vigorous than the riders, and this can also be a source of danger.

This work is designed to identify the possible risks to horse and rider and to define the specific actions which should be taken to eliminate or reduce these risks, without damaging the technical or functional characteristics of the bridleways.

Methods

Planning bridleways must begin with an in-depth study of the available maps, in order to identify the network of paths available in the area and to identify those routes which will appeal to horseback trekkers because of the scenery, the environment or the history of the area that they pass through. Naturally the needs of the horse and rider must be taken into consideration right from the beginning, so that the bridleways chosen meet their requirements. The bridleways must be, as far as possible, easy and not technically difficult and should not exceed the threshold where they become too tiring for horse and/or rider. This means a maximum daily ride of not more than twenty-five to thirty kilometres, or about six hours for a horse at walking pace in mixed terrain. Along the bridleways there will be places to take breaks and rest at intervals of not more than three hours between them. These will have watering troughs for the horses and benches and tables for the riders as well as covered areas, which will allow both horses and riders to rest in the shade. Where possible these halts will be in places of particular scenic beauty or where there are particularly interesting buildings or archaeological monuments. Once such places have been identified the next step is to connect them to a logical and functional bridleway.

Safety Planning

Safety planning begins with an in-depth analysis of the map of the area, so that, generally speaking, impassible areas and rest areas can be identified.

Characteristics of the bridleway

Information from the maps and on site inspection of the area will provide indispensable data for defining the safety characteristics of the particular bridleway.
This data will include:

- a map of the route, including the distances between resting points and the total distance;
- steepest climbs and descents;
- inclinations of the slopes for the parts of the bridleways that run along hillsides;
- width of the bridleways;
- condition and material of the bridleways;
- presence of obstacles;
- possible fords;
- road crossings and passing through built up areas;
- watering points;
- signposts;
- presence of resting points, and, if necessary, assistance for horses and riders.

Technically speaking certain of this data will be necessary for planning the bridleways, while other items are merely useful information.

<u>The Route</u>

Preparing a good map of the route is the most important element from the point of view of safety, because it allows the rider to immediately ascertain the distances involved and the difficulty of the trail. Thus the map must be very detailed and must show the total and partial distances and the halts, possible basic dangers and also other less tangible ones which may depend on the particular conditions of the day. Modern mapping techniques allow us to prepare a detailed map using GPS references which allow the user to establish exactly where they are at any moment, and their position on the bridleway with reference to watering points, halts for themselves and the horses, and bathroom facilities. The bridleway and all the points of interest (halts, emergency facilities etc.) must be marked in digital geo-reference form (UTM-WGS84), on a 1:25,000 IGM map or better still a 1:10,000 CTR map. The map should also contain extra information such as contact information from the qualified Local Environmental Equestrian Guide recognised by the Regional Authorities and those of Fitetrec – Ante guide.

Steep climbs and descents

The different climbs and descents in both the overall excursion and in particular parts of the bridleway are very important.

When the climbs and descents are very steep they may be too tiring to both horse and rider and there is also the risk of injury to the horse's legs, especially on steep slopes.

In order for the ride to be enjoyable and safer the maximum slope should not be more than 40%, as anything above this is very demanding for the rider and exceptionally tiring for the horse as well as being very dangerous. This is particularly true in descents where the horse may slip and, as a result, the rider fall off. In a similar way trails which run along hillsides with steep slopes should be avoided as much as possible, and where they are unavoidable should be furnished with barriers to protect horse and rider against falls on the lower side and protection against falling rocks on the upper side.

Width of the Bridleway

Although in natural conditions horses can traverse any type of terrain, the minimum width of the bridleway needs to be defined. This should not be less than 0.80 m, except in exceptional circumstances, and should usually be about 2.00 m. Where possible the bridleway should avoid bottlenecks, overhangs, marshy or swampy ground and open grazing lands where the riders and horses could be attacked by the sheepdogs.

Condition and material of the bridleway

The normal gait for horseback trekking is the walk, with occasional short intervals of trotting, cantering or galloping. The latter is better and less tiring for the horse than a continuous trot. However in order for an occasional gallop to be safe the bridleway must have a specially prepared surface. The basic substructure of the bridleway should not consist of large stones, in order to avoid the risk of the horses damaging or casting a shoe, or suffering bruising, and as a result becoming lame. In this respect it is important to remember that horses cannot modify the elasticity of their legs quickly when they move from a softer to a harder surface, and so sudden changes in the compactness of the surface may be dangerous for the horse. On particularly steep stretches it is better to dismount and to lead the horse in order to avoid pointless risks.

Presence of obstacles on the bridleway

The bridleway must be kept in good condition and well-maintained, so as to avoid risks for the horses and riders. Fallen stones, branches or tree trunks left lying on the bridleway may make it unsafe. The bridleway should generally be checked monthly, but also particularly after bad weather, to ensure that it is safe to use. Rapid maintenance and repairs should be carried out if there is damage to the surface or safety walls, branches, tree trunks, or bushes across the bridleway or large puddles left by rain, and surrounding vegetation should be cut back so that it do not restrict the bridleway.

Fords

A ford is a place where a stream or river is shallow enough for it to be crossed on horseback or even on foot. While it is one of the highlights of a trip, one must bear in mind that the river bed is generally stony and sometimes slippery because of weeds growing on the stones. Thus fords should be crossed with care. One must also bear in mind that after heavy rain crossing a ford can be very difficult. Normally a horse will not enter the water without encouragement, although horses which are used to being used for trekking may do so. Unless there are other horses present which set an example, it is better to dismount and lead the horse across on foot. When crossing a stream at a ford, if the water is clean and not too cold and the horse is not sweating, the horse can be allowed to drink as much as it wants, but only if it is being led across on foot. A horse which found that it liked the water might suddenly lie down and roll over in the water to cool itself down.

Crossing roads

Crossings of heavily trafficked roads are one of the key points to be borne in mind when assessing the safety of a bridleway. This is both because horses naturally feel nervous when vehicles are passing and also because of the real danger involved in crossing a road or riding along a bridleway which runs alongside a road. Collisions with vehicles are possible if one loses control of the horse.

The horse's saddle and harness should be fitted with reflectors and the rider should wear a brightly coloured vest or jacket. Road signs should also inform drivers that horses may be crossing.

Watering points

There should be a good number of watering points at the halts along the bridleway because horses need to drink frequently. The horse should be allowed to drink on all possible occasions, with the possible exception of surface water which may often be polluted by run-offs from slag heaps. Water from mountain streams is, however, usually good, although it may be very cold.

The rider should dismount and lead the horse by the reins before a planned halt so that the animal can slowly cool down. Thus it is a good idea to put up signs giving advanced warning of halts so that the riders can do this.

Signs

The official signs for danger, mandatory obligations, prohibitions and directions will all carry the official logo of the bridleway. The bridleway will be assessed for difficulty, and will be classified as **T** (Tourist) or **E** (Excursion) for most of the route, with only short stretches or secondary or alternative routes being classified as **EE** (Excursions for Experts).

Characteristics of halts

The bridle way should be furnished with halts whose number will depend on the length and difficulty of the ride. These can be either simple structures with water troughs, covered shaded areas and small paddocks or more complex structures where the trekkers can stop for a picnic or even over night.

Halts

These are an important part of the bridleway because they allow the horse and rider to interrupt the trek and so not become overtired, which may be risky.

These halts will be found every five to seven kilometres along the bridleway, depending on its difficulty, and may either be isolated structures or connected to a nearby associated farm or agri-tourist farm. In these cases the advantage is the trek is safer because the farms will be able to provide rapid medical or veterinary assistance if it should be necessary.

- Isolated structures. May consist of simple covered areas which offer protection from the sun or rain, with hitching posts for the horses, a water trough and benches and tables for the riders. The animals can also be given part of their daily feed ration here, leaving part of it for the evening feed.

- Structures in farms. The farms involved in the organisation of the bridleways must provide certain standards of service for the horses. The horses are usually kept in the open or in stall inside the stables, but ideally the stalls should also be connected to an open area where the horses can stretch their legs and take advantage of the halt in the open air and also the sunshine.

<u>Resting places and overnight stops</u>
These are the terminal points of each day's trek and so must offer more and better services than the simple halts. They must be linked to agri-tourism farms which can guarantee a relaxing overnight stay for the riders as well as feed and stabling for the horses.
The structures for the horses must include a stable with stalls and paddocks for the animals as well as trained staff who can feed and water the animals and take care of their general well-being. To be more precise the structures must include:

<u>Safety conditions of stalls</u>

They should be preferably rectangular in shape, e.g. 3 m x 3 m or 3.3 m x 3.8 m. The corridors between the stalls should be wide enough for the horses and stablemen to pass freely, with a minimum width of 2.5 m. The flooring must be chosen with great care. It must be rough and easily washable and there must be a slope of about 2% towards the door.
The traditional straw bedding may be replaced by specially designed rubber floor covering. These are mechanically ideal as they ensure that there is no danger of the horses slipping, in particular when they rise to their feet. However there are some disadvantages in terms of animal health as micro-organisms can grow in the rubber and the underlying floor and these may be dangerous for the horses' health. They are also not ideal in terms of the environment in the stall, as they may increase the internal temperature, above all in hotter periods. Well-maintained and frequently changed good straw, rice husk, or peat bedding can absorb the liquid wastes of the horses. Drains to remove the liquid wastes are useless, as they constantly block and become smelly.
The stalls should be at least four metres high so that there is sufficient space to provide heat insulation. This is indispensable in order to stop the horse from becoming too hot in summer and to be comfortably warm in winter.
The walls and partitions must be smooth so that they are easy to clean and without projections that could injure the horses. Whatever type of paint or varnish is used must be lead-free to avoid possible lead poisoning, or saturnism, which can cause permanent damage to the horse's bones. The window should be a sufficiently large fanlight, and should not be less than 2.5 m above floor level.

The water trough must be without taps and furnished with an automatic system that will maintain the water level constant. It must be mounted about 1.1m above the floor and positioned in a corner of the stall, next to the manger.

Conclusion

Many different accidents may happen in the countryside. To avoid them one must simply adopt a sensible and responsible attitude, choosing routes which are suitable for the horses and riders and avoiding useless fatigue for both horses and riders as that can lead to loss of attention and concentration and thus greater risk.

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Safety Winery Design in the 21st Century

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Keywords: winery design, check list, workers safety

Introduction

A modern winery is a great investment. While the fundamentals of winemaking may not have changed over the centuries, the design of a functional winery has changed dramatically. They must be able to support the brand image where required but of equal importance need to be efficient in terms of energy and resources, be environmentally responsible and a good occupational health and safety.

These factors will have a major impact on the design of the winery and its surrounding facilities and must be considered at the concept stage before hitting the drawing board. Here we will focus on the small to medium sized wine making enterprise.

Whether you are building a new winery or upgrading an existing facility proper planning at the concept stage is critical. You should develop a design brief which clearly identifies and addresses the stakeholders' requirements, including:

- the philosophy behind the project including environmental, processing and marketing considerations;
- production projections covering all likely eventualities;
- winemaking methods required for each style;
- a project timeline and budget;

While some goal were always considered in each project the problem of safety and health during plan design is a new goal!

For example equipment layout and workflow design must consider the safety of operating and visiting personnel as well as the hygiene requirements of the plant and processes. Other factors to be considered are forklift access, anti-slip floor treatments, operating and maintenance access, lighting, safety showers, chemical storage, fire fighting equipment and personal protective equipment.

When determining the ventilation requirements of the winery, consideration must be given to the dissipation of carbon dioxide produced during fermentation, which, being heavier than air will tend to collect at the low points of the building. Therefore the design of the building must avoid enclosed pits or trenches that cannot be ventilated, such as crushing pits. In areas where carbon dioxide build up is a concern, consideration should be given to installing forced ventilation plus a permanent atmospheric monitoring and alarm system.

