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Analysis of product shrinkage and waste in a potato bagging plant

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Abstract

Nowadays, an average of 2 kg of waste per person are generated in Spain. Furthermore, the household consumption is rising and, as a consequence, the waste production is also increasing. This trend presents a direct impact in the environment. Moreover, after two years of COVID-19 pandemic, it has been detected a stronger rise in consumption per person, while consumption through professional commercial channels for hospitality industry has been lower. This paper analizes the waste generation and product shrinkage in a potato bagging plant, which addresses its production to both final consumers and retailers. The raw materials washing line, as well as the production line, are taken into consideration in the analysis, while new uses to the produced waste are proposed, aiming at providing new useful life, such as the production of bioplastics or the production of biodiesel. As a consequence, the environment impact is minimized and new products are obtained.

Keywords: product shrinkage, waste generation, bagging plant, potato processing

1. Introduction

Potato, *Solanum tuberosum*, is one of the four crops, with wheat, rice, and corn, serving as main base food for a great percentage of world population.

According to the Spanish Ministry for Agriculture, Fishing, and Food (MAPA) the potato production in Spain, in 2021, was 2,141,349 tons, which constituted an increment in 4% with respect to 2020 production. As a consequence, Spain was the eight producer of potato in the European Union (MAPA, 2022).

The potato consumption per person and year in Spain in 2020 has been increased up to 32.1 kg (Orús, 2021). Table 1 represents the values of yearly potato consumption per person in Spain, which correspond to more than a decade.

Among the potato washing and bagging industry, a great amount of waste has been found. This waste is mainly produced to improve the visual quality of the raw materials. Despite the quality of the product could be fine, the aesthetic criteria, desired size, or visual quality could be insufficient for the product to be processed and sold (Usva et al., 2009).

All these organic residues come from wastes of the potato processing plant, as well as the raw materials that do not meet the quality requirements, producing an important environmental, economic, as well as social impact (Catarino et al, 2007).

The purpose of this research is the analysis and improvement of the mentioned potato washing and bagging process by means of a reduction in the generated waste. As a consequence, a reduction in

energy and water consumption is expected, improving the environmental impact of the process is expected to be improved (Mattson and Wallen, 2003), as well as a better use of the raw materials and other resources (Willersin et al., 2015).

Some of the causes of wastes in the potato washing and bagging process, is green color, scabbies, defects in the skin of the potato, rotting, as well as other types of defects that prevent the potato to enter the supply chain to the final consumers or retailers. In other cases, the rejection of a potato is not caused by one of the mentioned defects, but because the size is not appropriate or it does not meet the requirements of the consumer (Norton, 2008).

With the purpose of assessing the impact of the investigation and the feasibility of its possible implementation, a diagnosis of a potato washing line is performed, aiming at determining the daily amount of waste in the processing line. Despite every batch of raw materials presents specific characteristics and can differ from each other, uniformity in the product is intended. For this reason, it is performed an analysis at the arrival of the raw materials, regarding certain minimal basic characteristics, defined by the quality control, before the raw materials are introduced in the production line.

Table 1. Yearly potato consumption per person in Spain.

Year	Consumption per person (kg)
2020	32.1
2019	27.6
2018	28.2
2017	28.6
2016	30.3
2015	29.5
2014	30.5
2013	30.7
2012	30.2
2011	29.5
2010	30.6

In addition to this diagnosis, it has been studied the percentage of the waste that is caused by green product, dents, rotten product, scabbies, or other skin defects that do not decrease the quality of the product but they alter the visual appearance of the potato.

The economic viability of the actuation, in the context of the present economic situation, it is additionally analyzed. The increasing energetic and processing costs, as well as other costs related to them, are studied to determine the feasibility of the application of the results of this research.

In the context of the present investigation and with the purpose of minimizing the waste, three alternative destinations are proposed for this rejected potatoes or second-class products: reuse of the rejected products in potato omelette production plants, reuse for livestock feeding, or reuse as potato starch to reduce the utilization of plastics. Potato starch can be used in substitution of plastics or to produce biofuel, leading, in this way, to new line of business.

