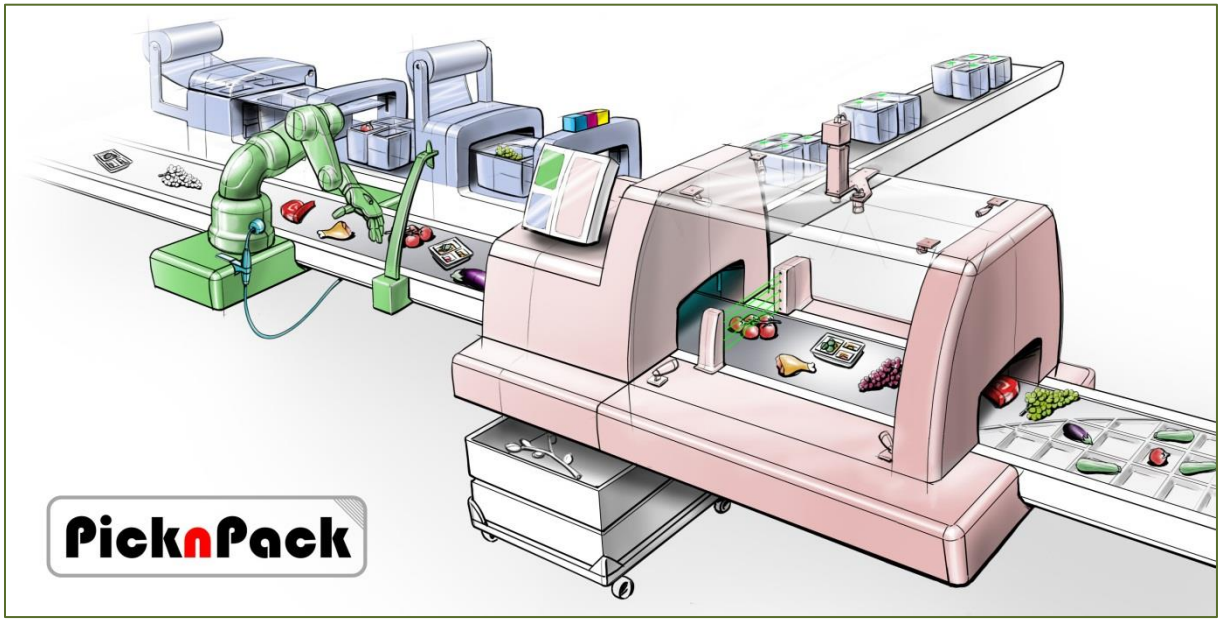
D12.3 – Report on aspects and measures to minimise societal risks and impacts of robotics systems in food

AZTI

9/30/2016



Flexible robotic systems for automated adaptive packaging of fresh and processed food products

The research leading to these results has received funding from the European Union Seventh Framework Programme under grant agreement n° 311987.

Dissemination level		
PU	Public	X
PR	Restricted to other programme participants (including the EC Services)	
RE	Restricted to a group specified by the consortium (including the EC Services)	
CO	Confidential, only for members of the consortium (including the EC Services)	

List of abbreviations and acronyms

OPR	Occupational Risk Prevention
PnP	Picknpack project
MSD	Musculoskeletal disorders
INSHT	Instituto Nacional de Seguridad e Higiene en el trabajo
REBA	Rapid Entire Body Assessment method
OCRA	Occupational Repetitive Actions method
NIOSH	National Institute for Occupational Safety and Health method

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1. Summary

This report describes the objectives, methodology and results of the study done in order to **evaluate the societal impact of robotics systems in the food packaging sector**. This deliverable, *D12.3 Report on aspects and measures to minimise societal risks and impacts of robotics systems in food,* is the result of the task 12.3. Evaluation of the social impact of robotics systems in the food packaging sector, performed under the work package 12(WP12)-"Acceptance, economics and exploitation". Its objective is the evaluation of the positive and negative impact of the development of automated systems on worker conditions and consumers. On one hand, the **impact of automated systems** is evaluated on the safety and ergonomics of the workplace and of the whole food process line, **focusing mainly on the ergonomic aspects** of the manual labour done by the workers. On the other hand, the **impact on consumers related to food safety, like a hygienic handling, reduction of cross contamination, etc.,** is discussed.

As a part of the study, the impact of an automated line such a **PicknPack line** was done, but because the functionality of the entire line of PnP was not reached, and thus, limited data were available for ergonomic assessment , this study was proposed as an orientation on ergonomic design to take into account to further developments. In order to study the impact on worker conditions, the followed strategy was to **check and evaluate the line design of PicknPack**; to **identify and reduce the ergonomic hazards** presents in it and to **minimize their effect** on the workers' health. For that issue a theoretical identification of the **critical points or critical tasks** was studied and **suggestions of improvement were described**. As a reference, several studies were consulted in the field of worker conditions and ergonomics [1-6]. The used methodology was based on international recognized ergonomic evaluation methods [7], which was explained to the partners in order to serve as a basis for future developments and technological improvements in process and thus, minimize the negative impacts from the ergonomic point of view.

Related to the influence of PicknPack line on consumers, is clear that this line has a social impact on the final consumers of products. The automation and the use of new technologies enable to have high process control and production flexibility. This allows meeting the expectations of consumers more accurately and efficiently than traditional forms of production. [8] This impact was also confirmed with the **acceptance study performed in the same work package** in which several European companies were surveyed about needs and perceptions about automation in their business. From this study the **impacts on social aspects and the impacts that were related to the consumer's** product acceptance were assessed. [9]

This deliverable includes:

- **Introduction to the impacts of robotics systems** with advantages and disadvantages of automation focusing in the societal impacts on worker conditions and consumers.
- PicknPack line **workstations and tasks description.** Workstations analysis in order to identify critical tasks and its estimation of the ergonomic risks.
- Specific measures of **improvement in order to minimise ergonomic impacts.**
- **Impact on consumers**.
- **Conclusions** from the report.

2. Introduction

Impacts of Robotics systems

In recent years, the automation and the use of new technologies and the Internet have allowed a high control of production processes, which is considered an improvement for the sector. These innovative changes in the way we work generates different impacts, among others, on working conditions and in the quality and safety of products [2]. These impacts are perceived as threats or opportunities by the industry. In the deliverable 12.2 the report on social, technological and economic barriers influencing the acceptance and implementation, the results of a European level study about the needs and perception of the food industry regarding different impacts of the automation were shown. [9].