This article discusses the factors demanding consideration by the safety law and society when building a winery in according with a low work risk and good welfare for the winery workers. These factors will have a major impact on the design of the winery and its surrounding facilities and must be considered at the concept stage before hitting the drawing board. Here we will focus on the small to medium sized wine making enterprise

Methods

The research was carried out in 15 wineries in the Friuli-Venezia Giulia region and started in

Farms	Vineyard (ha)	Yield hl	Workers	
			Fixed	Temporary workers
Az. N°1	140	17.000	6	5
Az. N°2	100	14.500	7	2
Az. N°3	14	800	2	1
Az. N°4	18	830	3	-
Az. N°5	20	1.200	2	2
Az. N°6	28	1.500	2	3
Az. N°7	200	24.000	6	6
Az. N°8	230	23.000	11	12
Az. N°9	85	8.700	4	5
Az. N°10	13	500	1	2
Az. N°11	140	16.000	9	7
Az. N°12	25	2.200	3	8
Az. N°13	9	650	3	6
Az. N°14	38	1.000	2	9
Az. N°15	6	350	2	2

Table 1 – Sample of Farms.

June until December 2008 following four steps:
- sample planning and compiling check list;
- risk analysis;
- data elaboration with individuation of critical point;
- applied step with new method for safety and health management.

In the first step we have analyzed the farm sample and compiled the check-list following previous study (Gubiani et al, 2007). The check list control fours main aspect:

- formal aspects;
- real aspects;
- technical aspect;
- management aspects.

The second step required to built a scale of values for risk assessment (tab. 2)

Value	Description	Frequency	Assessment
1	not congruity	hjgh	max risk
2	critical situation	high	very high risk
3	real deficiency	medium high	high risk
4	structural deficiency	medium	medium high risk

5	deficiency	medium	medium risk
6	low deficency	medium low	medium risk
7	nothing deficiency	medium low	light risk
8	best practices	medium low	low risk
9	all good	low	negligible risk

Table 2 – Risk scale adopted in this research.

Third step, comprise the application in farm and real time the check list created in the second step, after this the data was put into Excel sheet, controlled and elaborate statistic for create radar graphics.
In the last step was design equipment layout and workflow design must consider the safety of operating and visiting personnel as well as the hygiene requirements of the plant and processes, operating and maintenance access, lighting, safety showers, chemical storage, fire fighting e other factors to be considered are forklift access, anti-slip floor treatment, equipment and personal protective equipment.
For new vinery design was take following items:

- process flow;
- building characteristic;
- plant layout;
- rules for fire prevention;
- material and equipment used in vinery;
- ergonomic and comfort in workplaces;
- plant features for safety and health prevention.

  For good design we have take a typical vinery located in Friuli area "DOC Grave" and normal managed with a production about 10.000 hl of wine.

Results
The results are show by three steps.

In the risk analysis step were divided in some main points:

1- access area, viability, gateway and inner passage. In this checklist question was observed some risk in ladder because don't exist a best practices to use it (fig. 1).
2- buildings, structures, stores. In this case often we show scarcity of lighting and the bath not divided in man/woman. The pesticides stores not are signed and closed and often so little (fig. 2);
3- services plant. Not find a risk in this area (fig 2).
4- harvesting and processing area. The risk is high because a lot of worker are present during grave harvesting and often not use PPT and are also some foreign. Also in this area where find the critical point show not sufficient management and organization to the workplaces and space in the winery (fig. 2).
5- safety management. This area show how the little winery have more problems to management of safety than the largest winery where can have one or more manager for safety (fig. 3).

In general show others risk problems related to the logistics of grape receival (risks include slips, trips and falls, being hit, or hitting an object, body stressing and manual handling), Crushing/pressing (risks include plant, manual handling, body stressing) grape receiving, the specific requirements of the processes to suit the style of wine to be produced, efficient workflows, the impact of the site conditions, environmental considerations, efficient energy systems cause low attention in safety.

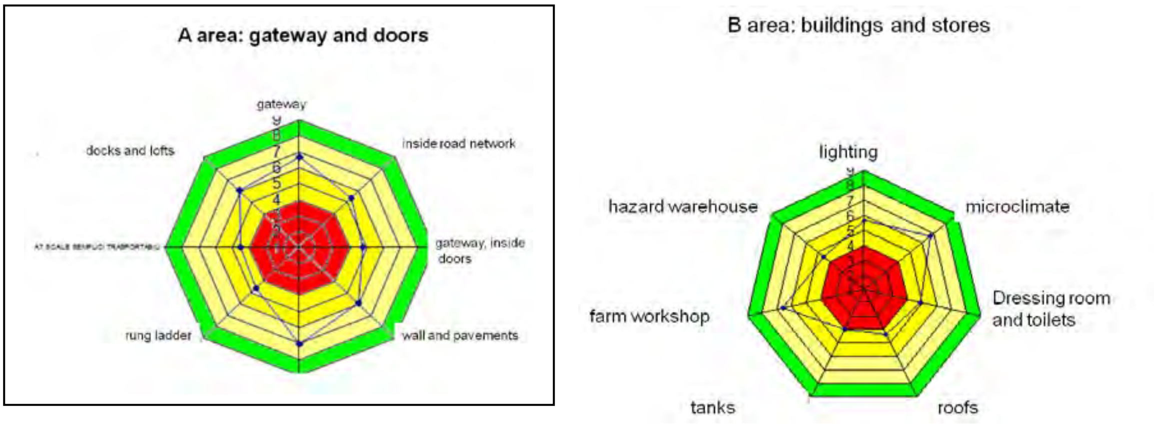

Figure 1 – Radar graph for risk in area A e B.

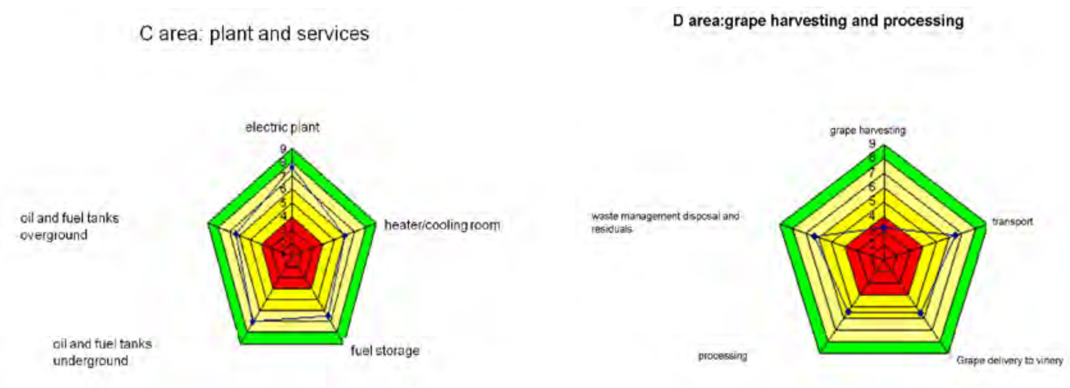

Figure 2 – Radar graph for risk in area C and D.

Figure 3 – Radar graph for risk in area E.

In the last step the research show that when the design was make considering also safety requirements is possible:
- one reduction of the costs for safety managements;
- better control of workflow;
- management rationalization in the winery.

For to get this goals we have design a vinery on two floors, the basement is assigned to ageing located under storage and bottling area while the other floor is assigned for wine production.
The building is divided in two main area, one for grape receiving and wine processing and is 45 m long and 22 wide. The second area include bottling , storage and offices and as 27 m long and 20 wide. The wall was in reinforced concrete while the roof is in wood beam and roof tile (fig. 4).

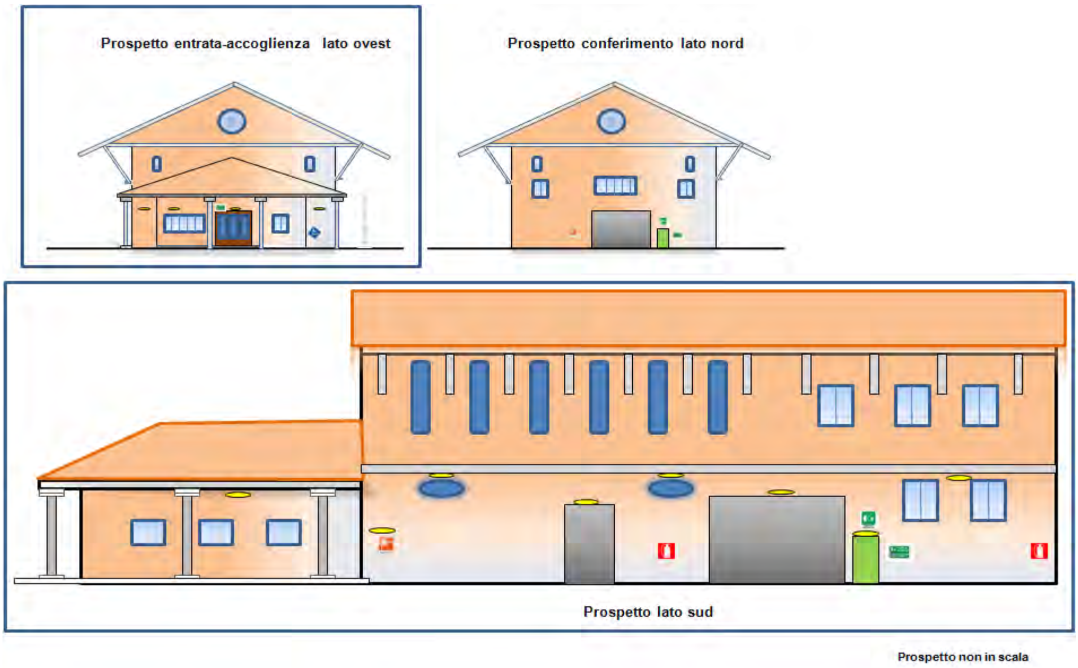

Figure 4 – Project view to building of vinery, in particular show safety solutions

On the north side of the building is located the receiving area with this equipment:
- weighbridge;
- crusching machine;
- winepress;
- berry store;
- store exhausted bunch.

