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Recycling of potato waste in the production of the bioplastic in the Souf Region (Algeria)

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Abstract

The plastic had been subject to several criticisms related to the environmental aspect when it experienced very slow biodegradability. On the other hand, it contains chemicals that are very harmful to health and cause many diseases, such as cancer. However, this situation, which our objective is carried out in the recovery of potato waste in the manufacture of a plastic material (bioplastic). That even this work is about preserving the environment and health. Bioplastics are made from starch, which is an extract from the potato tuber. When the potato is considered among the most starch-rich plants and also the most common crop in the Souf region (Algeria). According to the results, starch yield varied between 17.6 0.51% (Kondor) and 19.6 0.5% (Spunta). For bioplastic manufacturing, takes 5 g of starch and mix with water and glycerol in the presence of Naoh and Hcl. Then, make the mixture in a high temperature until the dough is obtained. Finally, after drying, a flexible and solid material (plastic) is obtained, with a yield of 41.4 0.1% to 42.4 0.7%.

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Introduction

Plastic is a synthetic material consisting of macromolecules, which are made from petroleum, the word plastic is originally from the Greek "plastikos" which means "malleable" (Jogdandm 1999; Ruhul *et al.,* 2019). World production is currently 311 million tonnes in 2014, of which China ranks as the world's largest producer by 26% of world production (Heddar, 2014). Algeria and according to the National Agency for the Development of Investment, plastic consumption is one million tonnes per year of which 2/3 of the primary materials are imported (Andi, 2013).

Despite the large use of plastics in our daily lives, they are exposed to a wide range of criticism because of their harmful impact on either the environment or human health (Steinbuchel and Doi, 2002; Ruhul *et al.,* 2019). Plastic waste causes $13 billion in financial damage to marine ecosystems (PNUE, 2011), Recent studies of chemicals in plastics show that they can cause diseases such as cancer (PNUE, 2011; Laurent *et al.,* 2013). A large quantity of residual material from packaging made of ordinary plastic; faced with this critical situation, certain measures are taken into consideration such as prohibiting the use of single-use plastic bags for example France prohibit the use of single-use bags from 1 January 2016 (Energy Transition Act Article 75 of 18 August 2015).

In addition, encouraging the manufacture and use of original plastics from renewable resources or bioplastics.

Bioplastics or plastics of biological origin are natural polymers derived from plants, algae or animals (Wertz, 2011; Ruhul *et al.,* 2019). In recent years, these polymers have been experiencing real growth due to their origin and especially their biodegradable character (Ellis *et al.*, 1998; Avella *et al.,* 2001). Bioplastics are made from the starch of several plants such as cereals and potatoes ...etc.

The potato plant (*Solanum tuberosum*) is one of the most important crops in the world. It is also essential in our diet. It has a high nutritional value and contains proteins, starch, minerals, vitamins and other substances (Leytem and Westermann, 2005; Errebhi *et al.*, 1998). Due to low soil organic matter content in the Souf (south-eastern Algeria) (Ghemam *et al.*, 2015, 2016). While, biochemical analyses on potatoes and in the same study area allow to record a starch content varying between 11.9% and 13.2%. While the protein content varies between 0.8% and 1.2% (Ghemam *et al.,* 2015).

This study is based on the production of bioplastics from potato starch. And for the objective of recycling potato waste in the manufacture of a plastic material (bioplastic). That even this work is about preserving the environment and health.

Material and methods

Region and stations of study

The Souf region is located in the south-east of Algeria, 600 km from the capital Algiers. It is positioned in the northern reaches of the east Erg (33° to 34° N. and 6° to 8° E.). It is limited to the east by the immense Tunisian chott El-Djérid, to the north by the chotts Merouane, Melrhir and Rharsa; to the west by the chott train of Oued Righ and to the south by the Oued M'Ya (Alia *et al.*, 2018).

This study area belongs to the Saharan bioclimatic stage in mild winter according to climatic data from 1980 to 2015. According to the same data, this study area is characterised by a dry period which takes place every month of the year. The potato varieties were harvested in Robbah station. Robbah station is 10 km south-east of the city of El-Oued.

It has a southern exposure and an altitude of 50 m. The crops practiced in the station of Robbah, it is noted a dominance of *Phoenix dactylefera* (L. 1753) with a rate of 24.32%, followed by Solanum tuberosum (3 x 100m radius pivots each) and *Arachis hypogaea* (Linné, 1753) with 14.13%. Other species are weakly represented with rates not exceeding 13%, such as *Allium sativum* L. (Garlic) and *Cucumis melo* (Alia *et al.,* 2018).