The threats perceived by the industry regarding automation were:

- Technology limits. **There is a perception that the automatic equipment is not flexible enough for handing and sorting efficiently the wide variety of food type and formats.** Current technology is unable to automate all desired tasks. Some tasks cannot be easily automated, such as the production or assembly of products with inconsistent component sizes or in tasks where manual dexterity is required. Perception that there are some things that are best left to human assembly and manipulation. Less versatility – by having a machine that can perform a certain task limits to the flexibility and variety of tasks that an employee could do.
- **Negative perception that the high cost of the purchase and maintenance of a new automated system is not going to be translated into economic benefits.** There can be several unpredictable costs that may exceed the actual cost saved by the automation itself. Some of these costs could include research and development costs of automating a process, preventive maintenance costs, and the cost of training employees to operate automated machines.
- **Large initial investment and economic limits**– automated machines can be one of the most costly operating costs for a company depending on the type and degree of automation. Further, certain tasks would cost more to automate than to perform manually. Automation is typically best suited to processes that are repeatable, consistent and high volume.
- A skilled maintenance department is often required to service and maintain the automation system in proper working order. Failure to maintain the automation system will ultimately result in lost production and/or bad parts being produced. It appears that the major barrier is the high cost perception of the purchase and maintenance (repair, updating and technical service) of a new automated system

The opportunities arising from the automation implementation with social impact were:

- **To improve production volume and efficiency** helps t**o improve the profit margins of the products.**
- **Increase in accuracy and repeatability** – when an automated machine is programmed to perform a task over and over again, the accuracy and repeatability compared to an employee is far greater, the risk for human errors is reduced.

- **Control of quality parameters: food sector** understands as an opportunity the control of quality parameters, especially those affecting process efficiency, product stability and shelf-life and risks, like foreign matters, that even though it is one of the most controlled risks, it has a high manual sorting. Automation systems can easily incorporate quality checks and verifications to reduce the number of out-of-tolerance parts being produced while allowing for statistical process control that will allow for a more consistent and uniform product.
- **Flexibility of the packaging**: **Both sectors**, food processing and postharvest are interested in sensors for a more flexible packaging for improving their business. They are concerned about several aspects like precision and manipulation for filling, as well as labelling, weight control and accuracy of the packages.
- **User friendly equipment**: there is an interest in intuitive and user friendly equipment for automation. Equipment which is ease of use after the corresponding training for the workers.
- **The automation can help the companies to differentiate from competitors by standardizing the quality of the products. Food industry** recognizes an opportunity in the standardization of the product quality attributes by the high accuracy determination of external and internal properties.
- All these opportunities bring at the end an **economic improvement** to the companies improving the benefit margins that they work with. Automation can serve as the catalyst for improvement in the economies of enterprises or society.

As it can be shown the social implications of automation are not only represented by the negative perspective of losing jobs (low qualification and tough jobs in general). Normally those replacements are low qualification jobs in which operators perform tasks that involve hard physical or monotonous work (handling heavy or large loads, manipulating tiny objects or the requirement to make products very quickly or slowly are examples of this). This perception is a simple way of summarizing more complex and wide effects, which many times masks the great competitive advantage of automation in today's manufacturing world and the opportunities that it offers to society.

Automation of food processes opens the opportunity to improve labour qualification and working conditions and to achieve consumer requirements regarding food safety and traceability.

Impacts on workers conditions

One of the most important problems in workers performing manual tasks in processing lines, are the musculoskeletal (MSD) disorders. In general, they affect millions of workers and cost employers billions of euros. Tackling MSDs helps improve the lives of workers, but it also makes good business sense. Thus, improving the workers working ergonomic is also a matter of economic benefits for the industry. As the automation has a big impact in the task performance of the workers, a deep study of the impact regarding these disorders was done.

Musculoskeletal disorders usually affect the back, neck, shoulders and upper limbs, but lower limbs can also be affected. They cover any damage or disorder of the joints or other tissues. Health problems range from minor aches and pains to more serious medical conditions requiring time off or

medical treatment. In more chronic cases, they can even lead to disability and the need to give up work.

The two main groups of MSDs are back pain/injuries and work-related upper limb disorders (commonly known as 'repetitive strain injuries').

Causes of MSDs

Most work-related MSDs develop over time. There is usually no single cause of MSDs; various factors often work in combination. Physical causes and organisational risk factors include:

- Handling loads, especially when bending and twisting
- Repetitive or forceful movements
- Awkward and static postures
- Vibration, poor lighting or cold working environments
- Fast-paced work
- Prolonged sitting or standing in the same position

In order to minimize MSDs, aspects of equipment design and online integration are basic. For this reason the aim of the work developed in the PicknPack project was, as well as for example, hygienic design was taken into account for the design of suitable equipment, to also take into account these aspects of ergonomics when designing the equipment and the line integration. Due to the fact that the whole functionality of the line was not reached this study was not performed with real data, although technical partial data from partners was gathered in order to give preliminary suggestions about ergonomic design and to base and to orientate the whole assessment.

Impacts on consumers

For consumers, the impact of automatic systems is not as straightforward as for workers. Retailers must react to customer demands for a wide variety of attractively packaged products, of consistent quality, at affordable prices. Full traceability is desirable for customer reassurance and safety. The market is fickle and product availability is paramount.

The intended impact of this project is to **enhance customer satisfaction,** ensure repeat purchases strip out costs and waste and provide financial benefits to both customers and the manufactures and their suppliers. The impacts related **to food safety** will be perceived by the consumers by the improvements that automatic systems make in aspects regarding:

- Better hygienic handling
- Less cross-contamination
- Detection of foreign bodies (existing along the line sensors will detect any possible presence).
- Detect problems in real time, thus lower product losses would be generated by the largest existing control.
- Product with consistent quality, and does not depend on the perception of workers but of a single system with standardized criteria.

Thus, thanks to automation, it may be reduced the number of consumer complaints: defects in product quality (lower lifetime or bad organoleptic quality), improper sealing of the container (greater loss of product), etc.

3. Societal Impacts: Workers conditions

Working conditions are influenced by different factors related to the workplace, machines, raw materials, packaging material, etc. Therefore, during the development of this project, information from the equipment developed in PicknPack was collected in order to assess the ergonomic risks and make suggestions for improvement. Moreover, videos from food processing lines of real companies have been revised, in order to define and estimate other working parameters and also in order to assess the impact that automated lines such as PnP can have in comparison to an standard one.

Information about PicknPack line factors obtained through questionnaire from project partners (Wageningen UR, TECNALIA and DTI technicians):

- Dimensions of the machines, heights of working surfaces, conveyor belts, boxes, trays, etc.
- Weight of boxes of raw material and final product.
- Number of machines they have to operate and control.
- etc.

Information on the current working conditions obtained from other sector companies:

- Postures when working
- type of loads manipulated
- movements performed
- etc.

