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Tangerine: Converting Residues into Antioxidant Food, Rich in Fiber and with Sensorial Acceptance

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Abstract

Waste from the fruit production chain is still rich in nutritional value, as well as in secondary plant metabolites, such as phenolics and others, which have antioxidant activity. These products could still be used on food. An alternative to the use of such waste is to obtain flour and biscuits. The present work aimed to evaluate the potential of reusing the pulp of tangerine in the preparation of food for human consumption. Tangerine bagasse was used in aflour elaboration (TF), and this TF was applied in the preparation of biscuits containing 10% of tangerine flour (TB), as a replacement of a wheat flour biscuit recipe control (CB). Both cookies showed antioxidant activity (TB: 82.07% and CB: 74.15%) and fiber content (TB: 1.53% and CB: 0.64%), in addition to being assessed to their acceptability (TB: 93.3% and CB: 83.3%). The biscuit with tangerine flour was superior in all aspects evaluated.The use of tangerine peel and bagasse in the manufacture of flour to produce biscuits proved an alternative to avoid the disposal of this waste and so introduce them in food.

Keywords: Tangerine; Integral use; ABTS; Fiber content; Sensory analysis

Introduction

The Brazil still faces two critical problems related to food: hunger and waste. The country produces millions of tonnes of food per year [1], with 101,402,184 million tonnes of cereals in 2013 [2] and despite being one of the largest exporters of agricultural products in the world, in 2009 had 5 million people undernourished without access to foods with sufficient quantity or quality [2].

Unlike non-perishable foods, such as grains and cereals, tropical fruits are perishable and have shelf life reduced by high content of moisture, soft texture and due to be easily damaged, in addition to high rates of respiratory and heat production [3]. These characteristics cause disadvantages in the post-harvest, resulting in high rate of losses due to lack of marketing or consumer of the product, since even in the most appropriate packaging they can lose their commercial features (physical, chemical and sensory attributes), quickly [4]. In addition, much of the fruit are wasted during processing [5].

The market of juices and squashes is growing too, in addition to the demand for fresh fruit. This is the preservation of chemical and sensory characteristics of fresh fruit through freezing, and so the consumer can find them throughout the year, without worrying about the time and the ripening of fruit [6]. As a result, the increase in pulp processing generates about 40% of the waste, such as remains of pulp, Peel, pits or seeds, from agricultural industries [7].

Many of these residues can be used in the development of new food products, raising your value associated, since many of them are rich in mineral nutrients, dietary fiber [8] and bioactive compounds, widely characterized by its antioxidant properties [9,10].

The citrus fruits, family of Rutaceas and genus *Citrus*, originate from tropical and subtropical regions of Asia [11], and due to globalization are grown in almost every country in the world. According to Ojha et al. [12] the interest in tangerine peel occurs primarily due to your pharmacological activity, as well as antioxidant effect, high nutritional value and presence of bioactive compounds.

Oil products, pulp, seeds and peels of citrus fruits are known to contain natural antioxidants. Vitamins, minerals, natural pigments and enzymes are antioxidant substances that block the harmful effect of free radicals and slow down the progress of many chronic diseases, as well as slow the oxidative rancidity in lipid foods [13]. The skins and the seeds are sources of phenolic compounds, which include phenolic acids and flavonoids, which are known to be rich in antioxidant activity [14]. The phenolic compounds in Tangerine peels also feature great antioxidant activity, behind only the grape and lemon [15].

In flour formulation is common to use peel, seeds, fruit bagasse [16]. The most used is the peel because they are formed basically by carbohydrates, proteins [8] and pectins, which are highly leveraged for candy manufacturing, and may become a viable alternative for disposal of waste. The flour from the tangerine is a natural source of antioxidants, flavouring agents, fibers and minerals [5].

Thus, the present work aims to produce a flour using peel and bagasse of tangerine (*Citrus reticulata*), identify the potential antioxidant and fiber content in biscuit formulated with this flour to propose the reuse of this waste, in order to reduce it and reduce impacts of its accumulation in the environment.

Materials and Methods

Fruits obtaining

Tangerines, murkot type, were obtained in local Market from Belo Horizonte, MG, according to Bublitz et al. [17] methodology, with some modifications. Fruits were chosen at the same stage of ripeness, and without blemishes that could be considered as damaged fruit.

Flour obtaining

Tangerines were used to develop the peel and bagasse flour (whitout seeds). Fruits were washed and sanitized with bleach containing chlorine active (2.5%v/v), for 10 minutes. For this preparation fruits were peeled and the seeds were removed manually. Then a wet milling in a blender on low speed for 15 seconds in a 1:2 ratio (v/v - fruit residue: water). The material obtained was filtered and dried. Drying was held in direct drying oven 70 °C for 15 hours. Later, residues obtained were crushed in a blender until obtaining the flour.

