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Soap production: A green prospective

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ABSTRACT

A green prospective based on the reuse of waste materials such as almond shells, orange peel and used cooking oil to manufacture soap is presented.

In Portugal, thousands of tons of waste are generated from used cooking oil and production of nut shells' residues is growing every year. In addition, the high consumption of citrus fruits, oranges in particular, generates large amounts of citrus peel. Therefore, it is necessary to diversify reuse mechanisms of these wastes, in order to make them back into raw materials. Complying with this trend, this work was carried out by processing and grinding almond shells, treating used oil, processing orange peels and extracting limonene, formulating and producing soap, and performing an acceptance study of the final product. Results validated a high potential of the idea in the field of environmental education, so it can be replicated in practical classes. It can also be useful for waste management, and it can support the development of community projects on an ecological approach.

1. Introduction

This work aimed to obtain a useful, cheap and good quality green soap, using waste products as major raw materials. Such studies are of great importance for replication in practical classes, and inspiring community projects intended to improve recycling on an ecological approach: on one hand contributing to families' economy, and on the other hand reducing the environmental impact of these residues and stimulating the use of healthier products, which can be relevant issues from the public health point of view.

1.1. Residues, their reuse and recycling

The encounters and mismatches between man and nature have always been present and have always strongly influenced our lives and health. Connections, cycles in nature, renewable energy and ethical issues are already present in environmental projects, however, due to the imbalance in our world, it becomes increasingly necessary to explore new perspectives, focusing not only in environmental education, but also and specially in the concerns of public health.

Population growth as well as changes in consumption patterns and lifestyle have been the main drives of an increased waste production which causes several impacts on environment and public health (Herva et al., 2014). In the last decades the waste management became a major issue, and several processes have been devised for organic waste treatment, such as composting. However, despite its low economic cost and waste reduction in landfills, some products cannot be composted (e.g. oils) and others can inhibit this biological process (e.g. citrus peel) (DR, 2009; Ruiz and Flotats, 2014).

According to official data, in Portugal each individual consumes daily *ca.* 40 g of vegetable oil, leading to the production of great amounts of residues (INE, 2012). Portuguese legislation establishes the regime of management for used cooking oils. It also refers that each year 43–65 thousand tons of cooking oil residues are produced, mostly from the domestic sector (62%), but also from restaurants and hotels (37%) and from the food industry (1%) (DR, 2009). Despite the European Community politics for energy forecasts that a large amount of these residues can be collected and converted into biodiesel (EC, 2009), data provided from the Portuguese Environment Agency (APA – Agência Portuguesa do Ambiente) indicates that only 340 tons of used cooking oil were collected in 2012, and 370 tons were collected in 2013 (APA, 2013, 2014), which is frankly far from the proposed goals in this area.

Traditionally Portugal has produced and consumed nuts for centuries, as part of its Mediterranean diet culture. In recent years nutrition recommendations have also raised nut's consumption, resulting in increased residues' production. Therefore, recycling these shells is increasingly becoming an important issue (Yang, 2015). Ranking after apples, oranges are the second most produced and consumed fruit in continental Portugal (OMAIAA, nd; INE,

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2013). However, and because of its acidity, citrus peel cannot be used in composting, generating large amounts of non-processed waste (Ruiz and Flotats, 2014).

In this connection the manufacturing of this kind of products using otherwise unusable wastes becomes more attractive both economically and ecologically.

1.2. Oils and saponification

Saponification reaction, also known as the cold process for making soap, is the alkaline hydrolysis of triacylglycerols. These esters are the major constituents of vegetable oils and animal fats; they can react with a strong mineral base like sodium hydroxide, in aqueous medium, to produce the sodium salts of the hydrolysed free fatty acids (the opaque soap) and glycerol (Fig. 1) (Panda, 2003; Hill, 2004; Mabrouk, 2005).

Historically, soap production used to be a method to reuse animal fats, lard and sebum. Nowadays, most people use industrial soap but, mainly in poor regions, there are families and communities that produce their own soap bars (Onyegbado et al., 2002; Konkol and Rasmussen, 2015). In fact, there are regions where the access to a simple washing hand soap is not assured, which highly increases the risk of infections (Francke and Castro, 2013; Madichie, 2016). There is also a growing movement to enhance artisanal production of good quality green soap, both because it is considered better for the skin and for health in general, as well as for reducing water and carbon footprints (Francke and Castro, 2013).

