

## **Risk profiles for workers involved in meat transformation processes**

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### **Abstract**

**In recent years the pig sector has registered the evolution from farm involved in breeding, to farms specifically dedicated to meat transformation. Accordingly the transformation process is completely accomplished by machine.**

**The present paper reports an evaluation of the relationship between the production process and risks to the workers' safety. Particular attention was paid to the manual material handling.**

**By using the NIOSH method it emerged that health surveillance must be taken into account.**

**Keywords:** workers' safety, ham production.

### **Introduction**

In livestock compartment of Umbria Region the pig sector plays a particularly significant role for both the high incidence on Gross Saleable Production of the regional animal husbandry and the historical tradition of this type of farming, as witnessed by many companies operating in transformation of pork meat.

In many cases the factories have evolved changing their dimensions from small and medium-sized, carrying out most of the breeding and processing to larger companies dedicated to processing phase. The reduction of factories engaged in breeding and more generally the decrease in the number of animals were substantially due to issues on environmental impact, linked both of wastewater and odours.

Various technological innovations (i.e. the use of machines) have been introduced in the production process of ham, in the past carried out by hand. These changes facilitate workers at work, but machinery use new risks for workers determines. The aim of this work is to determine the relationship between the production process and risks to the workers' safety.

### **Materials and methods**

Several visits in a ham in the province of Perugia were realized, in order to analyse the different phases of production and therefore evaluate the possible risks to the workers' safety.

The building consists of two levels: the ground floor used for the receipt and processing, and the underground floor housing the seasoning. The two floors are connected by stairs and a lift. The area of work presents quartz floors, washable walls and adequate lighting, not altering the colour of the food. To prevent insect infections the windows are equipped with net and the doors are with seals.

All rooms intended for pre-seasoning, seasoning and storage of the finished product have door, insulated walls and ceiling, all washable.

The forwarding area is located in the front of the establishment. A sink with foot pedal, soap dispenser and drying hands papers, are present in the processing area.

The rooms for maturation and local of packaging, are equipped with a transport system located on the ceiling. It consists of guides on which steel frames that support the hams flow.

This system makes quick transportation of ham and air circulation between them. Finally, all the staff's toilets and changing rooms are suitably located and separated from production areas.

The factory processes  $5 \times 10^5$  kg of meat deriving from national and abroad fresh pork hams with and without bone. After first visit particular attention was paid to the manual material handling and to the execution of the operations.

Such operations can be heavy and eventually lead to musculoskeletal disorders. The NIOSH (National Institute for Occupational Safety and Health) method was used to evaluate the Lifting Index as:

$$LI = LW \text{ (Load Weight)} / RWL \text{ (Recommended Weight Limit)}$$

For  $LI < 1$  do not have work at risk and need not be any health surveillance;  
 for  $LI \geq 1$  the work is at risk and require health surveillance.

The RWL is given by:  $LC \times HM \times VM \times DM \times AM \times FM \times CM$   
 in which:

- LC is load constant (tab. 1);
- HM is an horizontal multiplier, measured from the mid-point of the line joining the inner ankle bones to a point projected on the floor directly below the mid-point of the hand grasps (tab. 2);
- VM is a vertical multiplier, defined as the vertical height of the hands above the floor. It is measured vertically from the floor to the mid-point between the hand grasps, as defined by the large middle knuckle (tab. 3);
- DM is a distance multiplier, defined as the vertical travel distance of the hands between the origin and destination of the lift (tab. 4);
- AM is an asymmetric multiplier, is the angular measure of how far the object is displaced from the front of the worker's body at the beginning or ending of the lift, in degrees (measure at the origin and destination of lift) (tab. 5);
- FM is a frequency multiplier, defined by (a) the number of lifts per minute (frequency), (b) the amount of time engaged in the lifting activity (duration), and (c) the vertical height of the lift from the floor. It refers to the average number of lifts made per minute, as measured over a 15-minute period (tab. 6);
- CM is a coupling multiplier, is the judgement on the force a worker can or must exert on the object. A good coupling will reduce the maximum grasp forces required and increase the acceptable weight for lifting (tab. 7).