Ethanolic extract of flour

For preparation of ethanolic extract, flour (20g) were mixed with etanol 50% (20mL) in an amber bottle. This mixture was homogenized using the magnetic stirrer for 1 hour at room temperature (25 °C). Thereafter the mixture was filtered (Whatman filter paper n °1). The extract obtained was stored in an amber bottle, protected from light [6]. For comparison, was prepared a ethanolic extract of commercial wheat flour (obtained in local commerce in Belo Horizonte-Minas Gerais, Brazil), using the same protocol.

Biscuits obtaining

The formulation of the biscuit with tangerine-flour (TB), 10% of the flour was used in place of wheat flour. Sugar was used (40g), baking powder (15g), butter (12g), egg (50g), salt (2g), milk (15 mL) wheat flour (225g) and tangerine flour (25g), in accordance with the methodology of Santos et al. [18], with some modifications. Has been formulated also a biscuit without tangerineflour, a control biscuit (CB), which received 250g of wheat flour.

For dough preparation, dry ingredients, such as a portion of flour, baking powder, sugar, salt,as well as butter were mixed. Then egg and milk were added to mix. The dough was homogenized by hand for a minute. After adding the flour, the dough was mixed and kneaded by hand, later divided into portions, laminated and cut into discs. The discs were baked at 180 °C for 15 minutes.

Ethanolic extract of biscuits

Biscuits were crushed and a portion (1g) of each sample (TB and CB) was used. Thenetanol(20mL) was added.These mixes were homogenized in the dark room, for 1 hour. A filtration (filter paper Whatman n °1) was made andExtracts were conditioned in amber bottles, protected from light.

Antioxidant analysis

Antioxidant capacity was determined by inhibition of radical ABTS: 2.2′-Azinobis (3-etilbenzotiazolinna-6-sulfonic acid), described by Sande et al. [19], with some modifications. Initially prepared a solution of ABTS (ABTS 7mM; potassium persulphate 2.4mM) that remained in the dark room, for 2 hours. Then this solution was diluted with ethanol until obtaining the absorbance of 0.708±0.002 at 734nm, this was called working solution. The reaction occurred adding 0.8mL of extracts with 3.2mL of working solution (ABTS duluted solution). A reaction control was made replacing extract by ethanol. The reading was made in a spectrophotometer (734nm) and antioxidant capacity of the extract was expressed as percent inhibition of radical ABTS, calculated from the equation:

% Inhibition of ABTS = ((absorbance of control - absorbanceof extract)/ absorbanceof control) x 100.

Fiber analysis

Fibre content of biscuits was analyzed according to the methodology described by AOAC [20]. Biscuits samples (TB and CB) were weighed (2g), defatted (continuous Soxhlet extraction using a petroleum ether as solvent). The material obtained was mixed with 100mL acid solution and 0.5g of sand diatom. This material was attached to a reflux condenser for 40 minutes after addition of the acid solution, keeping under heating. Material obtained was filtered under vacuum. The resulting material was washed, initially with boiling water in order to eliminate all acid reaction and later with 20mL of ethanol and 20mL of ether. The material was dried (105 °C, 2 hours) and then it was takedto the desiccator to cool until room temperature. The heating and cooling were repeated until constant weight. The material was incinerated in the Muffle 550 °C and cooled until room temperature, these procedures also were repeated until obtaining the constant weight. The loss of final weight was considered as fiber content.

Sensory analysis

For sensory analysis, two samples of biscuit, TB and CB, were encoded as 293 and 185, respectively. An overall acceptability test was applied, to compare thesebiscuits. The test was conducted with 30 untrained tasters comprising staff and studentsfrom Centro Universitário de Belo Horizonte (UNIBH), Minas Gerais, Brazil. They were chosen at random,

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from different age groups. The evaluation was performed using a nine-point hedonic scale: DE=Dislike extremely; DVM=Dislike very much; DM=Dislike moderately; DS=Dislike slightly; NLOD=Neither like or dislike; LS=Like slightly; LM=Like moderately; LVM=Like very much; LE=Like extremely [21]. Samples that obtained 70% of the scores in like region (LE+LVM+LM+LS) were considered acceptable.

