Orange Peel Dehydration and Creation of New Edible Products

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***Abstract*—The current research shows that the fruit peels contain a high amount of antioxidants, dietetic fiber, and micronutrients. The recognition of its physiologically active components has impulse a growth research area. It is also of recent interest get to use these industry subproducts in the formulation of new and functional food. Currently in Mexico, orange peels are considered a waste material and are not being used as an alternative to create subproducts. This research project was developed through an innovative dehydration process in low temperatures for the subproduct creation, and it was possible to minimize the intensity of limonene contained in the fruit's peel to reduce its bitter flavor without losing its beneficial properties. The final result of this research project was the conversion of the orange peel into a flour type that was then used for the creation of a series of new and different edible products. The results of the present research opens an opportunity to increase the capacity of the orange processing industry.**

***Index Terms*—dehydration, limonene, orange peel, subproduct creation**

I. Introduction

Obesity and overweightness have become the main health problem in Mexico. In 2010, 32% of men and 26% of women were of normal weight. By 2050, the proportion of normal weight people will decrease to 12% and 9% for males and females respectively, and more people will be obese than overweight [1]. This situation is recognized as one of the most important challenges in public health due to its magnitude, the speed of its increase in incidence and the negative effect it has on the health of the people that suffer from it.

It's worth mentioning the importance citric fruits have on the populations that need to compensate and prevent the lack of micronutrients, as well as the populations that have problems due to obesity, overeating and people that have chronic illnesses related to the diet. The contribution of different citric species in the dissuasion of potentially mortal illnesses has been evaluated [2], [3]. The scientific studies show that the consumption of citric fruits can contribute to the reduction in the risk of contracting cardiovascular illnesses, cancer, anemia, cataracts and congenital malformations, amongst others. Citric fruits have been shown to be a good source of vitamin C, aside form being a good source of glycaemic and non-glycaemic carbohydrates (sugars and fiber), potassium, pectin, folate, calcium, thiamin, niacin, vitamin B6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of phytochemicals. These fruits also contain no fat, sodium or cholesterol. Additionally, citrus fruits have a low average energy value, ranging from 60 to 80 kcal. [4].

During the last few years, there has been an increment in the interest to the possible uses and benefits of dietary fiber by doctors, the industry and the general public. Its functional properties favor digestive performance, intestinal transit of food, hemorrhoids, constipation, glucose absorption [5], maintenance of insulin level and reduction of pre-prandial cholesterol levels [6]-[8]. These substances concentrate mainly in the skin of fruits and in citrics in particular. Moreover, a high content of dietary fiber, antioxidants like flavonoids o polifens and essential minerals were studied and evaluated in the skin of oranges [9].

According to SAGARPA (The Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico), Mexico has been prominent as a leader in the production of citrics, finding itself as the 5th largest producer (4.6% of the total) behind Brazil (21%), China (18%), United States (8%) and India (6%). Furthermore, according to studies performed in 2012, in total, it exports around 470, 000 tons of citric products. The citriculture is performed in a little more than half a million hectares in regions with a tropical and subtropical climate. Of that surface, approximately 80% is destined for citric fruits, mainly orange (83% of the total). Due to Mexico's production capacity for citrics, the citric industry has had an accelerated growth in the last decades, giving the merchants an opportunity to export the orange and its derivatives such as products with added value and essential oils for the creation of inedible products. The orange is one of the main citric products that are sown in Mexico and it is a source of employment and an important income for farmers in the country. The orange is in great demand in the juice and pulp industry and nowadays it is a current task to develop technologies for the use of seeds from processed orange.

As mentioned by B. Gerard and G. Mazza (1998), the waste products from citrics are primarily constituted by the peels, seems and capillary membranes. From the

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organic waste citrus flours, citrus pectin, essential oils, pigments and special citrus products can be obtained. The same waste products can be used to obtain bioactive compounds with beneficial effects on health, such as fiber and polyphenols such as flavonoids [10]. The orange that gets destined to the miller is processed for simple or concentrated juice extraction, which is mainly exported, assigning a minimum percentage to national consumption of industrialized juices, whose demand is stable in other countries. Once the juice is obtained as the main product, focus is put on recovering some of the compounds contained in the fruit by oils and pulp that remain as waste after the process of obtaining the juice. The recovery of these products represents a competitive advantage for those who acquire them, since by being by-products, they are usually acquired at relatively low costs that make the yields of the products created from them more useful.

The waste that comes from the production of orange juice is usually sent to open ground landfills, which generates serious contamination and greenhouse effect problems. Therefore, a raw material which contains a high concentration of beneficial compounds for human health is being wasted. However, due to recent changes in culture and the necessity to produce healthier products has led to the need to use the orange peel as an alternative for the creation of nutritional food subproducts of low cost to benefit the population’s health and take advantage of the full potential of the fruit.