**Table 1. Load constant**

	<b>Males</b>	<b>Females</b>
<b>Age</b>	<b>&gt; 18</b>	<b>&gt; 18</b>
<b>Load Weight [kg]</b>	<b>30</b>	<b>20</b>

**Table 2. Horizontal multiplier**

<b>Distance [m]</b>	<b>0.25</b>	<b>0.30</b>	<b>0.40</b>	<b>0.50</b>	<b>0.55</b>	<b>0.60</b>	<b>&gt; 0.63</b>
<b>HM</b>	<b>1.00</b>	<b>0.83</b>	<b>0.63</b>	<b>0.50</b>	<b>0.45</b>	<b>0.42</b>	<b>0.00</b>

**Table 3. Vertical multiplier**

<b>Height [m]</b>	<b>0</b>	<b>0.25</b>	<b>0.50</b>	<b>0.75</b>	<b>1.00</b>	<b>1.25</b>	<b>1.50</b>	<b>&gt; 1.75</b>
<b>VM</b>	<b>0.78</b>	<b>0.85</b>	<b>0.93</b>	<b>1.00</b>	<b>0.93</b>	<b>0.85</b>	<b>0.78</b>	<b>0.00</b>

**Table 4. Distance multiplier**

<b>Distance [m]</b>	<b>0.25</b>	<b>0.30</b>	<b>0.40</b>	<b>0.50</b>	<b>0.70</b>	<b>1.00</b>	<b>1.70</b>	<b>&gt; 1.75</b>
<b>DM</b>	<b>1.00</b>	<b>0.97</b>	<b>0.93</b>	<b>0.91</b>	<b>0.88</b>	<b>0.87</b>	<b>0.86</b>	<b>0.00</b>

**Table 5. Asymmetric multiplier**

<b>Angle</b>	<b>0°</b>	<b>30°</b>	<b>60°</b>	<b>90°</b>	<b>120°</b>	<b>135°</b>	<b>&gt; 135°</b>
<b>AM</b>	<b>1.00</b>	<b>0.90</b>	<b>0.81</b>	<b>0.71</b>	<b>0.62</b>	<b>0.57</b>	<b>0.00</b>

## Results

The raw material arrives to the factory through refrigerated trucks. This is thighs of adult pigs, except boars and sows coming from breeding of white races. The thighs have specific physical and organoleptic characteristics: no less than 13.5 kilograms weight, good looking and red colour.

The matter comes to the factory arranged on trolley having 7 platforms placed at different heights (one at 0.25 m from the other; the trolley is 1.85 m high). The thighs are weighed and transferred to a cell, where they stay for about 24 hours at a temperature between 0 and 4 °C (Fig. 1).

After 24 hours the salting operation is made by use of specific machines, consisting of a conveyor belt carrying the thighs inside the machine. At the beginning the product was stamped, after salt and other spices fall on it. In particular 2 workers, working at the entrance of the machine, manually take the thighs by trolley and put them on a conveyor belt; other 2 at the exit of the machine deposit thighs on empty trolley and finally a person carries trolleys empty and full (Fig. 2). In the case of thighs with the bone it is necessary to remove blood from main veins. This operation is carried out using a special machine, whose operating mechanism provides for the passage of thighs, through a series of rollers, which thanks to their particular shape carrying a gradual pressure. The salted thighs are then placed in special cells where they remain for 7 days at a temperature between 0 and 4°C.

**Table 6. Frequency multiplier**

<b>Frequency</b>	<b>0.20</b>	<b>1.00</b>	<b>4.00</b>	<b>6.00</b>	<b>9.00</b>	<b>12.00</b>	<b>&gt; 15.00</b>
<b>Duration &lt; 1 hour</b>	<b>1.00</b>	<b>0.94</b>	<b>0.84</b>	<b>0.75</b>	<b>0.52</b>	<b>0.37</b>	<b>0.00</b>
<b>Duration from 1 to 2 hours</b>	<b>0.95</b>	<b>0.88</b>	<b>0.72</b>	<b>0.50</b>	<b>0.30</b>	<b>0.21</b>	<b>0.00</b>
<b>Duration from 2 to 8 hours</b>	<b>0.85</b>	<b>0.75</b>	<b>0.45</b>	<b>0.27</b>	<b>0.52</b>	<b>0.00</b>	<b>0.00</b>