Experimentation is often necessary in order to be able to extract starch from the potato followed by the manufacture of bioplastic has trévère the starch extracted.

Starch extraction from Solanum tuberosum

Starch extraction from potatoes is done by the Davidovic method (2006). In the first step, well cleaned tubers, then peel it with the help of a peeler, after this step they are grated and recovered pulp in container. Then add the water to the pulp and mix well with a spoon. Then we filter the mixture using a strainer and let the solution decant. The starch is deposited at the bottom of the container after a few minutes and the water is lifted by means of a pipette. Then leave the powder in the air for a few days to dry and collect it in a bottle (Ghemam *et al.,* 2015).

Manufacture of bioplastics

To make the bioplastic, 5g of potato starch is mixed, which is already prepared with 50 ml of distilled water and 4 ml of glycerol and hydrochloric acid is added, followed by a glass rod (Wertz, 2011). The solution is then placed on a heating plate at 100°C for 15 to 20 minutes. During the formation of a very viscous homogeneous mixture that will gradually bind slightly, NaOH is added to neutralize the mixture and a few drops of dye are added according to our choice (Wertz, 2011; Kumar and Thakur, 2017). After the mixture is completely reliquefier we pour the mixture on a paper of amomum and let dry in the oven at a temperature of 90 to 100 °C for one hour. Air drying is then allowed for 3 to 4 days (Kumar and Thakur, 2017).

Statistical analysis

The results obtained are processed by statistical analyses using data processing software such as SPSS (IBM 20), Excel-Stat (2014.5.03) and Minitab (17.1.0). For the tests used, mention should be made of ANOVA (case of normal data), Kruskal Wallis (not normal data) and Wilcoxon.

Results

Starch yield results

The results obtained for starch yields of three potato varieties are summarized in Fig. 1. Depending on the variety, the starchiest variety is Spunta with an average of 19.6 0.5% (Fig. 1).

On the other hand, the variety with the least starch content is Kondor with 17.6 0.51%. Comparison of these damages by the ANOVA test shows a significant difference (p-value = 0.0091) between the starch levels (Table 1).

Table 1. ANOVA table of the starch yield to the potato variety.

Source of variation	SS	Df	MS	F	P-value	F crit
Between Groups	5,931667	2	2,965833	11,34644	0,009144	5,143253
Within Groups	1,568333	6	0,261389			
Total	7,5	8				

According to the Tukey test, 3 groups are distinguished (Fig. 1). The variety Spunta forms the group (A), which represents the most starch-rich variety. The latter has a significant difference with the variety Kondor (p-value = 0.008) (Table 2). The second group (B) represents the variety Kondor, which has a slightly lower starch content than the other varieties. Just after in third position comes the group (AB) which distinguishes itself following an intermediate rate to those of the previous stations. It includes the variety Bartina (Table 2).

Table 2. Matrix of comparisons of the averages (Tukey test) of the starch yield to the potato variety.

	Spunta	Kondor
Kondor	0,008	
Bartina	0,082	0,175

Performance in bioplastics

Results for bioplastic yields for three potato varieties

are summarized in Fig. 2.

Depending on the variety, Spunta (42.4 0.7%) is characterised by a high rate of bioplastics, while Bartina (41.4 0.1%) and Kondor (41.4 0.3%) are characterized by a relatively low rate than the other variety (Fig. 2). The ANOVA test shows that there is no significant difference (p-value = 0.058) between bioplastic levels between the varieties studied (Table 3).

Table 3. ANOVA table of the bioplastic yield to the potato variety.

Source of variation	SS	Df	MS	F	P-value	F crit
Between Groups	1,806667	2	0,903333	4,714957	0,058798	5,143253
Within Groups	1,149533	6	0,191589			
Total	2,9562	8				

Photographic results of bioplastics obtained

Depending on the temperature and the drying time, two types of bioplastics are obtained- 1. Flexible bioplastics for 90 °C for 1 hour, and 2. Rigid bioplastic for a temperature of 130 °Cfor one hour.

