Research Article

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Journal of Food, Nutrition and Population Health

2017
Vol.1 No.2:12

# Coffee Berry Processing By-Product Valorization: Coffee Parchment as a Potential Fiber Source to Enrich Bakery Goods

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**Tel:** 506-2511-8853

**Citation:** Elba C, Ana RB, Eva G (2017) Coffee Berry Processing By-Product Valorization: Coffee Parchment as a Potential Fiber Source to Enrich Bakery Goods. J Food Nutr Popul Health Vol.1 No.2:12

## Abstract

The objective of this research was to evaluate the coffee parchment as a rich fiber ingredient with antioxidant activity in cookie production. Different percentages (0%, 1% 2% and 5%) of ground coffee parchment were added to a cookie formulation. The best percentage of coffee parchment was established by a degree of liking test. Part of ground parchment was subjected to ultrasound treatment and added to cookies using the same percentage as the one that obtained the highest degree of liking. The measurement of the instrumental hardness and preference between the two products (using parchment with and without ultrasound treatment) were compared. Physical-chemical characteristics (dietary fiber, moisture, fat, ash, antioxidants and total polyphenols) were determined for the parchment and the cookies with the highest degree of liking. The cookie with ultrasound parchment presented the lowest hardness (52.0 N) compared to the cookie with parchment ground (168.2 N), but it was not preferred by the consumers. The cookie formulated with 2% coffee parchment had the highest degree of liking and had 5.4% total dietary fiber, 1.7% moisture, 24% fat, 0.9% ash, 1 116 µmol TE/100g of antioxidant activity and no total polyphenols were detected. It was concluded that coffee parchment is a potential source of dietary fiber with antioxidant capacity, which can be used to enrich bakery products without the need for treatments to alter its texture.

**Keywords**: Dietary fiber; By-product valorization; Coffee parchment; Enriched cookie; Sensory analysis

**Received:** September 26, 2017; **Accepted:** September 28, 2017; **Published:** October 02, 2017

## Introduction

Coffee fruits can be processed by either wet or dry processing methods. In the wet procedure the fruits are pulped, fermented, washed and sun or furnace dried. The pulping procedure removes the exocarp and most of the mesocarp, resulting in the coffee pulp [1]. Parchment or hull is removed after drying and hulling [2]. Parchment (endocarp) represents 6.1% w/w of the whole fruit [3]. Coffee parchment fiber is constituted by (α-) cellulose (40-49%), hemicellulose (25-32%) and lignin (33-35%) and it is classified as a short fiber [1]. It has been a common practice to use coffee parchment as a combustion material, in the same coffee process mill, and for animal feeding [4]. Until a few decades ago, food wastes were considered neither a cost nor a benefit, since they were used as animal feed, fertilizer or compost [5,6]. Nowadays, food industry waste has become an economic and ecological burden. Regarding the potentially marketable components present in foods wastes and co-products, high value components such as proteins, polysaccharides, fibers, flavor compounds, and phytochemicals can be obtained as nutritionally and pharmacologically functional ingredients [7]. Research on coffee pulp and silver skin has shown that these by products have functional compounds such as dietary fiber and antioxidants, within which chlorogenic acid is found [8,9]. This synergistic complex is known as dietary antioxidant fibers, and it is believed that coffee parchment can be rich in dietary antioxidant fiber, which is very advantageous for the elaboration of functional foods, adding more beneficial effects than only the fiber fraction [10].