**Table 7. Coupling multiplier**

<b>Judgement</b>	<b>good</b>	<b>low</b>
<b>CM</b>	<b>1.00</b>	<b>0.90</b>

After this period, the hams are desalted and salted again, and then reintroduced in cells for 11 days at temperature between 0 and 4 °C. Salt elimination (desalting) and drying with a machine driven air pressure. The eliminated salt is recovered and used again. The second salting operation is carried out as the previous one. After this phase the meat is desalted again and incubated for 15 days in a ventilated cell (T = 3.5 ÷ 4.5 °C - Humidity 45 ÷ 65%). After that period the hams are transferred to a not ventilated cell (T = 2.5 ÷ 5.5 °C - Humidity 62 ÷ 68%) and then finally to a ventilated cells for 70 days (T = 2.5 ÷ 4.0 °C - Humidity 10%). The

wash step in a washing machine follows. The hams are washed with water and automatic brushes. The drying takes place in a special cell for a time of 7 days ( $T = 18 \div 24 \text{ } ^\circ\text{C}$  - Humidity  $55 \div 73\%$ ).



**Figure 1. Detail of manual material handling.**

The pre-seasoning follows and it lasts for a time of 3 to 4 weeks ( $T = 16 \div 19 \text{ } ^\circ\text{C}$  - Humidity  $72 \div 77\%$ ).

All next operations are entirely carried out by hand. First the ham is sprinkled with lard of semi-seasoned ham. This operation is performed by 2 operators and practically it is composed of several actions: i) taking of hams from steel frames; ii) the deposition of them on a table; iii) the heating of a solidified block of lard and; iv) the sprinkling of meat with a brush (Fig. 3-4). Finally the ham is rearranged on the steel frame. The cycle ends after thirteen months inside the maturing cells ( $T = 16 \div 18 / 17 \div 18 / 17 \div 19 \text{ } ^\circ\text{C}$  - Humidity  $70 \div 72\% / 67 \div 70\% / 58 \div 61\%$ ).

The last operations are packaging and forwarding. In detail on the transport system above described (guides and steel frame) the hams are transferred from maturing cells to the packaging area, where an operator climbs a ladder, takes the hams manually and puts them on a trolley.



**Figure 2. Salting operation.**

Meantime another operator opens the carton boxes and places one product for each box. The boxes are close weight and labelled, before storing them in a wooden bench. All the utilized machines were in accordance with the Italian Machinery Directive. The hand tools showed a clean conditions and were stacked in special shelves. During the operation of sprinkle with lard no safety problems for the operators emerged due to excessive heat. However there were risks for workers entering and exiting from the cells with various temperature and humidity values. The workers are urged to wear an additional clothes but due to hurry this action is seldom accomplished.

The biggest risk for workers is the manual movements of hams. The different operations are carried out using the same repetitive manual actions although with different frequencies. To calculate the NIOSH Index it was considered that:

1. "VM" factor was evaluated as the average between the different heights of thighs positioned on the trolley;
2. "AM" factor was evaluated equal to 0° because the shelves are arranged on the same line of the machine and therefore any twisting of the trunk is required by operator;
3. "CM" factor was judged "low" by data collector;
4. "FM" factor was resulted 0.21 (middle frequency of 12) for a continuous work from 1 to 2 hours. This interval for calculating the frequency has taken into account the diversification of the tasks performed by workers in the same work time.



**Figure 3. Sprinkle of ham with lard.**

To calculate the recommended weight limit the quantity of items moved in one working time (it is resulted: 2000) and the different weight of the thighs worked (75% of thighs with bone having 14.5 kg of weight, 25% of thighs without bone having 9.5 kg of weight) were considered. Therefore the RWL is 3.08 kg; the LI of the hams with bone is 4.75 kg; while the LI of hams without bone is 3.11 kg. The LI has been evaluated according to the quantity of different types of thighs worked:

$$\text{Total LI: } (4.75 \times 0.75) + (3.11 \times 0.25) = 4.33 \text{ kg}$$

Because the value obtained exceeds 1, the operations carried out in the factory determine a risk for the workers. Therefore health surveillance is necessary.



**Figure 4. Movement of ham from and to steel frame.**

### **Conclusions**

The overall level of mechanization of the factory for hams production was good. Specific machines and a system of guides for the transport of thighs are adopted. However there was a problem of manual material handling. The survey conducted according to the NIOSH method showed a risk of musculoskeletal disorders for workers.

It is therefore necessary to do periodic health surveillance and especially a correct work organization based on appropriate shift. Therefore it is essential to train and inform on appropriate movements and on risks they have.

### **References**

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