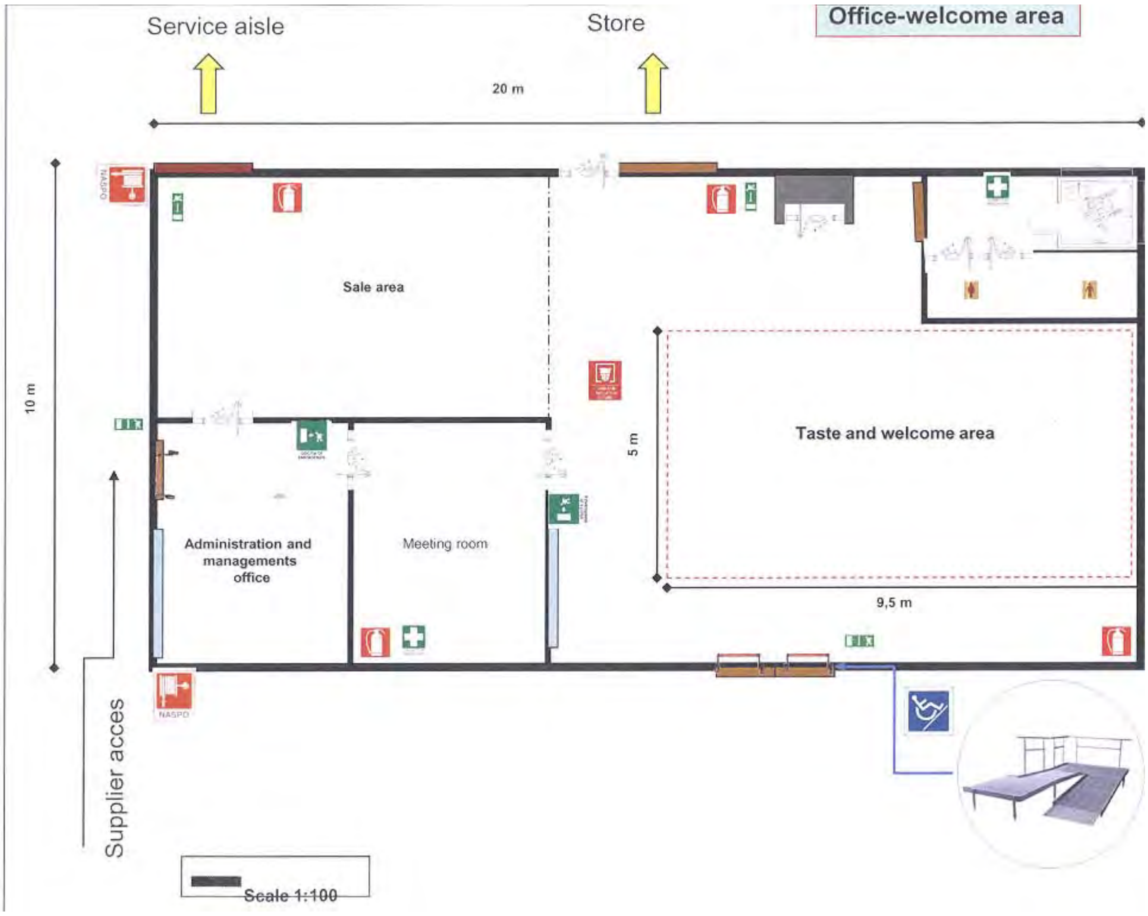

Figure 5 – Plant of second building with office and welcome area

In the south of winery building is located the wine processing area and the layout have laboratory, bath for m/f and kitchen for workers.
In the secondary building is located the bottling room, main store and office and reception area. This last area is composed (fig. 5):

- offices;
- toilettes;
- wine tasting room;
- sales room.

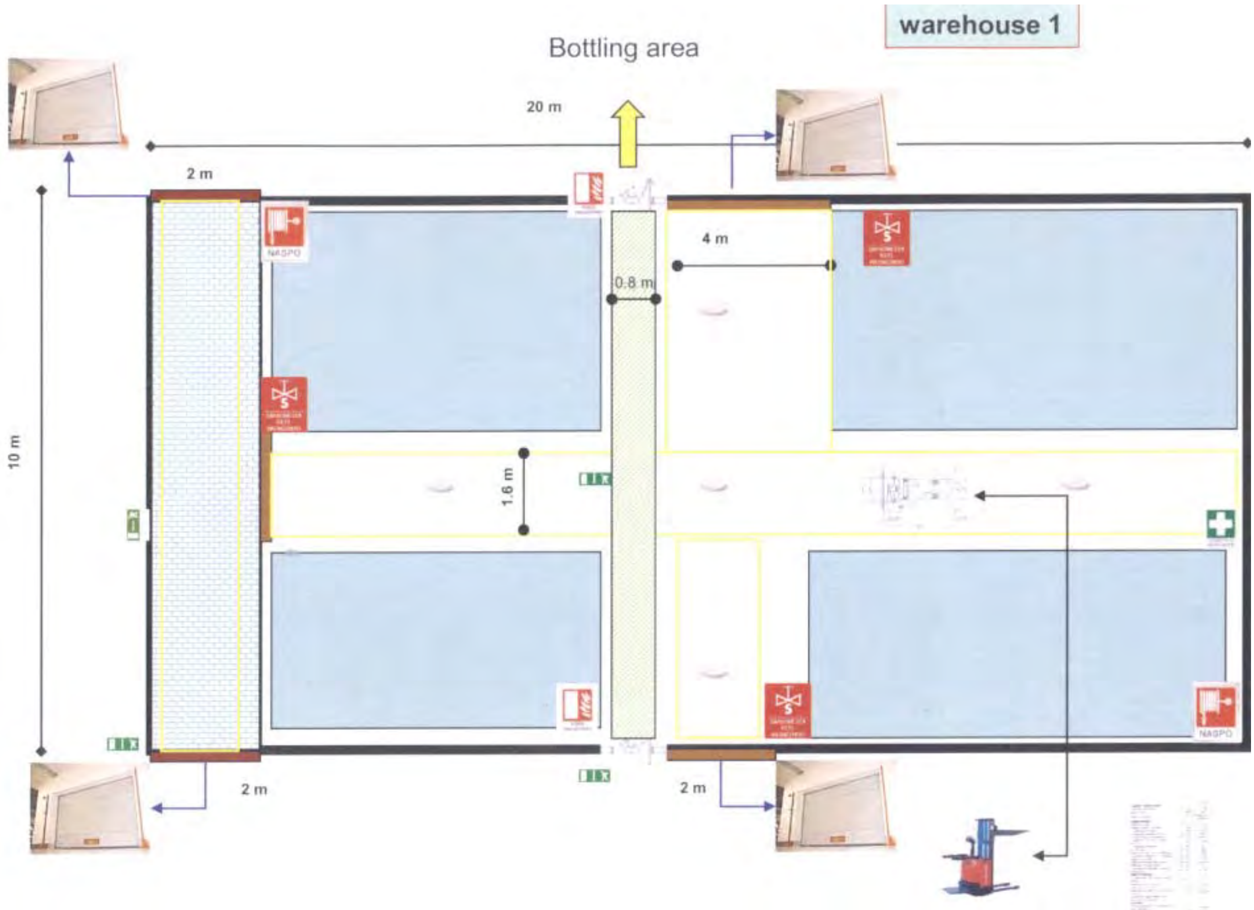

Figure 6 – Plant of bottling area

All the room in the winery were designed for:
- allow all the operations in safety mode;
- easy crossing by the fork lift or workers with equipment specially in bottling room where the materials is moved more (fig. 6);
- safety path for touristic visit in the winery.

The winery outside area is composed with green area and exhibition vineyard for the tourist people. Near the winery buildings is also the building for machinery and equipment used for vineyard working and store for pesticides. Particularly attention was make for design access to winery with different path for car, tractors and truck.
After structure design was also design equipment to winery. The wine tanks is all in stainless steel with temperature control and a safety system for inspection with a boardwalk with parapet about 100 and layer for stop foot about 15 cm.

Conclusions

The audit demonstrates that the areas presenting the greatest risks to employee health and safety related to:
- plant risk control;
- working at heights;
- chemical storage and use.

A significant number of notices were issued for safety breaches in these areas and more in little vinery.
One better design of winery allows:
- to reduce safety management costs;
- better control of processing flow;
- rational management into winery.

This work like to demonstrate how one good design of the winery can rise the work productivity and increase the welfare of the workers.
Spending time for project on health and safety will help create a better work environment and a better quality in wine.

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Thermal Disinfection of Poultry Grow-Out Facilities in Central-Northern Italy

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Abstract

Chemical treatments are commonly adopted for poultry houses sanitation. In fact, an ordinary floor disinfection is needed to achieve the depletion of pathogenic population (i.e. some species of bacteria and fungi) and reduce the risk of meat contamination. Recently, the increasing of popular attention to the consumers and operators health, and to the quality of food, brought the farmers to consider environmental friendly alternative methods.

A specific two-year experimental trial (2005-2007) was carried out in the Central-Northern part of Italy in order to set up new machines and strategies for floor disinfection of poultry houses by means of an open flame. Trials were run in the machine shop of the University of Pisa (indoor, under controlled conditions) and in two different private farms (a broiler house and an outdoor pheasant farm).

The first experiment consisted in a series of test bench trials, carried out in order to test the efficacy and the adjustment of LPG fed open flame burner on pre-inoculated steel plates. During the second experiment, the ordinary chemical disinfection strategy was compared, in the broiler house, to the innovative technique, carried out by means of an on purpose made 1.5 m wide mounted flaming machine. The last experiment consisted in the evaluation of the efficacy and operative performances of a 2 m wide flaming machine prototype on purpose built for open air pheasant farms.

The obtained results are very promising as, thermal disinfection strategy seems to be very effective on floor pathogens and cheaper than the ordinary chemical one.

Keywords: poultry house sanitation, flame disinfection, flaming machine

Introduction

Reducing bacterial and fungal populations is a major issue in poultry houses (Payne *et al*., 2002 and 2005).The presence of a high population of pathogenic bacteria in broiler grow-out houses can contribute in declining the wellness of the flock and lead to a sensitive production loss (Payne *et al*., 2002 and 2005).

Moreover there are further problems concerning industrial processing, food quality and consumers health as carcasses could be seriously contaminated by dangerous micro organisms like *Salmonella* and *Campylobacter* (Mead & Scott, 1994; Payne *et al.*, 2002 and 2005).

For these reasons, a major issue of poultry industry is to prevent product contamination through bacterial population reduction programs during the growing phase of animals (Payne *et al*., 2002 and 2005).

In this respect, specific researches have been carried out in Europe and United States aiming to find effective solutions to decrease dangerous micro organisms presence or significantly low their growth rate (Payne *et al.*, 2002 and 2005; Gradel *et al.*, 2004 and 2005).

In this regard, recent studies showed that considerable reductions of bacterial population can be achieved by removing the old litter followed by cleaning and disinfecting of facilities. It

usually occurs between the end of a growing cycle and the beginning of the following one, as broiler houses generally are not cleaned during the growing cycle. This disinfection treatment is generally performed by means of specific chemical sanitizers (Marin *et al.*, 2009). Moreover there is a common concern in Europe about food health and the application of potentially dangerous chemical products.
The aim of this research is to develop effective and environmental-friendly solutions in order to eliminate or reduce dangerous bacterial population in the period between flocks in broiler houses (indoor-reared broilers) and open air pheasant houses.
An on purpose made flaming machine was build and set up in order to carried out specific trials and evaluate the possibility to substitute chemical disinfectants with thermal treatments.

Materials and methods
Controlled conditions experiment
The first experiment was carried out in the laboratory of agricultural machinery and farm mechanization of Dipartimento di Agronomia e Gestione dell'Agroecosistema (DAGA) of the University of Pisa (Central Italy).
A specific test bench was used in order to evaluate the effectiveness of an on purpose made open flame burner for house floor thermal disinfection. This bench was used in the past to evaluate the effect of different adjustments of specific burners for flame weeding.
Artificially pre-inoculated steel plates were treated with an open flame cylinder shaped burner, the same one used for on-farm trials (fig. 1).

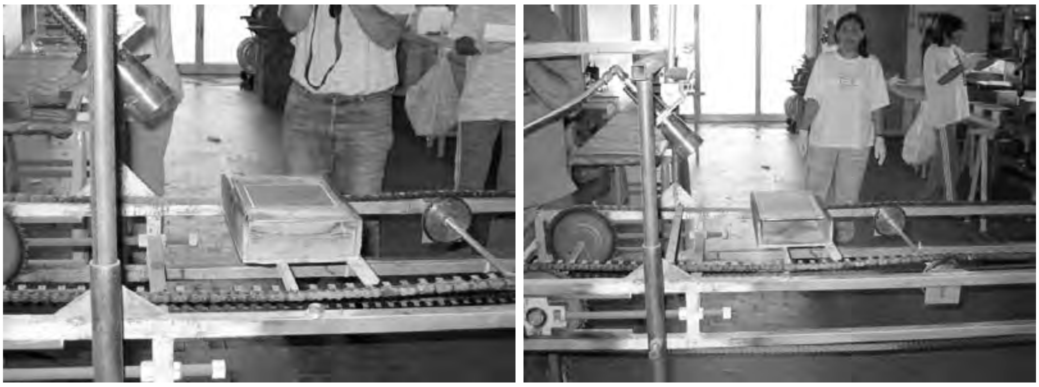


Figure 1. Flaming treatment of a pre-inoculated steel plate on test bench.