The main purpose of this approach is to give a new use of the waste from a potato processing line; thus, to minimize its ecological footprint and, also, to provide this rejected raw material with an economic viability. With this strategy, a larger sustainability is achieved, reducing to a minimum the environmental impact, while finding new applications to make the main product more competitive by reducing the production costs (Audsley, 1997).

Furthermore, it is convenient to take into account that, with the rise of the livestock food cost, the proposed reuse of the potato processing waste is an effective way to increase the benefits, while reducing the waste of the production process and its environmental impact.

2. State of the art

According to a technical report of the Government of Aragon (Spain) relative to industrial and culinary quality of the potato varieties (Ángel Borruey Aznar, 1999), referred to the potato washing and bagging industry, the visual appearance and the presentation of the tubers, in conjunction with their culinary quality and healthy properties, presents a large influence on the commercial success of the product.

Additionally, the alterations in the skin of the potatoes are assessed negatively. These alterations may be produced by Rhizoctonia, as well as potato scab and tubers with more than 10% of their skin affected by alterations are rejected.

The pealing easiness, produced essentially by the depth of the tuber eyes, and a uniform caliber can be very attractive by the consumer (Ángel Borruey Aznar, 1999).

Nowadays, society tries to find new alternative strategies to reduce the use of plastic. One of the most promising alternatives is biodegradable plastics, manufactured from potato starch. An example of these materials is potato plastic, whose main advantage is its decomposition in two months after its use, according to its inventor, Pontus Törnquist. This material is composed of potato starch and water and, when heated, thickens and is transformed into a dry piece.

In order to extract the starch, potatoes are grinded and the resulting paste is washed. As a result, a milky mass is obtained and, then, water is removed by decantation. A subsequent production stage is drying the precipitate (which is the starch), Subsequently, the resulting product is grinded and stored.

Other alternative materials, also obtained from potato starch, have been studied, such as thermoplastic polymers based from potato starch, analyzed in the University Carlos III of Spain (Mere Marcos, 2009) (Janssen, 2006).

In addition to this type of materials, there are other different feasible uses of potato starch, such as the

preparation of sweetener, thickening agent, food stabilizer, or even flocculation agent in the mining industry.

Furthermore, the use of vegetable oil, such as biodiesel, is a good option to reduce the ubiquitous use of hydrocarbons. This biodiesel can be used in conventional motors without requiring any modification, which is an important feature for its success in the market (Caro-Becerra, 2016).

3. Materials and methods

In the development of the present research, the production in a potato washing and bagging line has been analyzed for a period of three years, as well as the produced waste, which has been classified into three groups. This investigation has made available an important volume of raw data, which has been conveniently analyzed with the methods described in this section.

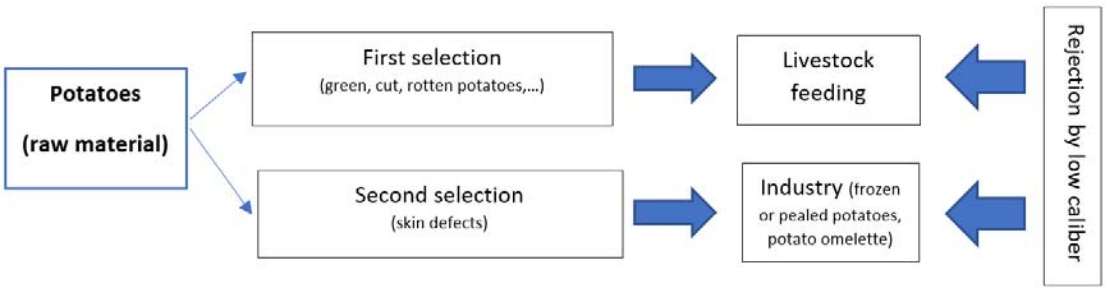

Figure 1. Selection processes in potato washing and bagging industry.

- On the other hand, potatoes selected and extracted from the main production line in the second selection stage is rejected mainly due to its visual appearance. Hence, the rejected products can be used in the potato omelet, frozen or pealed potato industries, since they do not present any culinary defect, but only skin defects that deteriorate their visual appearance, leading to a negative assessment by consumers.