Nowadays fat sources have become almost exclusively vegetable, and include a considerable number of different oils and fats which, in association with additives, origin soaps with different characteristics (Grosso, 2016).

Although all animals and vegetables possess a mixture of triacylglycerols and free fatty acids as structural lipids, different species, and even different individuals from the same species, have different lipidic profiles. This means that when vegetable oils are extracted from a plant, one cannot know the exact ratio triacylglycerols/free fatty acids.

The saponification index of an oil is an important parameter for the reaction efficiency, which indicates the weight of KOH (potassium hydroxide) in milligrams that is needed to saponify one gram of that specific oil (Wakita et al., 2014). This index value supports the decision on a formulation choice in a wide range of possibilities.

1.3. Fragrances and essential oils

An essential oil is a mixture of secondary metabolites from plants that are responsible for its characteristic odour. It's a combination of different aromatic and aliphatic compounds, frequently terpenes and terpenoids, which composition depends on the plant species, variety, geographic origin, soil and season (Figueiredo et al., 2008; Salgueiro et al., 2009).

Current cosmetic products use synthetic fragrances while high quality cosmetics' manufacturers choose essential oils. However, due to their high volatility, organic fixative molecules such as sucrose, sucrose derivatives, sodium carboxymethyl chitosan, among others are needed (Jimtaisong and Saewan, 2014).

Following this principle the use of an essential oil is increased with the use of a further additive which is not essential for soap cleaning function.

2. Experimental

2.1. Materials and reagents

The recycled waste products used as major raw materials in the soap formulations were used cooking oil, orange peel and almond shells.

In some formulations, commercial materials were used, such as bees wax, olive oil, coconut oil, palm oil and soya lecithin.

Some reagents were also used, namely: ethanol (C_2H_5OH absolute, Merck), potassium hydroxide (KOH, p.a., Merck), sodium chloride (NaCl, p.a., Sharlau), sodium hydroxide (NaOH, pellets, p.a., Riedel-de Häen). An agate mill was used to grind the almond shells.

2.2. Almond shells treatment

Almond shells were involved in a strong plastic bag and smashed with a hammer. After soaking overnight, the resulting pieces were washed several times with tap water, until clear water was obtained, and after that dried at 60 °C. After thoroughly dried (2–3 days), shells were finely ground using an agate mill and the resulting powder was sifted through a 210 μm sieve to remove the bulkiest grains.

2.3. Cooking oil treatment

Treatment of used cooking oil involves three phases: filtration, for the removing of particulate matter; washing, for the extraction of non-visible particles in suspension; and deodorization, for the removal of molecules that give the oil some odour (Araújo et al., 2013).

Although there were no visible particles in suspension, the used cooking oil was filtered under vacuum for removing eventual particulate matter. A volume of 100 mL of filtered oil was washed twice using 100 mL of warm (50 °C) brine solution (10 % NaCl), in a 250 mL separation funnel. In each operation, the aqueous phase was removed after 1 h separating. Washed oil was then poured in a beaker and deodorized by agitation with almond shells powder for another hour. This procedure was performed by first using 3 g of powder, which was filtered after this, and then repeated using 2 g of powder.

2.4. Determination of the oil saponification index

Saponification index was determined both on the used cooking oil and on the olive oil. In each case, 1 g of oil was rigorously weighed in a 100 mL round bottom flask. After the addition of 25 mL of KOH alcoholic solution, the mixture was refluxed for

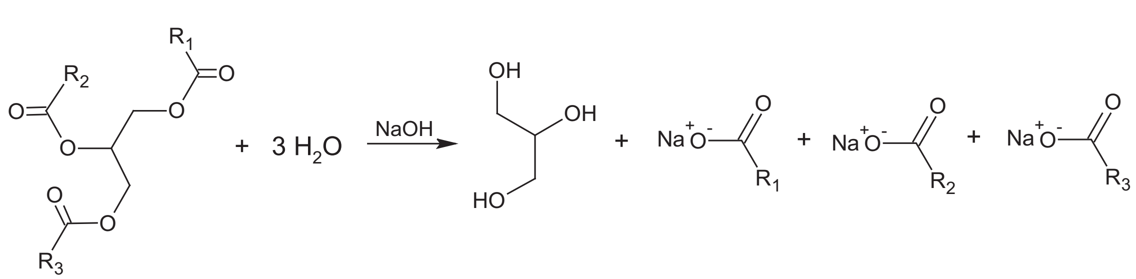

Fig. 1. Saponification reaction.