Three thermal treatments were compared, as generated by different combinations of LPG pressure and working speed: 0.12 MPa and 1 km h^{-1}; 0.12 MPa and 3 km h^{-1}; 0.16 MPa and 3 km h^{-1}. LPG consumption per hour and flame temperature were assessed.
Flame temperature was registered by means of a specific "R" type bifilar thermocouple (range 600-1700 °C). It was made by a platinum-rhodium alloy. The diameter of each filament was equal to 0.5 mm. LPG tanks were weighed before and after 15 minutes of continuous work in order to evaluate LPG consumption. Replication was 6-fold.
Each plate (containing an inoculated marked surface of 12 × 12 cm) was identified, sterilized and packed with a paper sheet. *Escherichia coli* AT 25922 and *Lactobacillus plantarum* ATCC 8014 were used as contaminating bacteria. Bacterial suspension was prepared with horse serum and a concentration of 10^9 cfu/mL.
Bacterial suspensions were successively titrated through decimal progressive dilutions, inoculating, by means of micro method (20 μL per dilution), blood agar for *E. coli* numeration

(24 h of growth at 37 °C) and MRS agar for *L. plantarum* numeration (48 h of growth at 37 °C - microaerophilic, 10% CO_2). After removing the package, each plate was inoculated with 100 μL of *E. coli* and 100 μL of *L. plantarum* suspension. Two drops were placed within the marked surface and uniformly distributed with a "L shaped" sterile spatula. Treatments were performed just after leaving plates drying out. Replication was 6-fold. Six plates were inoculated and used as untreated control. Bacteria were recovered after treatment in order to evaluate its effectiveness. Plates recover was carried out just by one operator in order to make this process as homogeneous as possible. Test tubes containing bacterial suspension were maintained at refrigeration temperature before laboratory analysis. Surviving microorganisms numeration was carried out following the same procedures described above. Moreover, *E. coli* numeration was carried out on both on blood agar and Violet Red Bile agar.

On-farm trials

Trials were carried out in two different farms: "Pratomagno" for house reared broilers and "La Viola" for open air reared pheasants.

Experiments in broilers house were carried out in September 2006 in two different barns of 1000 m^2 each. Ordinary chemical disinfection technique was compared to the innovative flaming disinfection.

Ordinary technique consisted in litter removal, equipments removal, equipments and ceiling washing, floor washing by means of water jet and/or submersion plus detergents based on sodium and potassium, washing water draining and dry chemical disinfection and finally litter re-establishment.

Innovative-low environmental impact method was characterized by the use of an on purpose made prototype equipped with LPG fed open flame burners with and a rear hood. Thermal treatments were performed as an alternative to floor washing and dry disinfection. Operative (working width, working speed, actual and operative working time, operative efficiency and fuel and LPG consumptions) and economic parameters were assessed and estimated referring to 1000 m^2.

"Biological" effectiveness of the two techniques was evaluated by means of steel plates placed on the floor after treatments. Plates were the same described above. After flock removal plates were recovered and analyzed. Plates recover was carried out just by one operator in order to make this process as homogeneous as possible. Microorganism numeration was carried out on mesophilic aerobic bacteria (Plate Count Agar, 48 hours at 37 °C), Enterobacteriaceae (Violet Red Bile Glucose agar, 24 hours at 37 °C), anaerobic sulphite reducers clostridia (TSC agar, 48 hours at 37 °C). On each plate (on a 30 cm^2 surface), *Salmonella* spp. was detected.

Trials carried out on pheasant open-air aviary were performed in April 2007 aiming to assess operative performances and biological effectiveness of an innovative on purpose made flaming machine.

In this case, ordinary strategy was already characterized by the use of thermal treatments. It consisted in dry *sorgum-chenopodium* meadow mulching (sowed for hosting game), thermal treatment, fertilization and deep moldboard plowing followed by secondary tillage. Thus this strategy was compared to a conventional one characterized by all the above described passes but thermal intervention. Aviaries dimension was ranging from 3000 up to 10000 m^2. Operative and biological assessments were carried out as described for broiler house.

Statistical analysis

Concerning bacterial data, Kruskall-Wallis and multiple rank comparisons tests were utilized for under controlled conditions experiment. On-farm data were processed with median test. Analysis were performed with R software (version 2..5.1).

Operative and economic data were not statistically processed.

Description of innovative machines for flame disinfection of poultry houses

Two different semi-mounted operative machines were tested. They were built in cooperation with Officine Mingozzi (Ferrara, Northen Italy).

Figure 2. Flaming treatment in broiler house.

They were similar concerning operative principle, but working width and the numbers of burners and LPG tanks were different.

The first prototype, PTE1600, was on purpose made for indoor treatments in broiler houses (fig. 2).The machine is small sized (1.60 m wide, 1.45 m long and 280 kg in weigh) and equipped with just one common commercial LPG tank 25 kg in weigh. These features allow this machine to be coupled with low power tractors (10-12 kW) and work on the upper floor of broiler houses without any problem of exceeding weigh and manoeuvrability. This operative machine is equipped with 20 cylinder shaped open flame burners (16 fixed under the hood and 4 placed on the side of the machine in order to treat the base of walls) and a manual lance connected with a 10 m long pipe (fig. 2). Moreover the machine is also equipped with an heat exchange system (that utilizes part of LPG contained in the tank) and an electronic panel placed on the hood of the tractor, reporting any anomalies in functioning, as burners turning off, pressure decrease.

The other prototype, PTR2000 (fig. 3), was developed to work outdoor on the soil, in pheasant aviary, thus it was characterized by a larger size. The machine was 2 m wide, 2 m long, 900 kg in weigh and it was equipped with two LPG tanks (25 kg in weigh each). In this case, the operative machine was coupled with a 55 kW 4WD tractor. All the other features are similar to those described for PTE1600.

Figure 3. Flaming treatment in pheasant aviary.

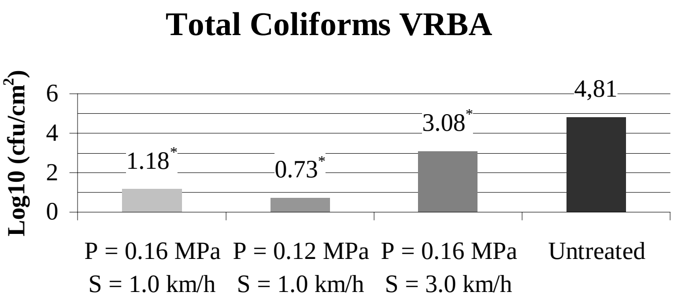
Results

Controlled conditions experiment

In table 1 it is shown that temperature of flame measured at the working level was the same for the two pressures tested but LPG consumption per hour was 20% higher for the higher pressure.

Table 1. Flame temperature and LPG consumption per hour of burner.

Pressure	Temperature	Consumption (kg h^{-1})
0.12	1220	2.5
0.16	1220	3.0



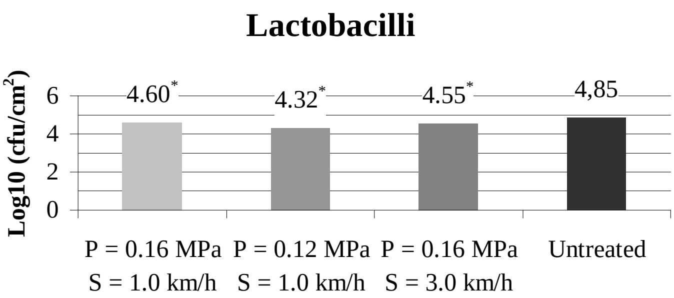


Figure 4. Microbial response to flaming treatments. Star means (*) significant differences *vs* untreated control.

In Figure 4 the microbiological results are shown. Recovery of Coliforms was considerably lower for treated plates, as flaming achieved relevant reductions of bacterial population. This difference was significant for Kruskall-Wallis test ($p<0.01$) and also for multiple comparison test.

Lactobacilli, as expected, showed an higher recovery, as it is known their superior tolerance to heat. However, statistical tests showed again a significant decrease in bacterial population. Furthermore, lower pressure treatment achieved better results with respect to higher pressure intervention.

On-farm trials

Operative performances for indoor treatments are shown in table 2.

Working speed ranged from 1.2 up to 1.5 km h^{-1}, and LPG pressure was 0.12 MPa as resulted the best adjustment during the previous series of trials. This technique required 30 minutes and 15 kg of LPG to treat 1000 m^2. Operative efficiency was equal to 85%. Fuel consumption was really very low (about 0.3 kg/1000 m^2).

Table 2. Operative performances of innovative flaming machine registered during on-farm trials carried out in broiler houses.

Operative performances		**Results**
Engine power	kW	12
Working width	m	1.5
Working speed	km/h	1.2-1.5
Actual working time	h/1000 m^2	0.45-0.54
Operative working time	h/1000 m^2	0.54-0.63
Operative efficiency	%	83-86
Working capacity	m^2/h	1590-1850
Fuel consumption	kg/1000 m^2	0.27-0.31
LPG pressure	MPa	0.12
LPG consumption	kg/1000 m^2	14.5-16.9

Operative cost evaluation for thermal treatment was about 30 €/1000 m^2. This value is very encouraging as estimated costs for ordinary chemical disinfection is over 200 €/1000 m^2 just for labour salary (two persons for the entire working day). Moreover thermal treatments do not require floor washing water and disposal.

Operative performances for indoor treatments are shown in table 3.

Table 3. Operative performances of innovative flaming machine registered during on-farm trials carried out in pheasant aviary.

Operative performances		**Results**
Engine power	kW	55
Working width	m	2.0
Working speed	km/h	1.5
Actual working time	h/ha	3.33
Operative working time	h/ha	3.84
Operative efficiency	%	86
Working capacity	ha/h	0.26
Fuel consumption	kg/ha	10.7
LPG pressure	MPa	0.12
LPG consumption	kg/ha	166.5

Tractor power, in this case, was 55 kW and working width was 2 m. LPG consumption was 166 kg ha^{-1} while fuel consumption was about 10 kg ha^{-1}. Thus, these values were definitively similar to the ones observed in broiler house.

Table 4. Biological results of on-farm trials.

Farm	Assessment	Flaming (cfu/cm^2)			Ordinary (cfu/cm^2)		
		min	median	max	min	mediana	max
broiler (1)	mesophilic aerobic bacteria	1,050,000	1,912,500	33,000,000	23,250	1,672,500	20,250,000
	Enterobacteriaceae	<150	125	375	<150	<150	225
broiler (2)	mesophilic aerobic bacteria	65,000	450,000	22,000,000	975	61,250	12,500,000
	anaerobic sulphite reducers clostridia	<50	<50	3,000	<50	<50	225
Pheasant aviary	mesophilic aerobic bacteria	1,150	22,500	107,500	17,500	65,000	170,000
	Enterobatteriaceefila	20	166	775	98	500	950

In table 4 bacterial populations results for on-farm trials are shown.
Concerning broiler houses, no significant differences were found between ordinary chemical disinfection strategy and innovative thermal technique. Thus the two methods appeared equivalent from a biological point of view.
Concerning open air pheasant aviary trials, median test showed significant differences, thus the use of flaming allowed a relevant decrease of bacterial population.

Conclusion

The results of this research showed that flaming disinfection of poultry grow-out facilities can be seriously taken into account as an alternative to chemical disinfection.
Moreover it is an environmental friendly technique and does not require floor washing and water disposal.
Under controlled conditions trials gave precious advice about burners adjustment and effectiveness, in order to set up on-farm trials properly.
The results of the on-farm trials showed that flaming can reach a very good bacterial control level, comparable to chemical dry treatment in broiler houses. Moreover flaming allowed to reach a significant reduction of micro organisms population when applied in open air aviary for pheasants grow-out.
Innovative equipments allow to carry out effective treatments with good operative performances in difficult contexts. Furthermore, for broiler houses, flaming estimated costs were relevantly lower than ordinary chemical dry disinfection. Finally, as future perspective, it could be possible to improve operative performances by means of a specific experiment, aiming to further reduce LPG consumption and costs.