Ethical aspects

This study was reviewed and approved by the Committee of ethics and Human Research of the Centro Universitário de Belo Horizonte (CAAE 68670617.6.0000.5093, in plataforma Brasil). All ethical and methodological aspects were in accordance with Brazilian laws (Resolution 466/2012) [22]. All tasters signed an informed consent term and were informed of the risks to which they were subject to participate in this analysis.

Statistical analysis

Averages of antioxidant activity of flours, as well as antioxidant activity and fiber content of biscuits (TB and CB) were submitted to an unpaired t-test (two-tail), with 95% confidence. The difference between the medians found in the sensory analysis of acceptance was evaluated using the non-parametric test of Man-whitney. For all the tests, the program Graphpad Prism (version 5.02) was used.

Results and Discussion

Antioxidant analysis

Analysis of the inhibition of free radicals (ABTS) showed that the flour obtained from the peel and bagasse of tangerine has an important antioxidant activity (86.12%), three times higher than that presented by wheat flour (28.25%) (Figure 1).

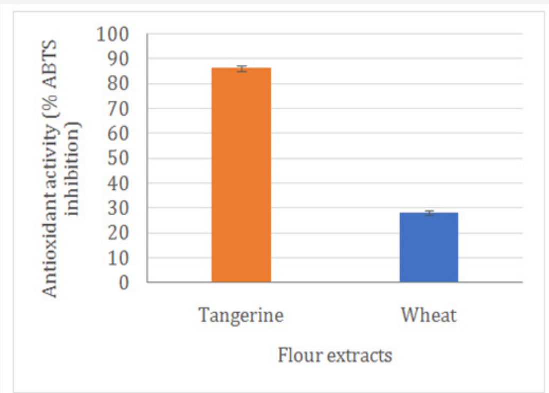

Figure 1: Antioxidant activity of ABTS radical's inhibition (%) of tangerine flour and wheat flourSamples were significantly different (P<0.05) with 95% confidence.

The inhibition of ABTS radical shown for the biscuits was corresponding to the observed in the results of flour (Figure 2). The biscuits with tangerine flour showed antioxidant activity greater (82.07%) than that presented by control biscuit (74.15%) (Figure 2).

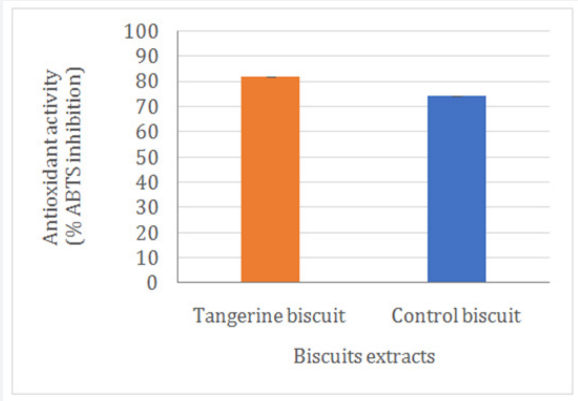

Figure 2: Antioxidant activity of ABTS radical's inhibition (%) of tangerine biscuit and control biscuit Samples were significantly different (P<0.05) with 95% confidence.

Biscuit is not a staple food such as bread but has high acceptance and consumption in different countries [23-25]. In this work, were formulated biscuit using a flour obtained from tangerine peel and bagasse, It was assessed it antioxidant capacity, fiber content and sensory acceptance, aiming to propose inserting it asfunctional food.

Tangerine flour presented a great antioxidant potential (Figure 1), surpassing values described in the literature(73.0%) [5]. By comparison, wheat flour showed a reduced antioxidant potential (Figure 1), however, also surpassed values (8.3%; 23.7%) described in the literature [5,26]. Differences in antioxidant activity, between flours of diferente crops and different fruits can occur depending on the concentration of secondary compounds of plants, such as polyphenols, antioxidant capacity holders [27]. In food, these compounds can vary according to the quantity of fruit used in the preparation, the variety of plants, agronomic practices employed, post harvest management of fruits and technological processing.

Biscuit containing bagasse and tangerine peel also presented great antioxidant activity (Figure 2), surpassing values described in the literature for biscuit with 6% tangerine peel (24.5%) [5] and biscuits with 10% lemon peel flour (13.5%) [18].

Results of antioxidant capacity of tangerine flour and biscuit were superior to those found in the literature and suggest that if these foods are consumed regularly can help reduce the harmful effects of the radicals free, contributing to the reduction of the risk of cardiovascular diseases, neurological, as well as to combating premature aging.

Amazingly, biscuit without tangerine flour also presented a reasonable antioxidant activity (Figure 2), differing considerably from previous report (7.8%; 13.3%) [5,27]. This can be related to any of the ingredients used for biscuits production, as those who have in your composition, phytochemical compounds vitamin C, as well as polyphenols,

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which are large responsible for antioxidant activity found in fruits and derivatives [28].