The general objective of the present project is to take advantage of the active components of the orange for the fabrication of healthy food products. Another particular objective is to promote healthy food products with the goal of creating a healthy consumption culture in the community due to the high obesity indexes and diverse illnesses that stem from this. Through this article, the development of functional products from the orange peel, taking advantage of its fiber and antioxidant compounds with the intention of generating healthy and delicious products is presented. It is hoped that beside the beneficial effects in the health of people, taking advantage of the whole orange (without getting to waste its shell) will be a great contribution in the solution of environmental pollution problems. The particular goals of the products are focused on their added value differing from the already existing products in the market. One of its differentiating factors is the processing: no chemical processes are used, nor any synthetic element or artificial flavors. In this way, a natural product 100% free of conservatives is guaranteed. In the same way, the process was sought in an efficient, economical and cost-effective way for the development of the product.

II. Orange Peel Flour and the Creation of New Food Products

Orange peels are inedible due to their hard consistency and bitter taste. The compound in charge of the bitter taste of the fruit is the limonin, which belongs to the family of limonoids (Fig. 1).

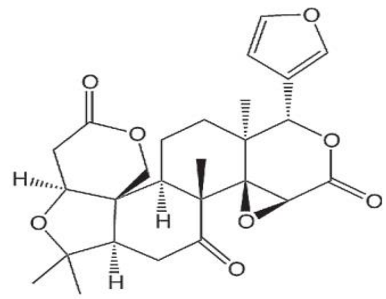

Figure 1. Chemical structure of the limonin [11]

Limonoids are bitter substances with a white and crystalline appearance that are found in the seeds and skin of the orange. Currently, there exist diverse techniques to eliminate limonin from the fruit’s skin, which vary in their degree of complexity. Some of them range from the use of chemical agents to obtain the characteristics sought from the final product, in this case being flavor and texture. Other techniques include using steam distillation of the outer rind of the orange or using trichloroethane as a solvent for extraction followed by hydrous sodium sulphate treatment as a drying agent [12].

The development of the prototype presented started with the use of the orange peel as a raw material subjected to different cooking processes. First, the orange peel was subjected to a cutting process in order to solely use the orange portion of the peel. The cuts were performed to obtain approximately 4 cm long pieces, using a stainless-steel knife. Once the desired material was obtained, the peel was boiled in water for 20 minutes, which successfully diminished the bitterness of the final product. Posteriorly, a dehydration process was performed for 24 to 28 hours under a 40 ℃ temperature until reaching a humidity level between 7% and 10%, to achieve the required amount of moisture for dehydrated powder products [13]. The pieces were distributed along the zone where heat will be applied preventing each piece from being on top of another. A flux of heat was irradiated from an oven containing a fan for a period of approximately 72 hours in a temperature range of 40 ℃ to 60 ℃ to remove as much moisture as possible. In the first 6 hours, the pieces were maintained at a 60 ℃ temperature, after which in the following 6 hours, the temperature was decreased to 50 ℃ and this process was performed along 72 hours to generate a more efficient flux of heat.

The dehydration process in ovens with low and controlled temperatures presented in the paragraphs above generated very satisfactory results. The applied dehydration avoided the biological deterioration of the food without sacrificing its nutritional and functional properties, such as the fiber, carotenoid, protein, polyphenol and antioxidant content. From de dehydration process carried out, a completely hard fiber of 100 microns of thickness was obtained, which was grounded and sieved with the purpose of obtaining a homogeneous flour. The following figure shows (Fig. 2) the flour produced at the end of this process, which has pleasant odor characteristics and can function as a base to mix with other compounds to produce a variety of products.

Figure 2. Orange peel flour

It is important that in the dehydration process performed, the structure of the food was not modified, and the level of nutrients and vitamins wasn't excessively affected (Table I).

TABLE I. CHARACTERISTICS OF THE ORANGE PEEL

Nutritional and functional properties	Orange peel
Potassium	0.181%
Calcium	0.040%
Phosphorus	0.014%
Magnesium	0.010%
Moisture content	76.74%
Solubility	8-13%
Ashes	0.44%
Carbohydates	11.75%
Sugars	9.35%
Fibers	2.4%
Proteins	0.94%
Lipids	0.12%
Vitamin C	0.0532%
Energetic Value/100gr	47 Kcal

Atomic absorption tests were performed (Fig. 3) to the different minerals: Potassium, Calcium, Phosphorus and Magnesium (Table II).