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Design Parameters of the Factory Buildings for Marmalades and Jams

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Abstract
A preliminary survey in Sicily highlighted thirty suitable companies specialised in making marmalades and jams of which half are within the protected denomination zones of "Ficodindia dell'Etna e di San Cono DOP", "Arancia di Ribera DOP" (Etna and San Cono Prickly Pear PDO, Ribera Orange PDO), "Arancia Rossa di Sicilia IGP" (Blood Orange of Sicily PGI), "Pesca di Leonforte e Limone di Siracusa IGP" (Leonforte Peach and Syracusa Lemon PGI). These companies work with various fruit varieties particularly with citrus fruit and prickly pears. From analyses of the factory buildings, and the environmental and organisational aspects of production phases there are design shortcomings which limit operations and the quality the production systems. Production often takes place in factory buildings built for other purposes and subsequently adapted, and furthermore some are totally off the beaten track. These buildings have spaces and operational flows which do not correspond to the necessities of either production or current norms. Apart from creating operational difficulties and health and hygiene risks, this denigrates the companies' role as driving forces in the re-appraisement of territorial assets based on developing tourist itineraries for gastronomy and local culture. The aim of this study, given the total lack of specific design outlines for rationalizing the production of marmalades and jams, is to propose guidelines for organising work-spaces and health and hygiene requisites.

Keywords: traditional produce, meta-project, building quality, company layouts

1. Introduction

National ISTAT (annual statistics for industrial output) data for 2007 show that average production of citrus conserves and marmalades was 153000 t. The greatest European consumers are Germany, Holland and France with Italy's consumption on the rise over the last 4 – 5 years at breakfast, as an appetiser, in confectionery, and in particular in babies' diets (Stefanoni, 2009).
In Sicily, marmalade production contributes to the local economy and helps maintain rural traditions. Some European studies have shown how the value of local products can help safeguard rural communities. Aside from being agricultural or artisan food products, they are also products of the territory – of its natural and cultural resources.
Analyses of factory buildings, and environmental and organisational aspects of the production phases of 'marmalades and jams in Sicily within the protected denomination zones of Etna and San Cono Prickly Pear PDO (Protected Designation of Origin), Ribera Orange PDO, Blood Orange of Sicily PGI (Protected Geographical Indication), Leonforte Peach and Syracusa Lemon PGI, have highlighted design shortcomings which limit operations and the quality of these production systems.
Production takes place in buildings designed for other uses which have been approximately adapted, and in some cases are quite far from the main routes of communication.
These buildings exhibit spaces and work flows which neither meet production requirements nor the applicable norms. For example, ingredients are often stored alongside empty jars and

cardboard. This inconveniences employees who are forced to work in cramped spaces between considerable stacks which limit visibility (D.P.R 327/80 art. 28). Other obvious examples are the absence or adoption of insufficient ventilation to clear the accumulated condensation; the absence of outside spaces for ferrying incoming or outgoing products and the lack of asphalt; wash-water and puddles on the floor making the environment unhygienic and dangerous for employees. Apart from creating production difficulties and health and safety risks, it denigrates the driving force behind the firm as a value-adder to the territory based on developing cultural and gastronomic tourism itineraries.
Making production buildings part of these itineraries with consequent product spread beyond regional borders can only improve current production systems while respecting tradition.
So, since there are no design templates for producing marmalades and jams/conserves, this study proposes design layouts for small, medium and large manufacturers.

2. Material and methods

This research uses the metadesign approach to analyse the production requirements for making marmalades and jams outlining the consequent functional and building requisites for the production facilities. This time-proven method applied to other sectors of the agricultural food industry has been able to define interesting outcomes for designing a variety of building facilities (Strano et al., 2006a).
The study was carried out in the following phases:
a) survey of marmalade and jam/conserve producers in PDO and PGI fruit areas choosing the most innovative ones;
b) analysis of employee activities and machine functions relative to production cycle and operational space;
c) defining the building most appropriate for producing marmalades and conserves.
Initially, the company survey chose samples as per point a). The following data were collected in for each company: production size, production spaces, organisational and building characteristics, health, hygiene and safety characteristics, products, production cycles, plant technology, raw material quantities and product sales, and employee activities and requirements (Strano et al., 2009b and 2009c). The data was collected on tick charts integrated with flow charts (products, employees & vehicles).
Furthermore, the main legislative norms on product hygiene and workplace safety were considered as they influence defining the *building regulations* and design.
Data processing and comparison highlighted production cycle requirements, employee and machine operations, as well as any design, environmental and organisational criticalities to define the building regulations. The methodology in this last phase has been amply developed in other scientific articles (Fichera et al., 1995).

3. Results

3.1 Analysing the existing buildings and facilities and identifying production requirements

In January 2009 on the website of the National Chamber of Commerce under 'Fruit and vegetable production and conservation' in Sicily, 30 companies specialised in 'marmalades and jams/conserves' were selected and surveyed.
Most of the companies are based in Eastern Sicily and they deal mainly with citrus fruit and prickly pears. About 50% of the companies lie within areas of protected denomination.

Of these, 13 companies from PDO and PGI areas were chosen to help identify the building requirements for production.

The data identified three company types:

- Artisan: the equipment used is simple – cooking is in a saucepan and all the preparation is manual. Pasteurisation is not always carried out. On average 4 employees produce 300 kg/day of marmalade and conserve.
- Semi-industrial: some production phases are technologically advanced but some are manual. The production line is interrupted for pasteurisation and cooling so most employee interventions occur at the beginning or end of the cycle. On average, 5 employees produce 1000 kg/day of product.
- Industrial: the building facilities are similar to the semi-industrial ones except the production line is not interrupted right up to packaging. The production line reduces employee intervention. On average, 12 employees produce 3500 kg/day of product.

Analysis of the production lines (process, equipment, facilities) has helped identify environmental, functional and technological issues relating to the companies' building characteristics within their territorial contexts (Strano et al., 2009b and 2009c).

The company study helped identify some invariants as references in defining the building facility:

- there are three production types: manual, mostly based on employees; semi-mechanized, based on machines which aid the manual work; mechanized, based on entire mechanized production lines;
- for the manual and semi-mechanized cycles, the equipment is similar to that usually used but it needs to be better organised and the spaces managed better;
- for the mechanized cycle, some equipment and plant used for other types of product (ready sauces, tomato extract, fruit juices) can be applied by rationalising the layout and organising internal space;
- it is recommended that production spaces are physically subdivided to differentiate protection levels and thermohygrometric parameters at every production phase. When necessary, these conditions can be evaluated according to company size. In small companies, it may be sufficient to physically separate 'dirty zones' from 'clean zones'.

Furthermore, all those areas dedicated to mechanized product conveying should be clearly marked to guarantee appropriate safety levels and create design solutions to maintain environmental hygiene.

3.2 Production phases

Marmalade production originated in ancient Greece to conserve quinces by slow cooking them to concentrate the sugar they contain. Various documents attest to their name as 'honey apple' (http://en.wikipedia.org/wiki/Marmalade, June 2010)

The procedure for making marmalade is simple: the peeled, cored and chopped fruit is cooked with sugar and hermetically sealed boiling into jars.

The sugar and residual heat in the jars guaranteed long conservation even without refrigeration.

Marmalade is defined as originating exclusively from citrus fruit, whereas jam is made with other fruit like apples, pears, peaches, prickly pears, strawberries etc. (Directive 2001/113/EC). Figure 1 chart the production process which when analysed together with its connected activities helps define the building regulations and then the reference design criteria for this sector.

3.3 Defining the building regulations

Analysing production helps identify size, environmental, safety and access point requirements so as to organise space into sectors or space units.

Sector planimetry derives from the aggregation of workplaces as a result of employee number, vehicular transit, product type and the specifics of production phase (aggregated activities).

By analysing the methods of production and taking into account the ‘invariants’ above, defining the building regulations makes reference to three categories of production line: manual, semi-mechanized and mechanized. The spaces (Spatial Units and Enviromental Units) shared by these three lines have been defined as have those exclusive to the manual and semi-mechanized lines (lines a & b fig. 2). Figure 3 shows the Enviromental Units specific to each line.

In the design phase, the different Enviromental Units must be arranged so that over time any production line expansion can be made without interference. Analysing the needs and interflow between production spaces helped produce the three organisational layouts in figures 4 & 5. They exemplify how to organise manual, semi-mechanized and mechanized production. Subsequently, there are summarised descriptions of the building characteristics of the production sectors, whereas at this stage the design characteristics of the support departments can be referred to in specialised manuals.

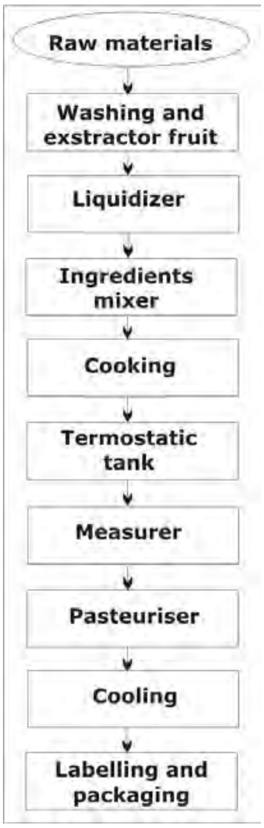


Figure 1. Chart the production process

<u>The Enviromental Units for preparing marmalades and jams</u>

Manual, semi-mechanized and mechanized production lines require the following units as part of the ‘production sector’: fruit store; ingredients store; jar store; cardboard and packaging store; cold store; equipment wash; fruit wash; transformation; finished product store and waste store. The three production lines are differentiated by the space they occupy, the fact that the manual line converges several enviromental units and by the differing equipment and spaces employed for fruit washing and transformation. Below, the enviromental units are summarised and figures 2 and 3 show the planimetric organisation.

The *fruit store* must be directly accessible from outside. It is characterised by cases of fruit, aisles for the transit of employees and vehicles, durable and easily cleaned floors and air conditioning. So its efficiency depends on ease of transit.

The *ingredients store* must be cool and well-aired. It should be equipped to store sugar, pectin, and juice concentrates and have platforms for bins and tanks. The organisation of space must be such that hygiene may be checked, there is protection against external agents, and there is easy transit of employees and small transport vehicles to and from other spaces. It should be connected to the outside and transformation space.