With all this information, it was established, the need of three workers for the operation and control of the PicknPack line. These three people were placed in the line to work in the following workplaces:

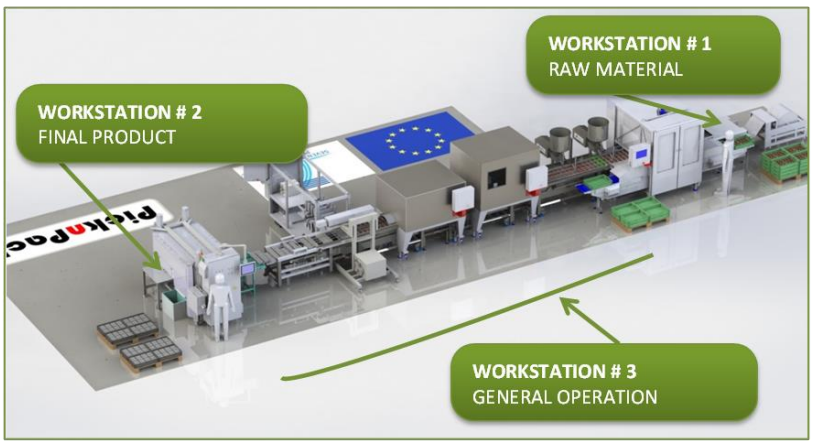


Figure 1 – PicknPack workstations.

3.1. PicknPack workstations and tasks description

The job description was based on the operation of the PnP line as a continuous process, from the supply of raw materials and packaging material, to final packaging of the product. As the PnP line didn't reach the continuous process, these ergonomic risks were not validated in the practice and the impact was assessed in a theoretical way. It is important to highlight that this theoretical description of the ergonomic risks is only for the line but it has to be adjusted when the line is placed in a food manufacturing plant, taking into account the rest of the machines of the company, the working place conditions and workers qualification.

The defined three workstations are: Raw material feeding, Final product palletizing and General operation control. The tasks description to perform in each workplace is described below.

Workstation # 1: raw material feeding

Figure 2 – PicknPack workstations # 1: raw material feeding.

This is the place where the raw material is introduced in the line. In this workstation, the worker has to take the crates of vegetables from the pallet, put them on the conveyor belt, remove the empty crates and place them in another pallet. These tasks must be performed at the same speed as the production line, to prevent line downtimes.

At the same time, the worker has to control the operation of the Pick-and-place robot and solve the incidents.

Table 1. PicknPack workstations # 1 tasks.

Workstation # 1	Raw material feeding
Task 1.1	Feed conveyor with raw material crates
Task 1.2	Remove empty boxes of the conveyor
Task 1. 3	Pick-and-place robot control

Workstation # 2: final product palletizing

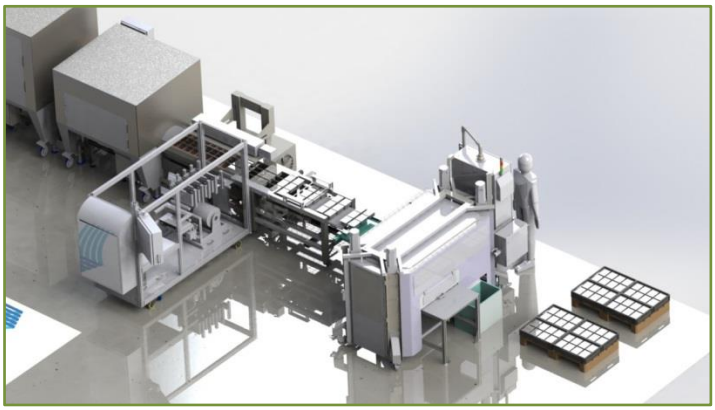


Figure 3 – PicknPack workstations # 2: final product palletizing

This is the place where the final product is removed from the line. In this workstation, the worker has to remove the full boxes from the conveyor belt, put them on the pallet, take the empty boxes from another pallet and place them in the line. These tasks must be performed at the same speed as the production line, to prevent the line stops.

At the same time, the worker has to control the operation of the Pickable cable robot and solve the incidents.

Table 2. PicknPack workstations # 2 tasks.

Workstation # 2	Final product palletizing
Task 2.1	Remove full boxes of the conveyor
Task 2.2	Feeding conveyor belt with empty boxes.
Task 2. 3	Pickable cable robot control

Workstation # 3: general operation control

Figure 4 – PicknPack workstations # 3: general operation control.

In this workstation, main tasks are: to check the operation of the entire line (thermoformer, sensing module, packaging-printing module, etc.), to solve the problems and to control the quality

parameters (sealing, weight, printing, etc.). The worker has also to change rolls of plastic in thermoformer and printing module, and collect nonconforming products that could stand in the line.

At the end of the production, he also has to take care of carrying out the cleaning of the entire line.

Table 3. PicknPack workstations # 3 tasks.

Workstation # 3	Raw material feeding
Task 3.1	Check the operation of the entire line and solve the problems
Task 3.2	Collect nonconforming product
Task 3. 3	Change rolls of plastic in thermoformer and Printing Module.
Task 3. 4	Control of quality parameters

3.2. Identification and estimation of ergonomic risks

The **ergonomic risk estimation** of the workplace **aims to avoid accidents and occupational diseases**, **reduce physical and mental fatigue, increase worker satisfaction and optimize productivity**. The **results of these estimations will be used to workplace design, tools and machines design, environmental conditions and physical and mental load control**.

The general ergonomic risks are: **repetitive movements**, **load handling** and **awkward postures**. In the magnitude of these risks have an influence equipment dimensions, distances between objects, working heights, weights and types of loads handled, grippability, working speed, need for attention, etc.

The first step to estimate the ergonomic risks is the **identification of body movements and ergonomic conditions** of the process. The second step is **to use international standards and methodologies** like REBA, OCRA and NIOSH [7] in order **to obtain the ergonomic risk estimations** based on collected data. Depending on the results, improvement measures that can be included in equipment and processes are advised.

In order to evaluate the PicknPack line impact on the safety and ergonomics of the workplace and worker conditions, the risks of the PicknPack three workstations and the conventional manual work have been estimated. The tasks identified in the PnP line and that were also appearing in conventional companies were:

- **raw material manual feeding**
- **final product manual palletizing**
- **general operation control**

And the jobs that have been replaced by implementing the PnP line and that only appear in conventional companies were:

- **raw material manipulation**
- **manual packaging**

These estimations are theoretical because not only depend on the conditions of each company, but also on **legislation of each country. So** this must be taken into account when conducting specific risk assessments and preventive measures of a food processing line.