With a growing trend towards foods and ingredients that offer specific health promoting benefits, the nutritional properties of coffee parchment or hulls can become interesting. Several studies on the conversion of plant-derived food waste reveal that the extraction of value-added chemicals such as antioxidants and dietary fibers is becoming popular. Recovery of high-added-value compounds is fundamental to the utilization of food waste for commercial applications [11]. The average daily requirement of dietary fiber is 25 g per day for women younger than 50, 21 g per day for women older than 50; 38 g per day for men younger than 50, and 30 g per day for men older than 50 [12]. Dietary fiber is defined as the polysaccharides present in cell walls of plants that are resistant to digestion and absorption in the small intestine, and partially fermented in the large intestine. Its components are divided into soluble and insoluble dietary fiber [4,13]. Dietary fiber (DF) decreases the risk for type 2 diabetes mellitus, cardiovascular disease, and colon cancer by reducing the digestion and absorption of macronutrients and decreasing the contact time of carcinogens within the intestinal lumen [12,14]. In fact, the antioxidant dietary fiber, which is an insoluble material, survives in the gastrointestinal tract for a long time and, it may positively act *in vivo* quenching the soluble radicals that are continuously formed in the intestinal tract and that have been demonstrated to play a central role in the promotion of various pathologies. Likewise, antioxidants play an important role in protecting against the harmful effects of oxygen in tissues [6], preventing neurodegenerative, cardiovascular and inflammatory diseases [15]. Brownlee [16] mentioned that initial observations link health benefits to the consumption of fiber-rich foods rather than dietary fiber supplements. Therefore, there is a need for development of novel fiber-rich foods that are both acceptable to the consumer and have health benefits. It is important to take into account that negative effects have been observed when unprocessed lignocellulose materials, such as cereal bran or vegetable pulps, are added to formulations for baked goods, by a loss of baked volume and a gritty texture [17]. Due to the demands for functional foods, the incorporation of fiber into the baking formulas has been used with great success [18]. Lately, nutritious and functional bakery products have been developed. The effect of new functional ingredients application on the properties of food products (e.g., freshness, appearance, and sensory properties) as well as on their biological functionality have been studied [13]. Dietary fiber is an ingredient from the new generation of functional food products, which meet consumer demands. The incorporation of these ingredients in bakery products has led to a great number of food applications. The role of food structure in the development of structured products with low starch digestibility, and the replacement of starch with other non-digestible polysaccharides are among the main areas of research by the scientific community and the food industry [19]. Also, fiber can impart functional benefits as gelling, thickening and water binding which may be utilized in many fields such as bakery products [20]. However, the most important criterion of the selection of the level of incorporation of any ingredient is the contribution in the acceptance that it will have in the final product [17]. The addition of fiber in the formulation of a product has been shown to affect sensory characteristics such as flavor and texture [18]. Besides, consumers tend to avoid food with nutrition claims because they associate them with inferior taste [21]. For this reason, physical and chemical methods have been developed to modify the characteristics of the lignocellulosic materials of the fiber, for instance alkaline hydrogen peroxide solution to reduce lignin, fine milling [17], extrusion, enzymatic modification [22], that modifies the ratio between soluble and insoluble fibers, fermentation [23] and ultrasound [7], resulting in a fiber with less negative impact on bakery goods quality. The objectives of the present study were (1) to evaluate in a cookie the effect of different levels of coffee hull flour on hardness and degree of liking, (2) to compare the hardness and degree of liking of the most accepted level of parchment flour with and without an ultrasound treatment and (3) to analyze the quality parameters (antioxidant activity, polyphenol content, microbiology and physicochemical composition) of a cookie enriched with the addition of coffee parchment flour.

## Materials and Methods

### Preparation of the parchment

The coffee parchment was collected in a coffee processing plant, at Alajuela province in Costa Rica, and stored at -18°C until used. The parchment was ground in a hammer mill (Fitzpatrick Company, Canada), cleaned and disinfected, using a 0.33 mm mesh. In addition, a part of the parchment was subjected to ultrasound treatment. The parchment was placed in glass beakers and water was added. A weight:volume 10:100 ratio (30 g of parchment/300 mL of water) was used. The suspension was shaken, placed into a Misonix Ultrasonic Liquid Processor model S4000 ultrasonic device with a power of 44W/cm$^2$ for 5min.

### Enrichment of cookie with coffee parchment flour

Cookies were made from a standard formulation containing 50% wheat flour with 1.5% dietary fiber, butter, sugar and egg. Cookies were prepared by replacing wheat flour by different percentages of coffee parchment flour (0%, 1%, 2% and 5%), baked at 180°C for 10 min. Consumer degree of liking test and instrumental hardness were carried out. After choosing the level of coffee parchment flour most liked by consumers, cookies were made using ground parchment that was subjected to ultrasound treatment. A preference test and an instrumental hardness were performed.