Fig. 1 shows a diagram of the mentioned processes.

The information obtained in the selection stage is composed by the number of potato kg per processing unit, average diameter, amount of the rejected product, classified by cause of rejection. In conjunction with this data, additional relevant information is stored, such as the origin of the product, variety, harvesting date, thermo-hygrometric condition in transportation and storage, as well as the processing date.

From all this raw data, it is possible to obtain useful information to develop an estimation of the nonconforming product amount and to decide its possible use. As a result of this investigation, the obtained information, by the consideration of the detected nonconformities, can lead to the development of a model to determine the ecological footprint of the industrial process (related to water and energy use), economic assessment as a function of the rejected product reuse, etc.

In the first stage of the production line, the potatoes not having an adequate caliber are selected and extracted from the main production flow. In the case that has been investigated, a caliber from 50 mm to 80 mm is consider for the processed potato, destined to be bagged.

Once the potatoes come out from the washing line, a second selection process of the product takes place. In this stage, the potatoes not meeting the quality criteria, which have not been detected previously, are detected and rejected.

As a consequence of the two selection processes described in the previous paragraphs, two characteristics appear:

- On the one hand, the rejected products in the first selection are green potatoes, cut ones or rotten tubers. This waste of the main production process is destined to feed livestock, since their organoleptic quality is lower than required for human diet.

4. Results

Data of the production and waste of a fresh potato washing and bagging plant has been taken and stored along three years. Some information obtained from this data has been represented in table 2.

Considering a daily average of 48,500 kg of processed potatoes, the product shrinkage that has been measured is presented in table 3, classified by selection stage and product caliber.

Table 2. Automobile land speed records (GR 5-10)

Year	First selection	Second selection	Caliber<45mm	Caliber>80mm
1	4%	12%	4%	5%
2	4%	9%	3%	2%
3	4%	9%	2%	2%

Table 3. Average daily product shrinkage in a potato washing and bagging line (kg).

Selection stage and product caliber	Daily product shrinkage (kg)
First selection	1940
Second selection	4850
Caliber < 45 mm	1445
Caliber > 80 mm	1445

In addition to this product shrinkage in the first stages of a potato washing and bagging plant, it can be considered the waste produced in the bagging process, caused by ripped or wrongly sealed bags. This last waste averages a daily amount of 825 kg.

Moreover, there is another source of waste, as an outcome of the quality control of the customers. The daily average shrinkage due to the rejection of product by the customers is calculated to be 121.25 kg.

5. Conclusions

As a result of the storage and analysis of data obtained from a potato washing and bagging plant along three years of operation, it has been possible to arrive to the conclusions stated in this section.

The waste produced in a first selection process is 4% of the production and it is destined to livestock feeding.

The rejection of product by caliber depends on the raw materials batches, and they are affected by their cultivation conditions, such as the weather conditions. Potatoes with a caliber smaller than 45 mm are rejected from the main processing flow, however, they can be reused as potatoes for garnish, a very appreciated product in certain markets and with a rising demand.

The waste produced in a second selection process is destined essentially to a market of pealed tubers for potato omelet or frozen tuber production.

Potatoes with a caliber larger than 80 mm and the shrinkage due to product returned by customers, due to lack of quality, can be used to manufacture bioplastics. The commercial interest of bioplastics can be found in manufacturing plastic film, 100% biodegradable, produced from potato starch. This film could be used in the bagging line itself; hence, closing the cycle and optimizing the use of raw materials.

The challenge of this industry is to give response to consumers, no matter if they are intermediary links in the supply chain or final customers, who demand more information, quality and safety every day in the products they purchase. More research is needed to acquire knowledge on the interest of consumers in these type of secondary products derived from the waste of potato washing and bagging lines.

With the purpose of opening new business lines and of minimizing the environmental impact, research is carried out in the efficient use of potato starch to produce biofuel. The result of this approach would contribute to the substitution of fossil fuels with a greener alternative, but a new life would be given to a waste, which had not any application so far.

There already are important limitations in these new fields, but new research lines are devoted to them, in order to give a second life to the waste of a natural product trying to obtain the maximal profit and the minimal environmental impact.

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