Estimations have been made only for **load handling risk**, since it was possible to collect data that could be used for the evaluation of each job. In the case of estimating risk for awkward postures and repetitive movements, it has not been able to make the estimation because the results differ depending on each case. To estimate the load handling risk it has been used a **method from INSHT** (Spanish Institute for Occupational Risk Prevention) based on UNE and ISO standards.[7]

This method takes into account gender and age of workers, the characteristics of the load, how to lift the load, work organization, etc. Data collected from the PicknPack line and from the videos is introduced into the method and the level of risk is calculated by comparing the raised mass and the recommended mass. The numerical result obtained is transferred to a risk level scale that indicates the damage it can cause on the worker.

Table 4. INSHT method risk assessment scale.

Risk assessment scale		
Risk index	**Colour**	**Risk level**
< 0,85	Green	Acceptable
0,85 < IL ≤ 1	Yellow	Very slight or uncertain
1 < IL ≤ 2	Soft red	Present. Low level
2 < IL ≤ 3	Medium red	Present. Significant level
IL > 3	Strong red	Totally unacceptable

The tool that is used to perform these calculations can be seen in the following figures:

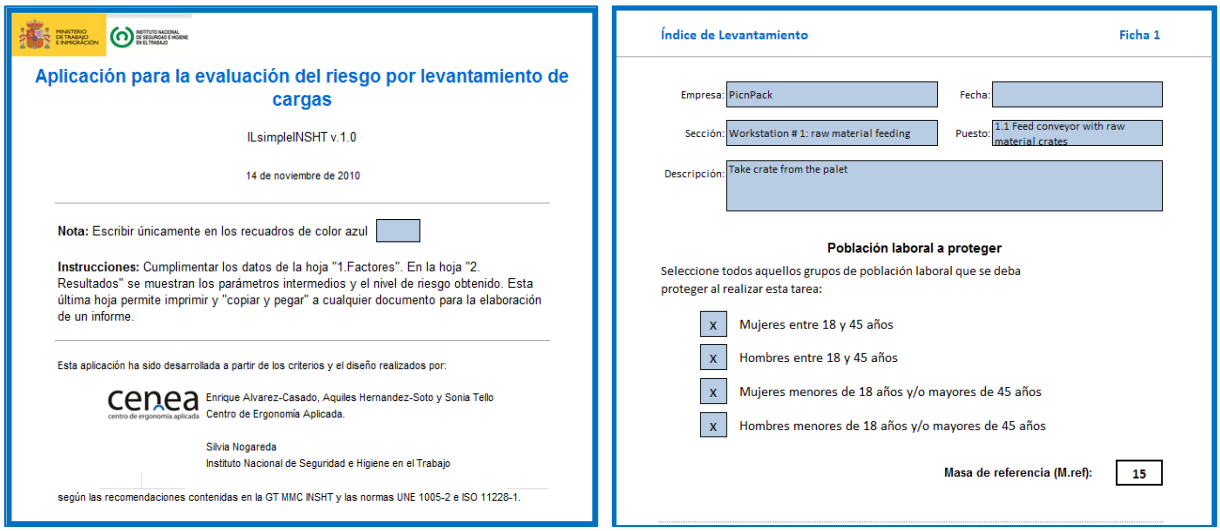


Figure 5 – INSHT method front page and general information collection.

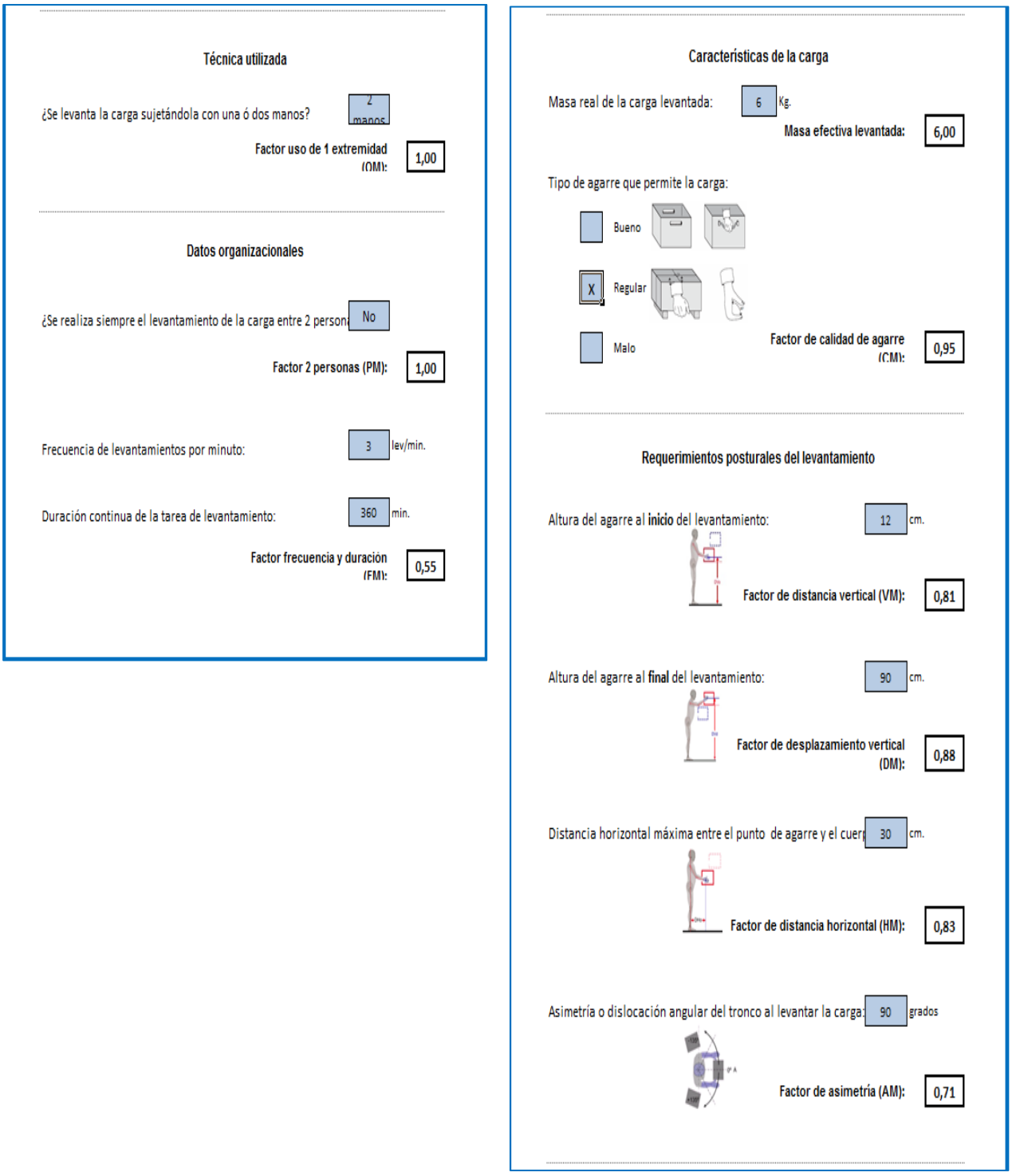
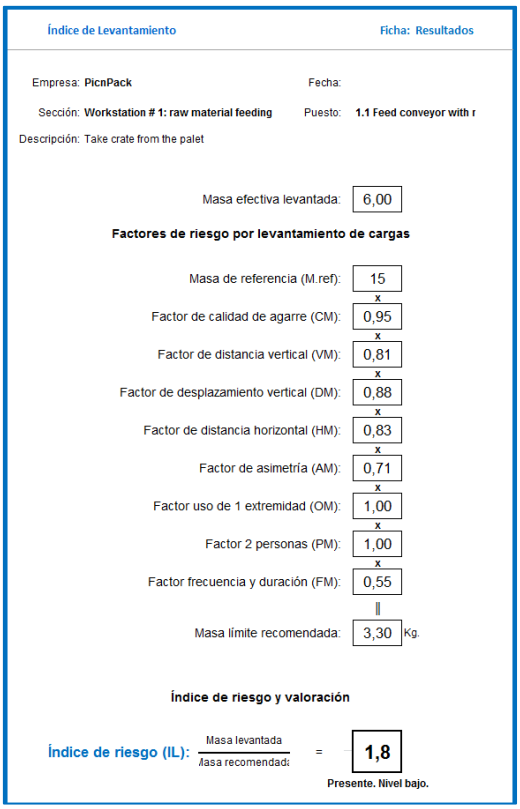