### Consumer sensory tests

The degree of liking was performed by 99 cookie consumers intercepted in the university campus. A written informed consent was obtained from each panelist. The four cookies with different levels of coffee parchment flour were coded with 3-digit numbers and presented in a balanced and randomized order. Consumers evaluated using a hybrid hedonic scale [24], where zero means ¨dislike extremely¨ and 10 means ¨like extremely¨. Participants were instructed to taste the sample, rated and rinsed with water before each sample. A preference test was used to compare both cookies that were prepared using parchment flour with and without ultrasound procedure, at the best accepted parchment level. Seventy cookie consumers evaluated the pair of cookie samples that were coded with 3-digit numbers and presented in a balanced and randomized order. They were asked about which cookie they preferred within the pair, or if they had no preference, so they were given a choice of three categories.

## Instrumental hardness measurement

The instrumental hardness determination was carried out using the TA-XT Plus texture analyzer that utilized Texture Exponent software of Stable Microsystems. Five cookies per batch were evaluated and an average value was obtained per batch and per level of coffee parchment flour. The operating conditions of the program were as follows: compression mode, 1 mm/s pre-test speed, 3 mm/s test speed, 10 mm/s post-test speed, 5 mm distance or penetration and the attachment used was a blunt-edged blade. The analysis was performed by placing the cookies in such a way that the blade compressed them in the middle. The hardness was calculated as the height of the maximum force in a blade-force vs. time plot.

## Experimental design and statistical analyses

Three different batches of the 4 cookie treatments using different parchment flour levels were prepared. A complete randomized block design was applied; where the blocks were the 3 batches, with one factor with 4 levels and the response variables were degree of liking and instrumental hardness. Consumer clusters were identified using Ward´s hierarchical clustering technique with Euclidian distances (Lee and Lee 2008) using the statistics software XLSTAT (Addinsoft, France). Cluster analysis provides consumers segments with homogeneous degree of liking within each clusters and different degree of liking between clusters. The sensory consumer data were analyzed by an analysis of variance (ANOVA), of each individual consumer cluster, to observe significant differences ($p \leq 0.05$) between the parchment flour levels and a mean comparison were applied when the factor was significant within a consumer cluster. XLSTAT software (Addinsoft, France) was used. The instrumental hardness data were analyzed by an analysis of variance (ANOVA) and a mean comparison when the factor was statistically significant ($p \leq 0.05$). Statistical analyses were performed with XLSTAT software (Addinsoft, France). The second design was a complete randomized design, with one factor with two levels (with and without ultrasound treatment) and 3 replicates. The effects on hardness and consumer preference were the response variables. The preference was analyzed by a chi-square test (Microsoft Excel), since 3 categories were utilized. The instrumental hardness was analyzed by a t-student test ($p \leq 0.05$) using XLSTAT software (Addinsoft, France).

## Parchment flour and parchment flour enriched cookie chemical analyses

Coffee parchment flour and cookies enriched with parchment flour with the highest degree of liking were analyzed for moisture, fat, dietary fiber, total polyphenols content and antioxidant capacity. Each analysis was done by triplicate. Moisture was determined by AOAC method 925.10 [25]. Fat analysis was performed according to AOAC method 945.16 [26]. Ash was determined according to AOAC method 923.03 [25]. Protein was quantified by method AOAC 979.09 [27]. Dietary fiber was quantified by AOAC method 985.29 [28]. ORAC (Oxygen Radical Absorbance Capacity) assay was performed to determine the antioxidant capacity of coffee parchment. The ORAC assays were carried out in microplate analyzer, Biotek. Final assay mixture was 0.2 mL total volume in each plate well. Fluorescein (61.3 nM) was used as a target of free radical attack with 18 mM of 2,2'-Azobis(2-amidinopropane) dihydrochloride (AAPH) as a peroxyl radical generator. 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox®) was used as standard for preparing a linear regression in the range 4-32 μM Trolox. The analyzer was programmed to record the fluorescence every minute in each well for 45 minutes. Final results were calculated by interpolating the data of the samples in the linear regression and data were expressed as micromoles of Trolox equivalents (TE) per gram of sample (μmol of TE/g) [29]. Total polyphenol assay was carried out according to Folin-Ciocalteu spectrophotometric method as described by Georgé et al. [30]. Extracts (500 μL thus pre-treated and no treated with oasis cartridges) were mixed with 2.5 mL of Folin-Ciacalteu reagent and incubated at room temperature for 2 min. Following the addition of 2mL of 7.5% sodium carbonate to the mixture and incubated at 50°C for 15 minutes. Absorbance measurements were conducted at 760 nm. Total polyphenol content was expressed as mg gallic acid per gram of sample.