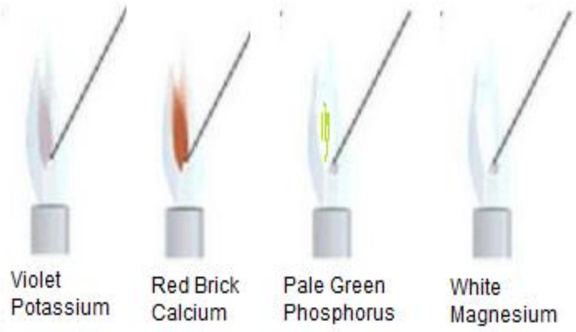

Figure 3. Atomic absorption tests

TABLE II: MINERALS CONTAINED IN THE ORANGE PEEL

Mineral	Orange peel
Potassium	0.18%
Calcium	0.04%
Phosphor	0.01%
Magnesium	0.01%

The product proposed in the present project was a seasoning for white and red meats, made mainly from orange peel flour condimented with lemon and pepper (Fig. 4)

Figure 4. Product brand

The resulting seasoning (Fig. 5) is rich in antioxidants, fiber and active compounds due to the high levels of orange peel. Their use for meat products will help not only improving its flavour, but also elevating its nutritional quality and making it healthier.

Figure 5. Packaging of the products

Traditionally, the fibers mostly used for the elaboration of snack-type foods come from cereals. The main idea in the creation of a second food product was to be able to use the orange peel to develop a snack product as an alternative for flour-based products. However, although less studied, the fibers that come from fruits and vegetables are considered of better nutritional value in general.

Diverse food products with a fruit piece or dehydrated vegetable base and their associated preparation methods are known. The dehydration prevents the biological deterioration of the food without sacrificing its nutritional values, it reduces its weight and volume for a more economical transportation and storage, and it allows a broad variety of final uses. In the elaboration processes of edible products in general, it is desired that the final product is attractive to the eye and also has a taste, consistency and / or texture desirable to the palate. A key factor to accomplish this is for the snack to achieve a crispy texture and for this purpose there are various dehydration and inflation techniques based on different principles that allow modifying the structure of the cells of the dehydrated fruit or vegetable.

For the elaboration of the second product, the orange peels will be cut in approximately 3 cm long pieces. Due to the amount of orange peel, this procedure was performed in an industrial processor with stainless steel blades. In the next stage, the orange was boiled for 5 minutes in water with some sugar. Posteriorly, the boiling step was stopped by submerging the orange in water with ice. Lastly, after drying, the orange peel was dehydrated in the oven at 80 ℃ for 6 hours in a silicon rug. The final product represents a species of crispy flakes with a very pleasant taste for the palate.

After this development, the possibility to enter into a potential market was analyzed. An analysis of the market was performed using the formulation and application of a survey to the potential clients to define which would be the characteristics of the final product needed to be accepted into the market. The survey was applied to the population of Monterrey, Nuevo León where based on the total population, a representative sample size was chosen to indicate the demand and ability to continue with the next phases of the project.

The following formula was used to define and validate said information.

$$n = \frac{N\, z_{\alpha}^{2}\, p\, q}{d^{2}\,(N-1) + z_{\alpha}^{2}\, p\, q} \quad (1)$$

where n the simple size that we want to calculate
N = Universe size
Z = Deviation of the average value that was accepted to achieve the desired level of confidence
d = Error
P = Probability of only one incidence
q = Probability on one omission

The value obtained for $n = 385$ and the value of $P = 75\%$

Currently, the use of fruit waste, particularly orange waste, is not exploited in its entirety. Therefore, the focus on the production of biodegradable products made from waste remains scarce. According to the results from the survey performed, the project presented in this article has allowed to find a niche in the market that hasn't been attended, which gives it a competitive advantage to elaborate new, healthy and natural products.

III. Conclusions

On this day, agricultural waste comes up more and more as a tool to design products with added value and competitive enough for the global market. The oranges that are destined for input for the agroindustry have become a substantial load for the environment lately. The use of their waste for the creation of subproducts of added value will help decrease another source of contamination for the environment.

The products designed in the present project are characterized for being healthy, besides being innovative, rentable, scalable and respectful for the environment. They have the potential to decrease the consumption of harmful products for the health, which are usually modified or elaborated through chemical and synthetic processes. The design of the products of the present project are strategic, starting from the capture of raw materials, to the obtainment of the final product. Obtaining the raw material from wastes allows the final product to have an economic price for sale. This will allow a price elasticity in the market and accessibility for the client. Besides, in its fabrication process, solvents won't be used to avoid possible secondary contamination. The surveys applied show that the designed products will have a positive impact in the population.

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