Figure 6 – INSHT method ergonomic information collection.



Índice de Levantamiento — Ficha: Resultados

Empresa: PicnPack — Fecha:

Sección: Workstation # 1: raw material feeding — Puesto: 1.1 Feed conveyor with r

Descripción: Take crate from the palet

Masa efectiva levantada:	6,00
Factores de riesgo por levantamiento de cargas	
Masa de referencia (M.ref):	15
x Factor de calidad de agarre (CM):	0,95
x Factor de distancia vertical (VM):	0,81
x Factor de desplazamiento vertical (DM):	0,88
x Factor de distancia horizontal (HM):	0,83
x Factor de asimetría (AM):	0,71
x Factor uso de 1 extremidad (OM):	1,00
x Factor 2 personas (PM):	1,00
x Factor frecuencia y duración (FM):	0,55
‖ Masa límite recomendada:	3,30 Kg.

Índice de riesgo y valoración

Índice de riesgo (IL): Masa levantada / Masa recomendada = **1,8**

Presente. Nivel bajo.

Figure 7 – INSHT method results calculation.

For risk estimations in the PicknPack line, responses to questionnaires made to the partners and the videos recorded in the integration and demonstration that took place at Wageningen were used as background information. The task, the body segment involved and the characteristics of the objects and equipment used has been taken into account in each workstation. In order to collect information about the workstations in conventional companies, videos recorded in several collaborating companies, and data provided in surveys among professionals have been used.

3.2.1. Risk identification and estimation in PicknPack workstations

PicknPack workstation # 1: raw material feeding

This workstation has the main ergonomic risk, **load handling**, in the moments when workers take the full crates form the first and last rows of the pallet to place them in the conveyor.

Other movements are varied and may individually do not generate a significant ergonomic risk, but problems may arise due to accumulation of overloads and generate an accident by overexertion.

Table 5 – PicknPack workstations # 1 information and risk identification

Action	Body segments and elements involved	Workstation data	Risk
Task 1.1. Feed conveyor with raw material crates			
Take crates from the pallet	Back, arms, hands pallet, full crates 	Full crates: - Weight: 6 kg - Dimensions: 60x40 cm - Crates with handles Conveyor: - Height: 90 cm - Width: 50 cm Crates in pallet: - Minimum height: 12 cm	Load handling
Task. 1.2 Remove empty crates of the conveyor			
Place crates on the pallet	Back, arms, hands pallet, empty crates 	Empty crates: - Weight: 1,5 kg - Dimensions: 60x40 cm - Crates with handles Conveyor: - Height: 90 cm - Width: 50 cm Crates in pallet: - Minimum height: 12 cm	Load handling
Task. 1.3 Pick-and-place robot control			
robot control **remove stuck product**	arms, hands robot interface and product	Weights, distances and effort required to remove stuck product depend on each case	Awkward postures

With all previous data a theoretical estimation of ergonomic risk, due to load handling, was made. It was present when the worker feed the conveyors with full crates and when they remove empty crates of the conveyor.

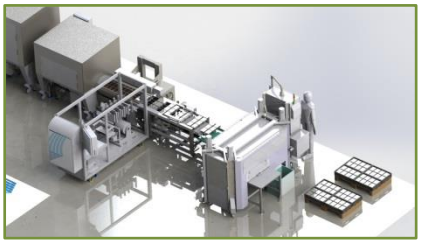
Table 6. PicknPack workstations # 1 load handling risk evaluation

1.1 Feed conveyor with raw material crates		
  		
Method: Load handling INSHT [7] Risk Evaluation result		
Level of risk:	1,8 – LOW RISK	
1.2 Remove empty crates of the conveyor		
   		
Method: Load handling INSHT [7] Risk Evaluation result		
Level of risk:	1,8 – LOW RISK	

The result shows **that there is a low risk of musculoskeletal disorder, but it is important enough to plan the implementation of preventive measures in the medium term.**

PicknPack workstation # 2: final product palletizing

This workstation has the main ergonomic risk, the **load handling**, in the moments when workers place the full boxes in the first and last rows of the pallet.



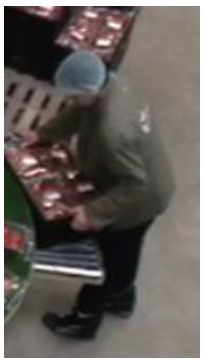
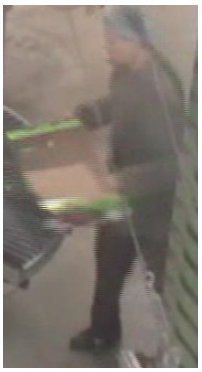
Other movements are varied and may individually do not generate a significant ergonomic risk, but problems may arise due to accumulation of overloads and generate an accident by overexertion.