## For these analyses, the mean and standard deviation were calculated

**Microbiological analysis:** A microorganism standard plate count (SPC) was performed on the cookie with the highest percentage of parchment, following the official method of AOAC 966.23.C [31]. For this analysis, 25 g of the samples were mixed with 225 mL peptone water, homogenized and dilutions were made up to 10-5; then 1 mL of each dilution was transferred to standard agar plates and maintained 48 h at an incubation temperature of 35°C ± 1°C. After the incubation time, colonies were counted on the plates and the results were expressed as Colony Forming Units per gram (CFU/g). The analysis was done in triplicate for each dilution used.

# Results and Discussion

## Cookie enrichment with 4 levels of coffee parchment flour

The enriched cookies using 0%, 1%, 2% and 5% of coffee parchment flour were tasted by a group of consumers to provide the degree of liking, besides an instrumental texture analysis was performed, to explain the effect of the amount of fiber on cookie hardness. Two consumer clusters were found which shared sensory similarities within the cluster and sensory differences between them, as shown in **Figure 1**. The first group consisted of 70 consumers, corresponding to 70.7% of the panelists. The 1% and 2% coffee parchment flour cookies were rated with the highest degree of liking, followed by 5%, while the control

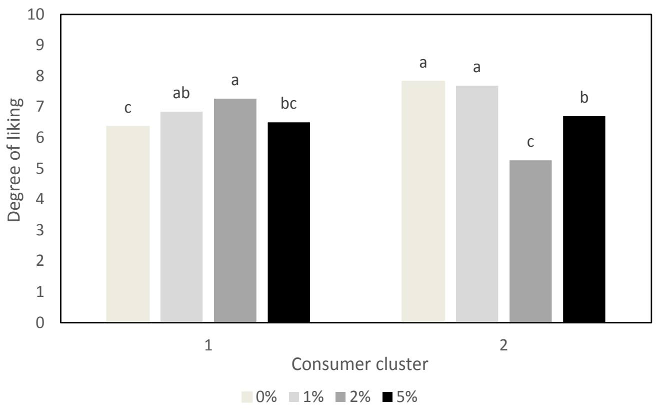


**Figure 1** Average degree of liking for two consumer clusters of cookies with different coffee parchment flour levels (0, 1, 2 and 5%). Cluster 1 gathered 70 consumers while cluster 2 was formed by 29. Different letters in the same group show significant differences at 95% confidence level.