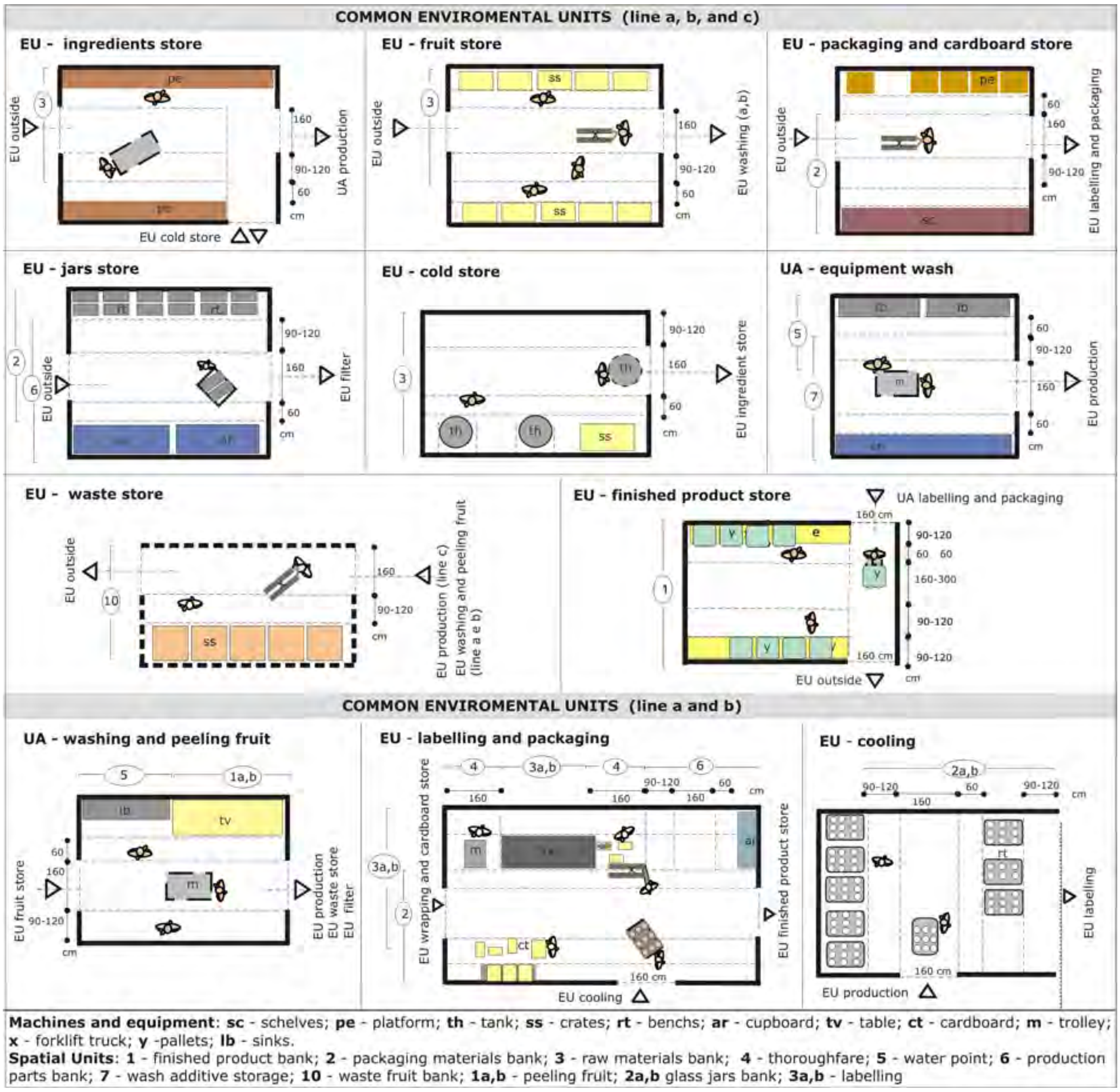
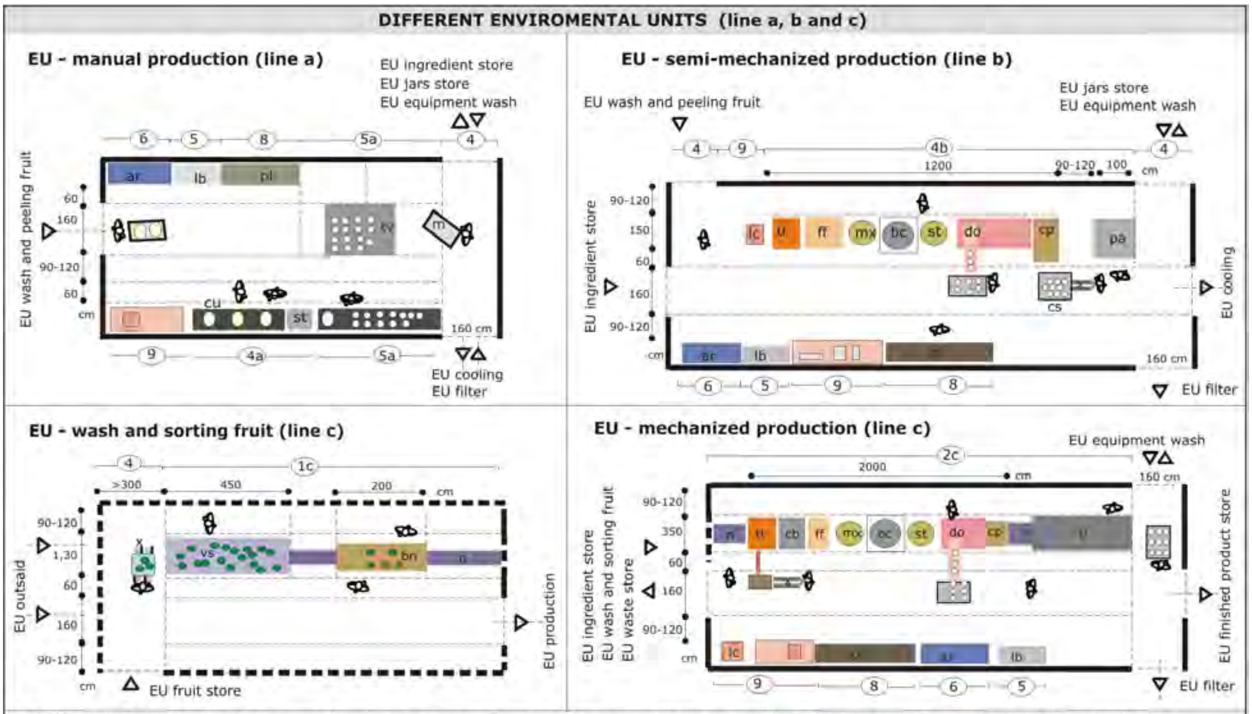


Figure 2. Organisational layouts of Enviromental Units common to all three lines and those just for the manual and semi-mechanized lines (a & b).

The *jar store* must accommodate all the empty jars. Its size depends on the numbers of pallets required. It should be connected to the outside and transformation space as well as enable easy transit of employees and transport.
The *packaging and cardboard store* holds shelving and enables the easy transit of trolleys. It should be connected to the outside and the labelling unit.
The *cold store* holds unfinished product, fruit and flavourings in appropriate containers or tanks. It is ventilated and cooled at -18 °C. Its size depends on production volume and its availability to employees. It should be located close to the transformation unit. It should also enable easy transit of employees and transport.
Both the *fruit and equipment wash* utilised during production are equipped with sinks which must be kept hygienic and free of stagnating water.
Identified as 'wet and dirty', they must be physically separate from te transformation unit.

In the *fruit wash*, the equipment includes sinks, peeling and coring benches, containers and trolleys for transport to the production unit. In the case of mechanized production, it should have a wash tank, conveyor belts and a sorting bench. This unit may be located outside. Its floor should have drainage channels.



Machines and equipment: pl - work bench; st - thermostatic tank; cu - cooker or panst; lb - sink; ar - cupboard; tv - table; m - trolley; x - forklift truck; vs - swilling tank; bn - select machine; lc - ingrdient scales; tr - fruit chopper; tt - exstractor; cb - cutting machine; ff - liquidizer; mx - ingredient mixer; bc - concentration boiling pan; cp - jar capper; do - measurer; n - conveior; pa - pasteuriser; tl - cooling-tunnel.
Spatial Units: 4 - thoroughfare; 5 - water point; 6 - production part bank; 8 - operative area; 9 - dosing and ingredient preparation . Manual production (line a): 4a - cooking; 5a - dosing jars. Semi-mechanized production (line b): 4b - trasformation. Mechanized production (line c): 1c - washing; 2c - trasformation.

Figure 3. Enviromental Units layouts for the manual, semi-mechanized and mechanized lines.

The *production section* depends on the production type (manual, semi-mechanized, mechanized). Manual production requires: cooker or pans, thermostatic tank, work benches for measuring the ingredients of marmalade, work benches for product testing, and space for employee and vehicle transit.

For the mechanized and semi-mechanized lines the size of the unit must be such to accommodate a longitudinal production line. They differ in the technology used in certain phases. The semi-mechanized line requires the production line be interrupted to add the fruit and sugar, for pasteurisation and cooling. During these phases, the employees intervene so there must be sufficient space for them and their equipment. The line may have a 300 kg/h (150 kg/cycle) capacity and is made up of: ingredient scales, fruit chopper, liquidizer, ingredient mixer, concentration boiling pan, thermostatic tank, measurer, jar capper and a pasteuriser. So, the fruit is chopped, strained of seeds and concentrated in a boiling pan of 800 mm diameter. After jarring, the jars are taken manually to the pasteurisation and cooling areas.

The continuity of the mechanized line requires employee intervention only during jarring and for adding the sugar. The line would have a 1500 kg/h (750 kg/cycle) capacity with a boiling pan of 1300 mm diameter. The washed fruit is conveyored directly from the liquidizer to the

ingredient mixer to the concentration boiler, the measurer and the jarrer as far as the pasteurisation tunnel and cooling. Labelling and packaging are the final sectors of the line.
Both lines (semi-mechanized and mechanized) require employee transit aisles to manage them as well as space for taking waste away. Space unit inter-connection and system type diversification (fig. 4 & 5) depends on production type.

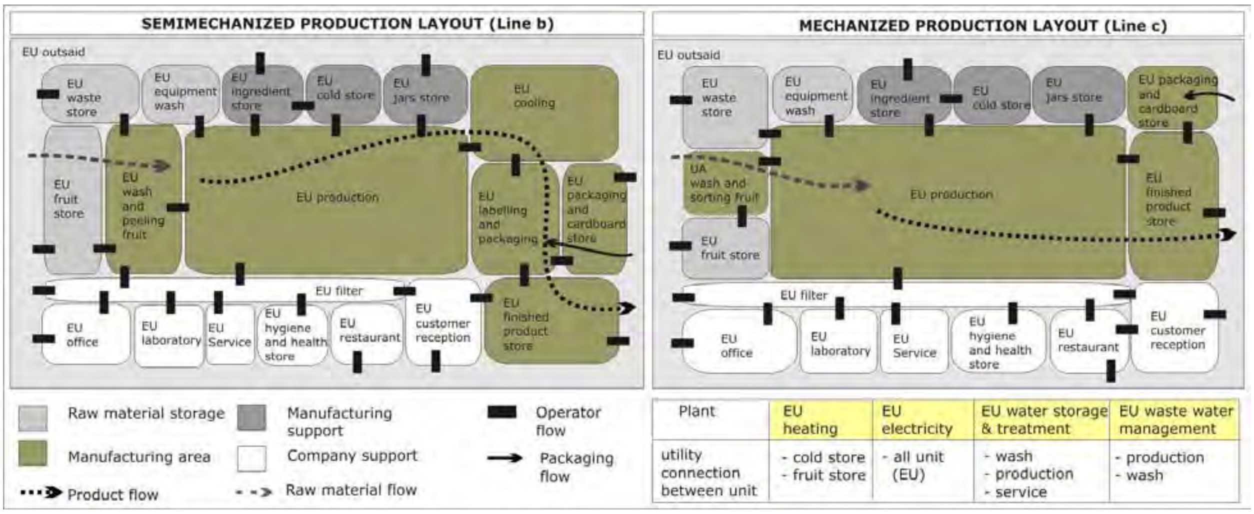


Figure 4. Aggregated Enviromental Units for semi-mechanized and mechanized production of marmalades and jams

The *waste store* can be located outside when immediate removal of organic waste is required or in a space unit with direct access to outside in which the waste remains in bins for brief periods. This space is subject to spills due to the fermentation of peel, so drainage channels and ventilation is required.
The *finished product store* should be such as to accommodate the product packs on shelving with access aisles.