Table 7. PicknPack workstations # 2 information and risk identification

Action	Body segments and elements involved	Workstation data	Risk
Task 2.1 Remove full boxes of the conveyor			
Place boxes on the pallet	Back, arms, hands pallet, full boxes	Full boxes: - Weight: 8 kg - Dimensions: 60x40 cm - Crates with handles Conveyor: - Height: 90 cm - Width: 60 cm Boxes in pallet: - Minimum height: 12 cm	Load handling
Task 2.2 Feeding conveyor belt with empty boxes.			
Take boxes from the pallet	Back, arms, hands pallet, empty boxes	Empty boxes: - Weight: 1,5 kg - Dimensions: 60x40 cm - Crates with handles Conveyor: - Height: 90 cm - Width: 60 cm Boxes in pallet: - Minimum height: 12 cm	Load handling
Task 2.3 Pickable cable robot control			
robot control **remove stuck product**	arms, hands robot interface and product	Weights, distances and effort required to remove stuck product depend on each case	Awkward postures

With all previous data a theoreticcal estimation of ergonomic risk was made, that would be present when the worker remove full crates of the conveyor and feeds the conveyors with empty crates.

Table 8. PicknPack workstations # 2 load handling risk evaluation

Task 2.1 Remove full boxes of the conveyor		
  		
Method: Load handling INSHT [7] Risk Evaluation result		
Level of risk:	1,7 – LOW RISK	
Task 2.2 Feeding conveyor belt with empty boxes.		
		
Method: Load handling INSHT [7] Risk Evaluation result		
Level of risk:	0,6 - ACCEPTABLE RISK	

From the results of the first task it can be seen that a low risk of musculoskeletal disorder is detected. Yet, it is important enough to plan the implementation of preventive measures in the medium term. **The second task did not show any musculoskeletal disorder risk**, so no changes in the line are necessary.

PicknPack workstation # 3: general operation control

In this position control movements are varied and may individually do not generate a significant ergonomic risk, but problems may arise due to accumulation of overloads and generate an accident by overexertion.

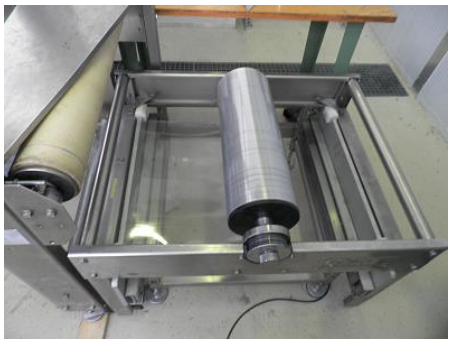
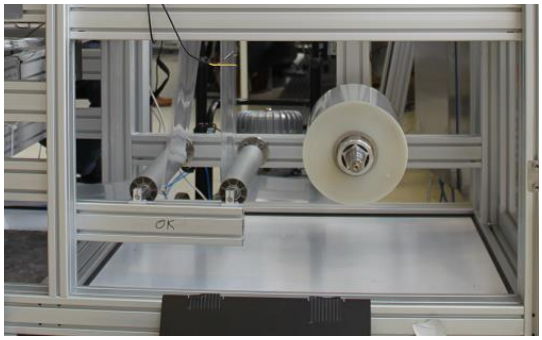
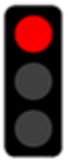
The main ergonomic risk**, the load handling**, appears in the moment of changing the plastic and paper rolls when a replacement system is not used

Table 9. PicknPack workstations # 3 information and risk identification

Task	Action	Body segments and elements involved	Workstation data	Risk
Task 3.1 Check the operation of the entire line and solve the problems				
	Equipment's control	arms, hands equipment's interfaces	Weights, distances and effort required to solve problems depend on each case	Awkward postures
Task 3.2 Collect non-conforming product				
	Remove non-conforming product	Back, arms, hands non-conforming product	Weights, distances and effort required to remove product depend on each case	Awkward postures
Task 3.3 Change rolls in thermoformer and Printing Module.				
	Place them on the equipment	Back, arms, hands Plastic and paper rolls	Thermoformer: - Roll place height: 70 cm - Roll weight: 15 kg or more - No replacement system Printing module: - Roll place height: 50 cm - Roll weight: 14 kg or more - No replacement system	Load handling
Task 3.4 Control of quality parameters				
	Parameters checking **samples picking**	arms, hands equipment interfaces and product	Weights, distances and effort required to take samples depend on each case	Awkward postures

With all previous data a theoretical estimation of ergonomic risk of load handling in the task of changing the rolls in thermoformer and printing module was made.

Table 10. PicknPack workstations # 3 load handling risk evaluation

Task 3.3 Change rolls in thermoformer and Printing Module.		
		
Method: Load handling INSHT [7] **Risk Evaluation result**		
Level of risk:	2,1 - SIGNIFICANT LEVEL	

The result shows **a significant risk of musculoskeletal disorder**, so the planning of the implementation of preventive measures in the short term is needed.

3.2.2. Risk identification in raw material manipulation and manual packaging in processing companies

Raw material manipulation and manual packaging could be replaced by implementing the PnP line, so, the knowledge of the **ergonomic risks that appear in conventional companies is important**, **in order to know the potential contribution of the PnP line in the minimisation of musculoskeletal disorders** in this sector.

During this project, collecting first-hand information on vegetable packaging plants was not possible. Data came from videos and information gathered from surveys. Therefore, general information about musculoskeletal problems in the sector was compiled.

Table 11. Processing companies workplaces information and risk identification

Action	Body segments and elements involved	Workstation data	Risk
Task A - Raw material manipulation			
Product selection and weighing	Back, arms, hands boxes, bags, product, cutting tools	- 8-hour shifts with 1-8 breaks - Plastic or cardboard boxes, bags - Line speed: 10-50 kg/h.	repetitive movement and load handling
  			
Task B - Manual packaging			
Product packaging	Back, arms, hands product, punnets	- 8-hour shifts with 1-8 breaks - 0,5-1 kg./punnet - Line speed: 20-50 punnets/min	repetitive movement
 			

The most important **risks that appear in these tasks are repetitive movements in sorting, grading and packaging of the product**.

It is defined “repetitive movement” if any of the following characteristics is produced:

- The main repetitive cycle lasts less than 30 seconds.
- Irritating friction movement is carried out in more than 50 percent of the repeating cycle

If both characteristics are present in the workstations, injury and health problems may show up in different ways, such as:

- Injury to backs and limbs; employees wearing bandages, splints, etc.
- Aches and pains; frequent employee complaints and rest stops
- Poor product quality and low output
- High material waste;

Some of these conditions are chronic and develop slowly, so it is very important to study them early.

3.3. Measures to minimise ergonomic impacts

One of the principles to minimise ergonomic impacts in processing lines is to adapt the work to the person, taking care in the design of the workstations and in the selection of work equipment and work and production methods, with the specific objective of reducing manual handling and monotonous and repetitive work, decreasing its impact on worker´s health.