cookie (without parchment flour) obtained the lowest degree of liking. The second cluster was made up of 29 consumers, who evaluated the control cookie and the 1% parchment flour cookie with the highest degree of liking. The lowest scores were given to 2% and 5% parchment flour cookies. This group showed the most marked differences among cookie ratings and, therefore, more variation due to different fiber concentrations. Cluster 1 grouped most of the consumers (more than 70%) and they liked fiber in their cookies which might reveal a market opportunity for coffee parchment flour as a potential fiber source. According to Grigelmo-Miguel et al. [32], consumers evaluating different percentages of peach fiber (0, 2, 3, 4, 5 and 10%) in muffins found less pleasant those containing 5% or more than the control product. On the other hand, it can be used up to 25% levels of corn hull in cookies without causing deterioration in food quality and acceptability [33]. Texture is an important element in the quality of cookies, directly affecting consumer acceptance and sales [34]. Therefore, the effect of fiber on hardness was evaluated. **Figure 2** shows hardness of cookies with different fiber levels. There were no significant differences ($p > 0.05$) in the cookie hardness because of coffee parchment flour levels, although a tendency to increase hardness was observed as the amount of parchment added increased. Consequently, hardness was not a critical parameter and it was not driven cookie acceptability. In contrast, several authors mentioned that higher fiber content in cookies contributed to increase hardness in comparison to a control cookie (with no fiber added) [34]. Higher hydration leads to soft cookies [35]. Champ and Guillon [36] pointed out that grinding might affect the hydration properties of dietary fiber, in particular, the kinetics of water. Schneeman [37] mentioned a positive relationship between dietary fiber particle size and density. Particles of 0.5-0.3 mm retained about 12 g water/g dry sample whereas the particles <0.075 mm had about 7 g water/g dry sample. Sangnark and Noomhorm [38] observed the same pattern with a reduction of particle sizes regardless the material type. Consequently, coffee parchment was milled using a mesh of 0.33 mm rendering a fiber that can hold more water with particle size close to 0.5-0.3 mm. This particle size might prevent texture changes when using different fiber levels or no fiber. Qualitatively, it was observed during cookie dough preparation, that those containing 2% and 5% of coffee parchment flour were more malleable and change shape after being cut, as the texture was softer, while the dough was firmer, harder and maintained the shape when cut during preparation of control cookies and the one with 1% coffee parchment. Cookie with 2% coffee parchment flour substitution was selected because it had the highest degree of liking for most consumers and it did not present difference in hardness from the control cookie with no added fiber. Loebnitz and Grunert [21] mentioned that consumers placed nutrition second in importance to taste in factors for food selection; therefore, obtaining a cookie with higher fiber content that was better accepted that another with less fiber represent an advantage at consumer selection level. Coffee hull fiber likely did not deliver a flavor to the cookie nor a different texture. Redgwell and Fischer [13] mentioned that fiber from cereal-derived brans or beets can confer a particular flavor and color and can lead to consumer rejection.

## Comparison of the cookie, with the percentage of parchment of greater degree of liking, with and without ultrasound treatment

Negative effects have been observed when unprocessed lignocellulose materials, such as cereal bran or vegetable fibers, are added to bakery formulations by a loss of baked volume and a gritty texture [17]. Therefore, the coffee parchment flour received an ultrasound treatment to improve texture. Comparing cookies with 2% level of parchment flour with and without ultrasound treatment showed that consumers preferred the cookie baked with coffee parchment fiber without ultrasound treatment **(Figure 3)**. The maximum force required to break the cookie in half, which indicated the cookie hardness, is shown in **Figure 4**. Cookie prepared with no ultrasound parchment flour (168.8N) had a higher hardness than cookies containing ultrasound parchment flour (52.06N). The presence of a layer of turbid nature floating

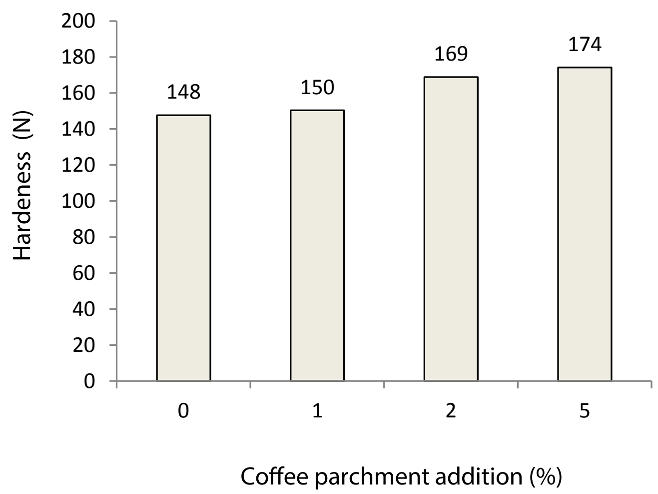


**Figure 2** Cookie hardness (N) with different added levels from coffee parchment. Different letters show significant differences at 95% confidence level.