Fiber analysis

Fiber content of biscuits with and without tangerine flourcan be seen in Table 1. Fiber content of control biscuit was significantly lower, and equivalent to 41.8% of tangerine biscuit fiber content (Table 1).

Table 1: Fiber content of biscuits with and without tangerine flour.

Biscuits	Fiber content (%)
Tangerine	1.53
Control	0.64

Fibers exert intestinal operation to regularise function, which makes them relevant to the well-being of healthy people and for dietary treatment of various pathologies [29]. In this work, biscuits prepared containing 10% of tangerine flour showed a high fiber content (Table 1), similar to other works described in the literature (1.41%) with biscuitelaborated with the same fruit flour [5] and larger than has been described with biscuits containing 10% lemon flour (0.96%) [17].

Fiber content in biscuits prepared only with wheat flour was significantly lower and similar (0.62%) to the levels found in the literature [30].

These results allow to infer that the conditions for preparation of flour and biscuit containing peel and bagasse of tangerine allowed obtaining high levels of components with antioxidant activity, as well as high fiber content, higher than those described for flour and cookie containing lemon peel. This indicates the potential for conversion of tangerine residues intoantioxidante food, rich in fiber, which can contribute to the proper functioning of the body.

Sensory analysis

Overall acceptance of biscuits are presented in Figure 3. Twenty-eight tasters said like (like extremely to like slightly) biscuit with peel and bagasse tangerine flour (93.3%) while twenty-five tasters (83.3%) said like control biscuit (Figure 3). These values allowed sort both cookies as acceptable sensorial levels. This tangerine biscuit showed greater acceptance than othersbiscuits described in the literature made with residues of mango, passion fruit and jabuticaba (80%) [31], as well as made with 6% (68.8%) of tangerine flour [5]. This reflects the good sensory acceptance of tangrine biscuits from this study (Figure 3).

Despite having obtained a overall acceptance lower than tangerine biscuit, control biscuitwas also classified as acceptable, surpassing values described in the literature (78.6%) for similar formulations [32].

Sensory analysis results made it possible to observe that the medians of acceptance of control biscuit and tangerine biscuit (8.0 and 8.5, respectively), were significantly different (95% confidence; $P<0.05$) stating that tangerine biscuit had greater overall acceptance.

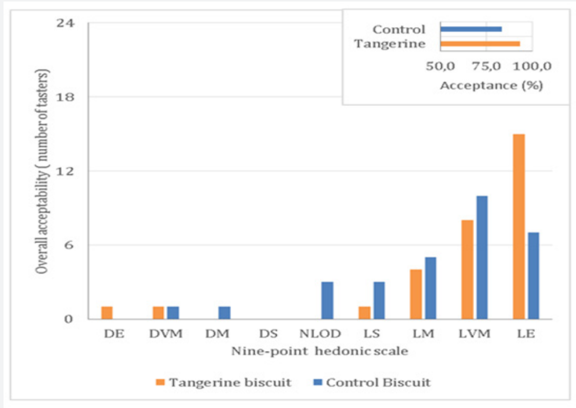

Figure 3: Overall acceptability of biscuits with and without tangerine flour.
Nine-point hedonic scale: DE = Dislike extremely; DVM=Dislike very much; DM=Dislike moderately; DS = Dislike slightly; NLOD = Neither like nor dislike; LS = Like slightly; LM = Like moderately; LVM = Like very much; LE = Like extremely.

People seeking healthier alternatives and sustainable, as well as people looking for palatable products, rich in fiber and antioxidant activity, can benefit from this product since it have components able to assist in the intestinal peristalsis Act on reducing the risk of cardiovascular diseases, neurological and obesity in addition to acting in the fight against premature aging.

At the same time, tangerine flour and biscuits, are an excellent way of usingtangerine residue as an alternative source of nutrients and bioactive components, reducing ambiental impact of the disposal of this waste.

Conclusion

In conclusion Its possible to say that the biscuits with tangerine flour are an excellent alternative to wheat flour biscuits. Biscuits made with the tangerine flour contain fibers (1.53%), as well as compounds with antioxidant activity (82.07%) and may be used for the benefit of human health, which makes these biscuits commercially attractive for the functionality that they provide, in addition to having a high acceptability (93.3%) among people.

This biscuit was offered as food waste reuse option to a food bank (PRODAL) of CeasaMinas, which benefits 193 entities and focuses on donate food to avoid the waste of these.

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