Discussion

Starch is a polyoxide sugar of the crude formula $(C_6H_{10}O_5)$ n. Derived from photosynthesis, starch, which constitutes the sugar reserve of plants, is in the form of grains of variable size (1 to 200 µm) and gives a colloidal solution in water.

It is one of the most important constituents of foods because of its gelling, viscosifying and water fixing power. Potatoes are very rich in starch (Sudesh and Iwata, 2008; Ezeoha and Ezenwanne, 2013).

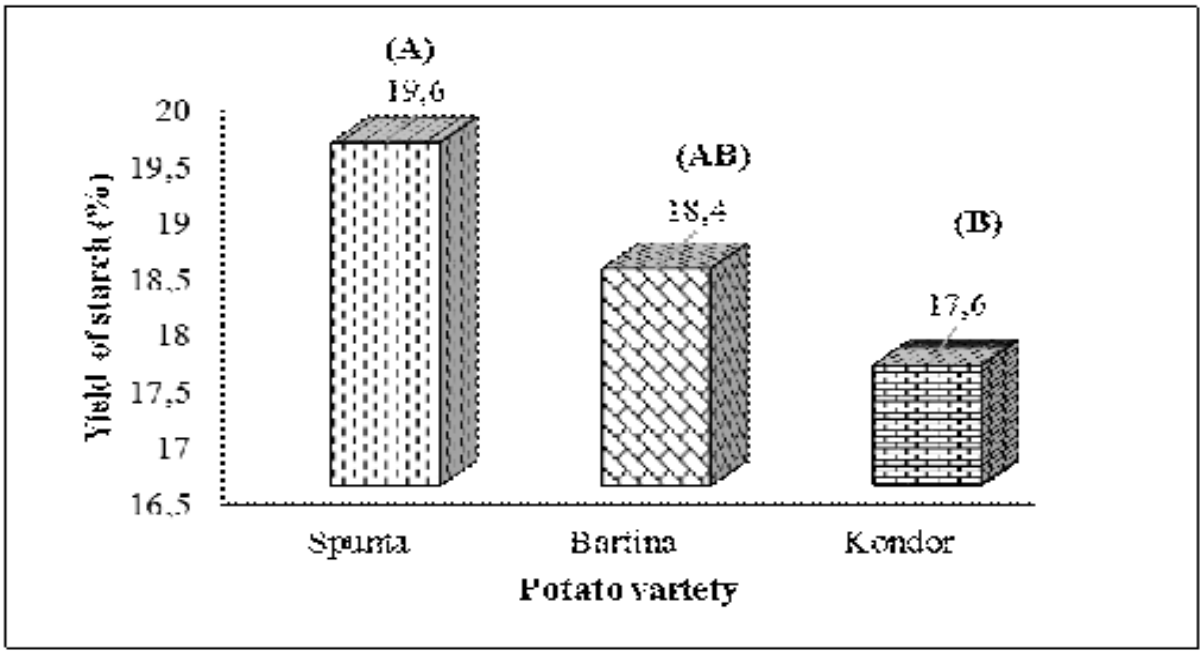

Fig. 1. Starch yield by varieties.

The results obtained on the starch content for the three varieties (Spunta, Bartina and Kondor) most cultivated at the Souf show that there is a slight significant difference between the variety Spunta and the other two varieties Bartina and Kondor. On the other hand, there is no significant difference between the variety Bartina and Kondor due to the variety grown and the nutrient richness of the soil (Song and *al.,* 2009). While Ghemam *et al.* (2015) and in the same study area find starch yield in potatoes ranging

from 11.9% to 13.2%, these results are relatively low compared to our result. Similarly, in the studies of Alvin *et al.* (2011), which is working on 10 potato varieties finds a starch yield varying between 25.2% and 29.1%. On the other hand, Dorota *et al.* (2011) in Poland finds a starch yield varying between 10.3% and 12.5%.