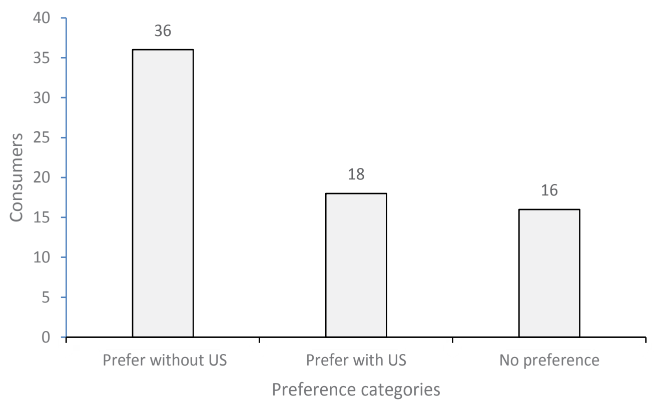


**Figure 3** Number of consumers out of 70 that preferred a cookie made with 2% coffee parchment flour (without US), a cookie with 2 % coffee ultrasound parchment flour (with US) or had no preference.

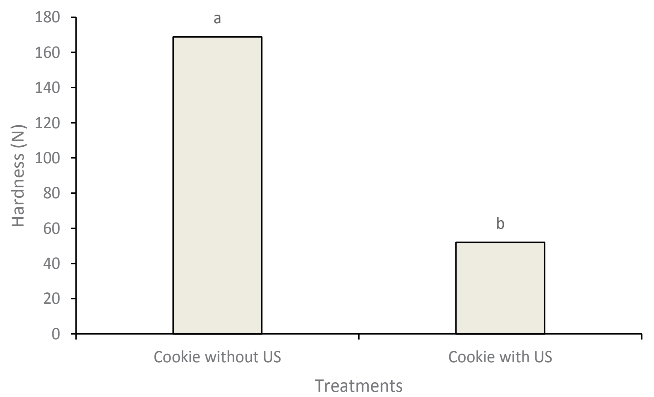


**Figure 4** Hardness (N) of cookies with 2% ground parchment (without US) and 2% parchment ground and ultrasound (with US). Different letters show significant differences at a 95% confidence interval.

above the material was observed in the ultrasound parchment storage flasks. During ultrasound treatment, lysis of the material cell wall occurs, releasing intracellular compounds such as starch or sugars [39]. The ultrasound treatment has been known to degrade cellulosic material as it changes the morphology of cellulose fibers, such as rice grains, where surface layer destruction and grain fragmentation occur [40]. It is hypothesized that intracellular compound release would be involved in the change of cookie texture. Consequently, ultrasound softened parchment structure causing cookie hardness decrease. It is not necessary to perform post-milling treatments, such as ultrasound, on the coffee parchment that will be used on bakery products, to obtain a consumer accepted cookie. The above has an advantage from the economic point of view, since an ultrasound treatment implies an additional investment in the product process.

## Quality attributes of the most liked level of coffee parchment flour cookie

The coffee parchment flour had a moisture content of 7.6% and cookie moisture was 1.68%, which meets the maximum allowed limit for this parameter in simple cookies (without filling). The Mexican Standard for Cookies (NMX-F-006-1983) sets a maximum of 6% moisture in this type of products. The baking process at high temperature influenced the low moisture content of cookies. Also, cookie ash value complied with the standard, which establishes a maximum level of 1.5%. Fat was not detected in the coffee parchment flour, while the fat percentage of cookie was 24.1% **(Table 1)**. As a result, the coffee parchment did not contribute with fat addition. Fat was one of the main cookie ingredients. The total dietary fiber of ground coffee parchment was 88.7%. This value was understood to be high considering that other by-products obtained from agro-industrial processes have lower values of total dietary fiber. The red grape pulp has 77.2% of fiber content, mango peel has 51.2% and they are good source of dietary fiber [41]. Coffee hull or parchment had potential as a source of fiber and can be used in food industry fields such as bakery products. Total dietary fiber content in the cookie was 5.4%. According to the amount of wheat fiber (1.2%) and the addition of 2% coffee hull flour the total cookie fiber should have been 3.2%. Coffee parchment fiber was constituted by cellulose, hemicellulose and lignin and some soluble fiber. This increase in the amount of cookie dietary fiber could be due to the formation of type III resistant starch. This concept has been applied to starch that resists degradation by amylolytic enzymes *in vitro* and *in vivo*. Resistant starch is included within the dietary fiber. Type III resistant starch is formed after certain treatments that involved heat, cooling or moisture. This type of starch can be found in bread, cooked potatoes and canned vegetable products [40,41]. Resistant starch is assayed as insoluble fiber, but has the physiological benefits of soluble fiber [42]. In this research, the fiber assay method used quantifies the dietary fiber in a way that resistant starch is included. Cookie wheat flour starch suffered retrogradation, either in the product baking or cooling stages [43], consequently fiber amount increased. According to FDA/DHHS, the minimum values to consider a product as 'sources of dietary fiber' are 5 and 3 g of fiber per 100 g of product, respectively. Thus, this cookie, with 5.4% of fiber, can be considered 'dietary fiber source' [44] . Although, previous studies used higher fiber percentages (5%-25%) than the present study [29,30], coffee parchment flour provided enough fiber to generate a dietary fiber source cookie. The antioxidant capacity of coffee parchment cookie was 1 116 µmol TE/100g according to ORAC method. This antioxidant capacity was acquired from the coffee parchment,