Enviromental Units for preparing marmalade and jams (semi-mechanized)
The semi-mechanized preparation of jams requires a cooling unit and one for labelling and packaging.
The *cooling unit* should have transit aisles and space to park the jar packs. Its organisation depends particularly on the rotation of products. Its indispensible that space is oriented to sequential operation avoiding any employee cross-traffic. It is preferable that this unit is connected to the production and labelling units.
The *labelling and packaging* unit should have enough space for making up the boxes and filling them as well as a table for jar-labelling and aisles for parking and trolleying the product to the store.

The aggregation of Enviromental Units for manual production Given that in traditional production only a few hundreds of kilos of fruit are used per cycle, it is preferable to unite different units especially regarding functional, health and hygiene, thermal hygrometric and luminosity requisites. So, considering that the dirty and clean areas must remain separate, the fruit store and equipment wash could be united to the fruit wash and peeling fruit. The cooling remains separate. Labelling and packaging for small quantities which are immediately marketable requires simple shelving and boxing which may be located in the finished product store (fig. 5).

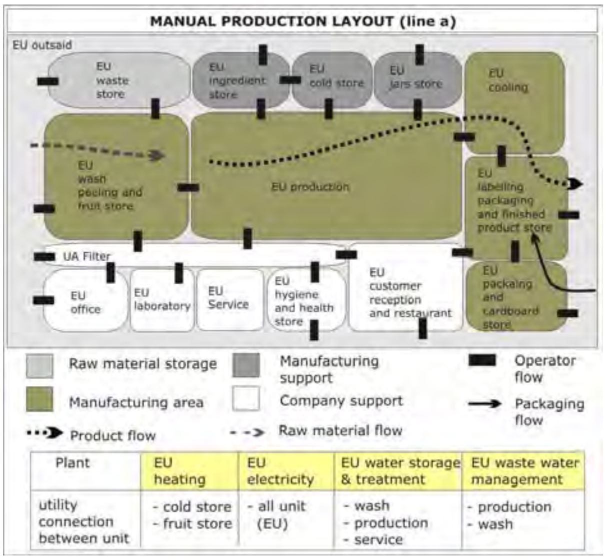


Figure 5. Aggregated Enviromental Units for manual production of marmalades and jams

Conclusion

The research results could provide useful design references for small to medium countryside businesses without specialised buildings.

It proposes specific building regulations for the production of marmalades and jams by defining the environmental and typological characteristics of the production complex whose organisation can vary according to production and equipment type. In particular, space attributes were defined to assure the optimum benefits of the process (manual, semi-mechanized, mechanized) and associated activities. Particular attention was paid to the planimetry of each single Enviromental Unit and their inter-correlation. Thus it was possible to define several layouts, one for each production line which schematizes the organisation of factory space. They show how production spaces correlate which is determined by the type of flow. The proposed layouts and inter-connections are the result of the research and analyses carried out and summarised graphically and represent the principles for correct planimetric organisation.

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The authors’ contributions towards the present work are to be considered equal in every way

Acoustic Levels in the Wood Processing Industry in Northeast Italy

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Abstract
Acoustic pollution regulations, recently modified, are characterized by some important innovations on the prevention of a risk factor which is well known as the first cause of occupational disease in Italy and the second in Europe. The sector of wood processing is one of the most concerned by such a problem. The data collected by the Agencies in charge of this issue do confirm that timber processing accounts for a high risk activity in terms of hazard occurrence. The timber processing sector relies on a variety of processing plants and production lines which are characterized by a high level of process automation. In Northeast, the productive compartment of the wood working presents many issues in term of occupational safety and health. This sector represents a crucial role in Italian economy; in fact, Northeast Italy plays an important role in the supply of primary and secondary wood products. The exposure to the acoustic levels is one of the principal risks for workers. The acoustic survey was carried out under full and normal operating conditions of the industries. The examined industries do not always comply with the ergonomics and safety standards established by law for an acoustic comfort meeting workers' needs. Such interventions take into account the change of the lay-out of the production cycle, the reduction of acoustic emissions directly at their sources, an effective organization of work and a greater awareness towards the use of personal protection devices.

Keywords: acoustic pollution, noise reduction, wood processing, Northeast Italy

Introduction

The timber processing sector relies on a variety of processing plants and production lines which are characterized by a high level of process automation. In spite of this, many businesses, also due to the low added value of their finished products, still make use of obsolete machines and processing lines which, while still assuring a good operation and production efficiency, are by now inadequate to comply with the new requirements in terms of workers' health and safety. The data collected by the Agencies in charge of this issue do confirm that timber processing accounts for a high risk activity in terms of hazard occurrence (INAIL, Italian Workers' Compensation Authority, 2008). This is also ascribable to the fact that the production chain in question still includes many hand-made processing phases, which imply direct exposure of workers to work environment risk factors (equipment, machines and materials). This exposure results from a closer and more continuous contact with dangerous equipment and environment compared to other sectors (Table 1). In Northeast, the productive compartment of the wood working presents many issues in term of occupational safety and health. The exposure to high acoustic level is one of the principal risks for workers.

On the technical level, the cycle of the factories manufacture, which gets inspiration from the hand-crafted tradition, is today nearly wholly mechanized. The good levels of productivity achieved, must not allow to under estimate the risks for the health of the workers who work in these factories. In particular, the process of mechanization of the manufacture processes has led to an increase of the noise sources and, as a result, of an increase of the percentage of workers exposed to this risk. Not by chance, in the wood macrosector, the majority of recognized cases of hypacusia and deafness take place in furniture factories; still, the index of frequency is not particularly high (Verdel *et al.*, 2001, Zimbalatti *et al.*, 2008).

Table 1. Activity sectors. Occupational hazard.

Sector of economic activity	**Index of frequency** (*)				
	Temporary disability	Permanent disability	Death rate	Total	Index number
Metal processing	65.79	2.47	0.08	68.34	191.2
Non-metallic minerals	63.86	2.64	0.12	66.61	186.4
Timber processing	**58.51**	**4.13**	**0.06**	**62.70**	**175.4**
Construction	54.43	4.10	0.19	58.72	164.3
Industry and Services (combined)	34.19	1.49	0.06	35.74	100.0

(*) Accidents indemnified per 1,000 covered by INAIL (Italian Workers' Compensation Authority)

The study has been conducted in Trento, one of the most important Italian regions in terms of timber production with an annual amount of processed timber of 631.458 m^3, i.e. 33% of the total amount of timber processed in Northeast Italy (ISTAT, 2008). Given the great economic importance of the Trento wood sector and in view of the problems related to the work conditions of this sector, it has been decided to start from the acoustic survey (on the basis of the laws currently in force) correlated to the production processes considered to be a representative sample of the entire regional sector (Proto *et al.*, 2009).

Timber processing encompasses a number of different kinds of processes which are almost always characterized by an elevated level of automation. In spite of this, many businesses, also because of the low added value of the finished product, still rely on obsolete equipment and machines which, while still keeping a pretty good level of productivity, are likely to create many problems and jeopardize both the safety and the health of the workers (Zimbalatti *et al.*, 2005, Giametta *et al.,* 2007).

Materials and methods

The sector of wood transformation is traditionally marked by high levels of exposure to noise, due to a series of attendant circumstances, such as the use of facilities with high acoustic power in often narrow work environments. Starting from these considerations, the Mechanical Section of the D*i*STA*f*A of the Mediterranean University of Reggio Calabria, in collaboration with the Trees and Timber Institute, has carried out a survey about acoustic levels in the wood processing industry in Northeast Italy.

The legislation reference

The legislation about noise pollution has been recently changed. The D. Lgs. 195/2006, in fact, has changed the D. Lgs. 626/94. The title has been replaced by the Title V-bis, which regards the rules for the accomplishment of the "Protection from Physical Agents" at work. In particular, it has received and accomplished the European Directive 2003/10/CE on the workers' exposure to noise, and it has introduced a series of articles which define the minimum requirements for health and safety with regard to exposure to noise. First of all, the limit of daily exposition to noise decreases from 90 to 87 dB(A); this limit considers also the noise reduction produced by the personal protective equipment (PPE) worn by workers. Moreover, the peak level of impulsive noise is measured by the weight curve C, instead of the linear system. The maximum value of exposure to noise beyond whom it is obligatory to signal and/or to define the borders of the area, decreases from 90 to 85 dB(A); finally, the evaluation of noise considers also the possible interactions with vibrations or hearing toxic substances (Casini S., 2006). The new legislation defines, coherently with what said before, two values of reference: the **maximum value of exposure**, that is the level it is not possible to exceed, and the **action values**, lower and higher, that have to be considered by the employer to take specific protection measures for workers; in particular, if the lower value is exceeded, activities of "information, formation and PPE supply" must be carried out; if the higher value is exceeded, actions of "information, training and PPE supply with the obligation of use" are needed (Table 2).

Instrumentation and test parameters

The researches have been carried out with the use of a precision integrator phonometer Delta Ohm HD 9020. This instrument is set every year at the laboratory S.I.T.; before and after each daily series of measurements, the calibration has been controlled by a calibrator Delta Ohm HD 9101. The collected data have been transferred through a serial cable to a laptop to be processed successively. The modalities of measurement and the methodology of research include the arrangement of the instrument, through a special tripod and a bracket with a feeler, at the height of the operator's ear, and at such a distance from his head, so as to reduce, as much as possible, the effects of diffraction and the distance of the measured value. The tests, have been carried out during full activity and normal operating conditions of the industries and, after evaluating the workers' residence time in their work stations, the level of daily personal exposure has been calculated ($L_{EX,\,8h}$).
The knowledge for each worker of the level of exposure and the value of peak acoustic pressure makes possible to verify the respect of the limit values established in the art. 49-quater of D.Lgs. 195/06, to decide the prevention and protection measures to be taken. Moreover, it is very useful to estimate also the uncertainty related to the level of daily personal exposure, to define if a specific limit of exposure is, or can be exceeded.

Level of daily personal exposure = $L_{EX,8h} = L_{Aeq,Te} + 10 \log \left(\frac{T_e}{T_0}\right)$ (dB(A))

$$\text{where: } L_{Aeq,Te} = 10 \log \left\{ \frac{1}{Te} \int_0^{Te} \left[\frac{P_A(t)}{P_0} \right]^2 dt \right\} \qquad (1)$$

T_e = daily period of a worker's personal exposure to noise;
T_o = 8 hours;

P_A = instantaneous acoustic pressure (weighting scale A), in Pa;
P_0 = 20 µPa.

Table 2. Main differences between the old and the new legislation

Estimated provisions	**D.Lgs. 277/1991**	**D.Lgs. 195/2006**
Periodicity for noise evaluation	No	4 years
Interaction with vibrations and hearing toxic substances	No	Yes
Areas to be signaled/boundaries to be defined	≥ 90 dB(A)	≥ 85 dB(A)
Measure of peak level	dB(lin)	dB(C)
Lower value of action	85 dB(A)	80 dB(A)
Higher value of action	90 dB(A)	85 dB(A)
Maximum limit of exposure	90 dB(A)	87 dB(A)
Training for the use of PPE	≥ 85 dB(A)	≥ 80 dB(A)
Register of statements	Yes	No

Reduction of personal protective equipment

The new legislation imposes the employer, in case of exposure beyond the maximum value of 87 dB(A), to check the efficiency of the devices of hearing individual protection. So, during the tests in the different factories, the indications given by the D.M. 02/05/01 which fix the standards for the identification and the use of hearing protection devices through the reception of the rule UNI-EN 458 (Table 3), have been applied.
The action level (L_{act} - 85 dB) is the value beyond whom the employer make sure all workers wear PPE when noise levels are over 85 dB(A). In case the valuation points out an insufficient protection, it is necessary to use another kind of hearing protector with a higher reduction. On the contrary, if the valuation reveals that the protection effect is too high, it is necessary to use a different PPE with a lower reduction: we know indeed that hyperprotection can cause feelings of isolation and difficulty to perceive sounds. So it is necessary to make sure that the protection offered by the PPE stays in the limits of acceptance according to table 2. To verify the suitability of a PPE there are several methods based on the level of knowledge of the peculiarities of the environment noise and the values of acoustic reduction provided by the constructor of the device, together with the mark CE.
The method used in this research for the evaluation of the efficiency of PPE, is the system of simplified reduction of noise level - SNR (Simplified Noise Reduction) - that uses the equivalent level of acoustic noise pressure according to curve C. Successively, the equivalent level for each worn device (L'_{Aeq}) has been compared to the action level to evaluate the suitability of the hearing protector itself.