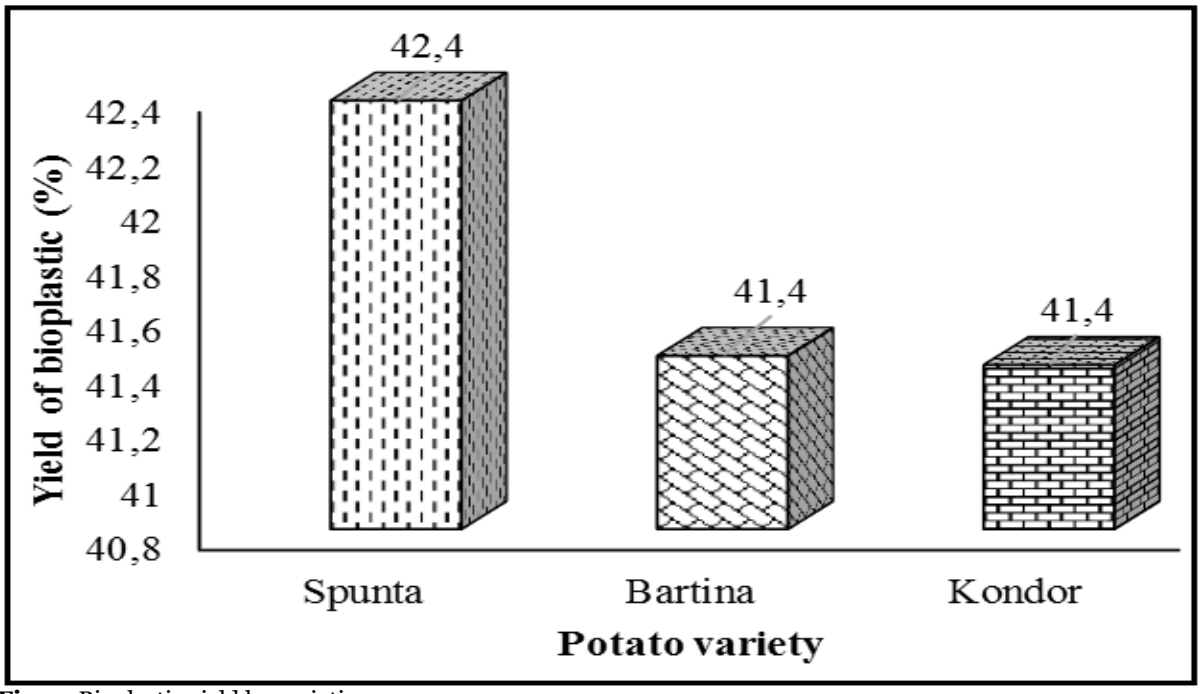

Fig. 2. Bioplastic yield by varieties.

Starch is soluble in solvents which are good acceptors of hydrogen bonds such as glycerol which enters the operation of plastification. The insoluble native starch can fix 40% of its weight in water.

Fig. 3. Bioplastic manufactured.

If one raises the temperature of the medium, the amount of water fixed increases. This water absorption is manifested by reversible swelling of the amorphous phase and the formation of new hydrogen bonds between the chains. Small molecules of amyloidosis are more easily released, and water causes crystalline alignment after the extension of amorphous zones (Copinet *et al.*, 2004; Dovidovic, 2006; Sriroth *et al.*, 2014).

When the temperature exceeds 55-65°C, the hydrogen bonds begin to break. Starch granules swell and break down, and its macromolecular constituents disperse and solubilize before forming a stock. There is then an increase in the viscosity of the aqueous medium by colloidal dispersion of starch (Copinet *et al.*, 2004; and Wertz, 2011).

Starch gelatinise and loses its crystallinity. After cooling, the empois forms an opaque gel, flexible first and then rigid (bioplastic) this terminal phase in the manufacture of bioplastics is the same for other

results of the starch polymerization studies as (Copinet *et al.*, 2004 ; Dovidovic, 2006 ; Wertz, 2011 ; Haddar, 2012;) The bioplastic yield for the three varieties in our study is not significant. For the three varieties seen that the chemical composition of the starch is the same, all of the studies we consulted are studies that target biochemical and non-industrial processes to calculate yields and physical and chemical characteristics for bioplastics.

Conclusion

Despite its positive applications in various fields, plastics can pose serious environmental and health problems. In fact, the capacity of the adjuvants and monomers, in larger or smaller quantities, in polymers presents the risk of harmful chemical reactions during the manufacture and use of these materials. During decomposition at high temperatures, these materials generate significant emissions of gases, solvents, dust and air. The toxicity of these materials on the health of the personnel of the plastics industry when the various additives are introduced is very important, causing serious illnesses, dizziness, loss of consciousness, cancer (lung, brain), etc. Faced with its irreversible risks, it becomes necessary or even indispensable to replace this chemical material with other material of plant origin, to protect the environment and human health on the one hand and the recovery of waste from plants like our potato on the other.

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