More specifically, manual handling of loads causes 14% of the work-related accidents with worker absence and it represents the third highest incidence of work-related accidents and diseases. Similarly, the repetitive work done with arms and hands is the source of most musculoskeletal disorders of the upper extremities. [6]

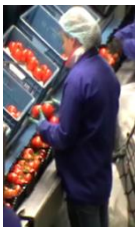
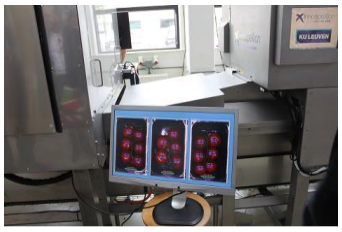
Therefore, preventive measures to be taken in processing lines are the inclusion of equipment and work procedures to eliminate or reduce most of these movements.

3.3.1. Ergonomic improvements by incorporating the PicknPack line in the process

The PicknPack line is one of such preventive measures, as it eliminates and reduces the majority of the repetitive movements and manual handling related with raw material manipulation and manual packaging.

Improvement measures that are introduced into the process by using the PicknPack line are shown in the following table:

Table 12. Improvement measures introduced by PicknPack line.

	Processing companies	PicknPack
Raw material manipulation	Sorting, cutting and weighing the product	Pick and place robot, and Quality assessment
	  	 
	PicknPack line eliminates completely repetitive movements and decreases load handling through “Pick and place robot”, which moves raw product from crates to trays, and “Quality assessment module”, which controls weight, colour, etc.	
Packaging	Placing product on trays and final product in boxes	Pick and place robot and Pickable robot
	 	 
	PicknPack line eliminates completely repetitive movements and decreases load handling through “Pick and place robot”, which moves raw product from crates to trays, and “Pickable robot”, which moves trays from conveyor to boxes.	
Line speed and movement frequency	placing and taking crates and boxes from the conveyors	Buffer area in the inlet and outlet conveyors
		
	PicknPack line allows the worker can work at a different speed to production, reducing effort and stress level	

Although the PNP line introduces many preventive measures in product handling processes, it is advisable to include procedures to improve the tasks performed during operation. Ergonomic risks

that appear in the line are awkward postures and handling loads, therefore, it is necessary to incorporate equipment and methodologies to reduce them to a minimum

The first measure that should be adopted is to use mechanical assistance as hand pallet trucks, carts, conveyor belts, forklifts, etc. When this is not possible, or does not completely eliminate manual handling of loads, other measures will need to be adopted, such as reducing the weight of the load, if possible, and following safe work methods.

3.3.2. Preventive measures for crates and boxes manipulation and for palletizing

To prevent the occurrence of musculoskeletal problems in handling tasks and palletizing boxes, different equipment can be used to lighten the load being handled or to equalize work surfaces.

For the task of transfer boxes from pallets to conveyors weightless manipulators can be used, that reduce the weight of the handled box. The worker guides the equipment to take the box from the conveyor and leave it on the pallet or the reverse handling.

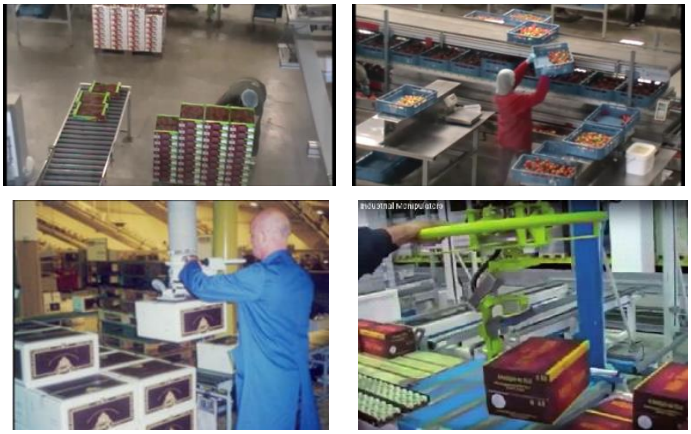


Figure 8 – Improvement measures to transfer boxes from pallets to conveyors or vice versa

For this task, an automated palletising machine or a pick-and-place robot can be used. In this case the worker is not involved in the task and the movement is done autonomously.

Figure 9 – Improvement measures to transfer boxes from conveyors to pallets

In the task of boxes handling the vertical distance at which the work is done has to be reduced. For this, the pallets can be placed on an hand adjustable height pallet truck, so that the worker does not have to bend down to stack the lowest level on the pallet.

Figure 10 – Improvement measures to transfer boxes from conveyors to pallets

Selecting the type of boxes used can also improve or aggravate the ergonomic conditions of the task. Handles design is important to have a good gripping position, so it is advisable to use boxes and crates with open handles to improve the hands position.

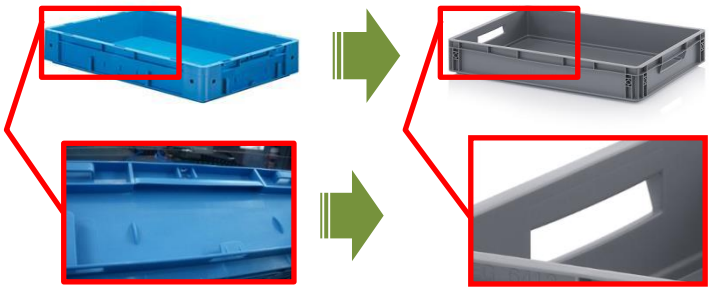


Figure 11 – Improvement measures to manipulate crates and boxes

Another factor to improve in this task is the working speed. The dependence between the speed of work and production has to be minimized.. This is achieved by placing longer conveyors in the input and output zones, so that the conveyor belts can accumulate boxes without stopping the line and the worker can manipulate the boxes in a convenient way.

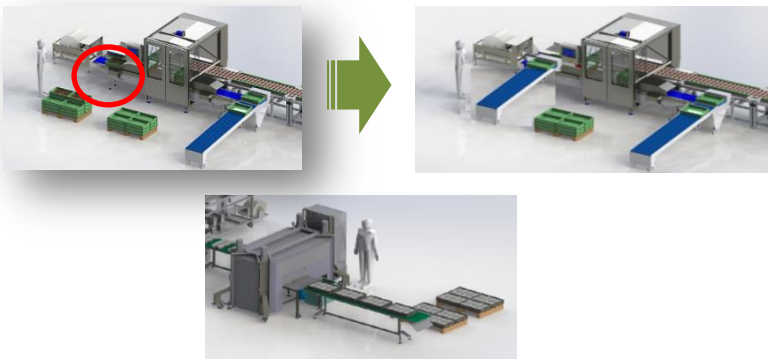


Figure 12– Improvement measures to minimize dependence between the speed of work and production speed

Job rotation is another preventive measure that can be implemented at the same time as the measures listed above.