Real level at the ear = $L'_{Aeq} = L_{Ceq} - SNR$ (2)

where:
L_{Ceq} = Equivalent level of acoustic noise pressure according to weighting scale C;

SNR = Value of acoustic reduction per octave band of a hearing protector.

Table 3. Evaluation of acoustic reduction

Real level at the ear	**L'_{Aeq} dB**	**Evaluation of protection**
Higher than L_{act}	80	Insufficient
Between L_{act} and L_{act} - 5	80 - 75	Acceptable
Between L_{act} - 5 and L_{act} - 10	75 - 70	Good
Between L_{act} - 10 and L_{act} - 15	70 - 65	Acceptable
Lower than L_{act} - 15	65	Too high (*Hyperprotection*)

Examined factories and production cycles

The sawmills under study had an average annual production of 3.700 m³ wood products. The timber usually process comes from the provincial area (68%), from the other provinces of the Trento Region (20%), and from both national and international markets (12%). In particular, all the sawmills studied use to buy long stems which are then cut in to sawlogs by means of cross-cutting. Softwood sawlogs have an average length of about 4 m, whereas hardwood sawlogs are on average 3 m long. The wood products fall within three categories: carpentry and construction materials, semi-finished products to be additionally processed and products for packing, boxing and shipment.

Table 4. Peculiarities of the examined sawmills

	Number of workers	**Timber volume** (m³/year)	**Species of wood**	**Products**	**Workforce** (days/year)
A	5	2.600	Chestnut, beech,	Carpentry and packing timber	215
B	6	4.800	Spruce	Trusses, semi-finished products	240
C	5	3.500	Spruce, beech	Semi-finished and capentry timber	230

Results

In tables 5, 6 and 7 you can see the results of measurements and the processing activities carried out in each sawmill in the different work stations. The machines working wood through the shaving removal by tools, disks or rolling knives at a high speed, give out high acoustic levels, especially if they are not well used and repaired. In no station the value of L_{peak}(C) came out higher or equal to135 db(C), so the verification of the respect of the action values and the exposure limits has been carried out exclusively on the base of the values of the daily personal exposure $L_{EX,8h}$. In particular, in the three sawmills the equivalent levels of the multiblade saw are equal and sometimes higher to 85dB(A). As a result, the values of the daily personal exposure in a period of eight hours are different in the three examined

factories. Indeed, for the 32% of the 16 examined workers the maximum exposure value of 85dB(A) is exceeded, and the choice of PPE does not seem to be satisfying.
In sawmill A, four workers are subjected to acoustic levels higher than 85 dB(A), high action value which, not only forces workers to wear PPE, but also imposes the employer to create and apply a specific programme of technical and organizing measures to reduce this exposure. All workers have been provided with auricular insets with an arc of EAR model ReFlex, certificated according the norm EN 352-2. The test of the reduction produced by these PPE shows as the use of insets is acceptable for all other workers. They are the highest of the whole factory because of the old age of the machine, the bad conditions of maintenance and his closeness to walls (Figure 1). The sawmill, therefore, does not comply with the minimum requirements for an acoustic comfort; the overcoming of limit values found in all machines must induce the employer to reconsider the factory layout, its management and maintenance, and incidentally think about the replacement of some machines (Zimbalatti *et al.*, 2008).
In B, acoustic levels exceed 80 dB(A) and the acoustic conditions compared to the previous one are similar; in fact, the six persons work in conditions that exceed the legal limit value (Figure 1). The values of daily personal exposure, according to what has been said, are higher than legal values both for the bad conditions of maintenance. The reduction produced by earphones - EAR Ultrafit - in favour of the six workers is acceptable.
The data collected in sawmill C show quite different acoustic levels (Figure 1); there are machines with values higher than 87 dB(A), in comparison with other machines which have values around 85 dB(A). In particular, high levels have been registered near the multiblade saw and the trimmer machine. The choice of the earphone (Peltor H4A), used by this factory, appears to have good reducing levels. It could be useful, in addition, to isolate acoustically the machines with higher emission levels. It would be also necessary to draw attention on the work areas where this machines work, as they exceed of 10 dB the medium values, to warn the operator about the importance of using PPE.

Table 5. Acoustic levels in factory A

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator			
			A1	A2 – A3	A4	A5
			Residence time t_i (hours)			
1. Head Band saw	85,4 (± 0,5)	112,4		8,00		
2. Trimmer	84,9 (± 0,7)	114,1				8,00
3. Edger	82,2 (± 0,6)	108,3	3,00			
4. Multiblade saw	86,4 (± 0,8)	115,1	5,00			
5. Pit saw	86,2 (± 0,1)	116,5			8,00	
$L_{EX,8h}$ [dB(A)]			**85,3**	**85,4**	**85,7**	**84,9**
ε $L_{EX,8h}$ [dB(A)]			± 1,1	± 0,9	± 0,7	± 1,0
Level of exposure with PPE			66,0	66,0	67,0	68,0
Reduction			Acceptable	Acceptable	Acceptable	Acceptable

Table 6. Acoustic levels in factory B

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator				
			B1	B2 – B3	B4	B5	B6
			Residence time t_i (hours)				
1. Head Band saw	84,4 (± 0,9)	116,1		8,00			
2. Alternate saw	83,9 (± 0,8)	111,9					8,00
3. Multi-blade saw (A)	85,1 (± 0,5)	116,4			8,00		
4. Multi-blade saw (B)	84,7 (± 0,4)	114,1	4,00				
5. Edger	83,3 (± 0,5)	113,2	4,00				
6. Trimmer	84,6 (± 0,7)	114,1				5,00	
7. Pit saw	85,3 (± 0,5)	113,2				3,00	
$L_{EX,8h}$ [dB(A)]			**84,1**	**84,4**	**85,1**	**84,9**	**83,9**
ε $L_{EX,8h}$ [dB(A)]			± 0,8	± 1,1	± 0,9	± 0,9	± 1,1
Level of exposure with PPE			66,0	66,0	67,0	67,0	65,0
Reduction			Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

Table 7. Acoustic levels in factory C

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator				
			C1	C2	C3	C4	C5
			Residence time t_i (hours)				
1. Head Band saw	84,5 (± 0,7)	115,4	6,00				
2. Trimmer	85,9 (± 1,1)	116,2		8,00			
3. Edger	85,7 (± 0,8)	117,7	2,00				
4. Multiblade saw (A)	86,7 (± 0,4)	119,3					8,00
5. Multi-blade saw (B)	87,1 (± 0,5)	120,1				8,00	
6. Pit saw	84,2 (± 0,2)	108,7			8,00		
$L_{EX,8h}$ [dB(A)]			**84,8**	**85,9**	**84,2**	**87,1**	**86,7**
ε $L_{EX,8h}$ [dB(A)]			± 1,0	± 1,3	± 0,7	± 0,9	± 0,8
Level of exposure with PPE			68,0	69,0	67,0	70,0	70,0
Reduction			Acceptable	Acceptable	Acceptable	Good	Good

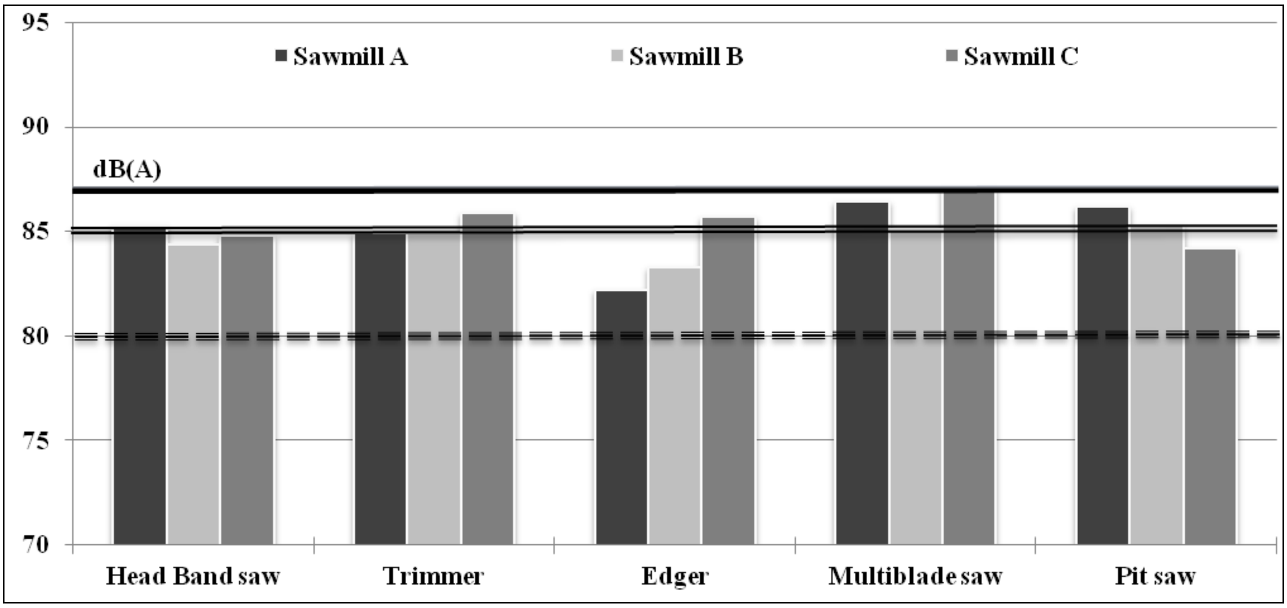

Figure 1. Equivalent levels in the examined machines

Conclusions

This study has enabled to widen our understanding of the general picture of the sector of primary timber processing whose many criticalities in terms of work safety have not only been highlighted and observed, but also analysed. The sector of primary timber processing in Trento has been found to be characterized by extremely promiscuous tasks as well as by ill-designed and managed work premises ad a lot of gaps in terms of compliance with safety and hygiene standards. On the grounds of the first results obtained it seems evident that research and personnel training efforts are essential to improve safety conditions within wood processing businesses. In the work stations where there is an equivalent acoustic level higher than 85 dB(A), it would be important to adopt specific balancing measures or precautionary interventions, and limit the access only to the employers with appropriate personal protective equipment, as well (earphones or auricular insets) (Zimbalatti *et al., 2008)*.
The noise reduction, at the source or on the run, should be one of the main management programmes of this risk factor. This activity must take into account both the facilities and planning, as well as maintenance to control acoustic pollution inside factories during the cycle of wood processing. The clearing of work stations can be positively carried out by limiting the productive lines in soundproofing cabins and tunnels, and coating the plates subjected to impacts (Bianconi A., 2004). With regard to work places, there is in all three factories, a complete saturation of spaces. The acoustic field is the sum of the direct field and the one reflected by walls. To eliminate the latter, it is reasonable to put appropriate soundproofing panels hanging from the roof and applied to the factory walls. In general, the visited enterprises rely on the supply to workers of the different kinds of PPE hearing protectors in commerce for the protection from noise. But with regard to legislation, it is important to remember that no auricular protection is valid everywhere. It is necessary to know the

peculiarities of noise in the different environments where people work, to choose the right acoustic damping factor. It is also important to consider the length of stays in particularly noisy environments. In some cases, if hearing is not constantly protected, it risks permanent damages.

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