3.3.3. Preventive measures for non-conforming product manipulation

During production, non-conforming products are generated, and they have to be eliminated from the process line and taken to another site for a correct management. To do this, it is neededto place pallets and / or bins of non-conforming products at different locations of the line.

The size and handling of these bins should not require the worker to make efforts. They can use dolly wheels that can transport several crates or mini-skips that are lifted by a fork-lift truck and transported.

Figure 13 – Improvement measures to minimize non-conforming products manipulation

3.3.4. Preventive measures for lifting rolls of packaging materials

The rolls of packaging materials are, usually, very heavy (60 - 75 kg) and the machines have to be loaded a couple of times per day or per shift. The rolls are difficult to grasp, have no good handholds and present a risk of finger-crushing as they are loaded onto the spindles. The spindle heights are below knee level and above shoulder level. It is a two-person lift to get the rolls into place on the spindles, and changing the rolls requires the lines to be stopped, so speedy replacement is also important.

An easy-lifter that pick the rolls from the pallet, and put them onto the spindle can be used.

Figure 14 – Improvement measures to minimize rolls of packaging materials manipulation

4. Societal Impacts: Consumers

The PnP line has a clear social impact on the final consumers of products. Automation and the use of new technologies allow to have a high process control and production flexibility. This allows to meet the expectations of consumers more accurately and efficentely than traditional forms of production.

Currently, consumer expectations are changing and it is important to know in advance to adjust production and characteristics of the products as quickly as possible. Furthermore, customers are more concerned with the inforamtion of the product and its traceability. Based on a study by AZTI on trends in food consumption that are currently in society, we could estimate the suitability of PnP line for meeting the consumer demands in the future and check the potential impact of such an innovative automatic line in consuemrs.

The most direct impact of the Pnp line is related to the basic characteristics that consumers expect in products:

- Product hygiene: PnP line gets minor contamination due to reduced product handling.
- Product Quality: Controls performed during production classifies products based on their quality and eliminate those that do not meet the minimum requirements.
- Product loss: more accurate classification of products allows defining the uses and expiration dates that are given to each batch. This allows a better management of stocks in warehouses and reduces product loss, both in the company and in the homes of consumers.
- Product traceability: PnP line gathers all the data concerning to each product, since the origin to the quality assessment, so the consumer has access to a full display of information about the product he is about to consume: origin, harvesting date, sweetness, defects etc.

There are other characteristics that are more influenced by consumer trends and that can also be achieved through the implementation of the PnP line in manufacturing plants:

- Temporary and rapidly changing products: This is the result of the current nomadic city lifestyle and commuting (working in an office, at home, in cafeterias, etc.) which creates the need to adapt active lifestyle tasks to daily. This trend requires introducing flexibility in manufacturing lines, promoting instant access to almost immediate use of products and added satisfaction for consumers.
- Sustainable food: This is the result of growing consumer awareness about the direct impact of each activity on our environment. This is translated into a greater demand for designing products and services which not only generate economic rewards but also benefits for society and for our planet. Consumer demand for transparency is translated into providing information and evidence about impact on the environment and society, from production to consumption. Traceability system of PnP line has the same aim, generating the possibility of following up a product throughout the entire chain, up to consumption.
- Food designed for me: Each person is unique and we have the desire to express our identity as well as being acknowledged for the way we are together with our individual likes and dislikes. Consumers are more proactive than ever to individuality and expression which results in the demand of personalised products, services and experiences in an easy and agile way. The

online control of the production in the PnP line is nurturing this trend and customisation is easy and accessible.

- Simple and smart: In view of the accessibility and over-exposure to products, services and information, the current challenge is to simplify and be effective. This is how the demand for flexible, smart, accessible solutions which save time and help the consumer to make their lives easier, is born. In the food scope, the search for continuous convenience remains unstoppable, with products and services which make life easier or packaging bearing smart labels to provide fast, visual and intuitive information. This is possible thanks to the flexible printing module of the PnP line.

The trends presented here are “changing” and will be relevant for the food sector in the short and medium term. As their application may be immediate, the challenge is for companies to interpret trends in time and adapt their production and equipment that is their business..

5. Conclusions

To take into account the impact of automation in **worker conditions** is of main relevance. **Adapting jobs** to suit the operators doing them often reduces fatigue, accidents and increases motivation and satisfaction. This leads to **increase productivity and better health and well-being**, as many of these cases of study show. Such investment in workers wellbeing will probably saving the industry money, from sickness absence, accidents, loss of production, workers loss of motivation etc.

The investment in automation does not mean by default a direct improvement in ergonomy and quality of workers. Badly designed automatic equipment can make the worker in charge of the equipment to suffer higher risk of accidents or sickness. That means that **automatic tasks must be well designed to adjust workers activity** to the processing work and time. Not only must the equipment design take into account such issue, the ergonomic design must also be taken as a whole and take into account the integration of the equipment and line in the specific work sites of the companies, because the specific conditions (space, weather, speed of production, etc.) of the companies can make the risks to be different. Thus, all the ergonomics risks should be checked and redefined when the automatic equipment is in place.

In this study several ergonomic risks and suggestions for minimizing them have been done. Although the study was semi theoretical, the information , methodology and guidelines are proposed to be followed when integrating this process line in a real production plant, so the equipment manufacturers are **encouraged to, as much as possible, to take into account such recommendations in order to make the equipment user friendly and safe for the workers**

Employers are required to implement the most effective solution to eliminate or reduce the risk of manual handling injury. But it is not required to implement every applicable solution but the ones that are 'reasonably practicable'. In deciding what is reasonably practicable, it is needed to weigh the overall likelihood and severity of possible (or actual) injuries against the cost of preventing them.

The new **manual work must be adapted to the automatic line**, the way of **working spaces, times** and **risks** are new so it is a must to make a **suitable ergonomic design** and to **train the worker** for such new tasks with new requirements. The automation brings to workers new opportunities for higher education and training that can improve their qualification, welfare and economic situation.

The final driver for automation of the food processes are the aim of meeting consumers demands in the most effective way. Consumer requirements leads the products to be of different formats, personalized, defined quality, traceable information, hygienic, safe, etc. This is a challenge. Automation is gaining flexibility and efficiency. Improvement in sensors is gaining efficiency in identifying foreign matters in food and in sorting by quality in a more efficient way. The hygienic design is a must for implementing any kind of equipment and processing food lines, that makes the cross contaminations to be more difficult to happen. The efficiency of automatic system is making the consumers to be more confident about the quality and safe of the products they buy. The increase of the margin of producers by improving the efficiency with innovative automatic equipment makes also the consumer not to suffer the increase in price as much, so everybody can benefit from the impact of the automation.

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