**Table 1** Chemical characteristics of ground coffee parchment and cookies with 2% coffee parchment.

| Determination | Coffee parchment | 2% Coffee parchment flour cookie |
|---|---|---|
| Moisture (%) | 7.6±0.1 | 1.7±0.04 |
| Fat (%) | Undetectable | 24.1±1 |
| Ash (%) | 0.7±0.002 | 0.9±0.05 |
| Total dietary fiber (%) | 88.7±0.1 | 5.4±0.4 |
| Antioxidant capacity (µmol TE/100g sample) | 1 239±2 | 1 116±27 |
| Total Polyhenols (mg gallic acid/100g sample) | Undetectable (<3.0 mg/g) | Undetectable (<3.0 mg/g) |

Values are means and standard deviations of three replicates which presented 1 239 µm µmol TE/100g. Antioxidant activity remained in the cookie after baking; however, some losses of antioxidants during dough mixing and baking are also reported [45].

Ground coffee parchment and cookie total polyphenols were not detected by the Folin-Ciacalteu method. According to Negesse et al. [46], coffee parchment has high concentrations of phenolic compounds when dry processing was used. In Costa Rica, the wet process is most commonly used to obtain commercially available coffee beans [47]. Phenolics are very unstable and reactive compounds and certainly some degradation of phenolics will occur due to heat and oxidation during the baking process [48]. A standard plate count (SPC) was carried out on three cookie batches with 2% of coffee parchment flour. Only the plates with 1:10 dilution had few colonies (less than 25) [49]. However, an estimate count showed 4 x 10 C.F.U./g, which is far below the maximum permitted, in this product or similar products, of 103 C.F.U./g [31]. This finding showed that cookie processing was carried out using good manufacturing practices and, besides, any contamination due to the ground coffee parchment was minimal and was reduced during high baking temperature.

## Conclusion

Coffee parchment can be considered an important source of dietary fiber to be used in bakery products. A 2% of coffee parchment flour is enough to produce a cookie that is a dietary fiber source and has antioxidant capacity. Coffee parchment flour did not generate rejection on consumers which is a positive characteristic since dietary fiber from cereals has generally low acceptance. Coffee parchment has advantages compared to other products available in the market due to its high fiber content, its antioxidant compounds and low-fat content. Ultrasound treatment, which focused on causing cell lysis of the coffee parchment cell walls, generated an ingredient that decreased cookie hardness and consumer preference. Using coffee parchment without a pretreatment can reduce costs by not carrying out preliminary treatments. Therefore, the use of coffee parchment flour in cookies may increase the availability of functional ingredients that is a source of dietary fiber for bakery products, add economic value to coffee processing by-products and decrease environmental impacts due to the high amounts of waste generated by coffee processing mills.

## References

1 Bekalo SA, Reinhardt HW (2010) Fibers of coffee husk and hulls for the production of particleboard. Mater Struct 43: 1049-1060.

2 Belitz HD, Grosch W, Schieberle P (2009) Food Chemistry 4th revised and extendended edition. Ger Springer-Verlag Berlin Heidelberg 53: 377-385.

3 Bressani R (1979) The by-products of coffee berries. Coffee pulp Compos Technol Util Inst Nutr Cent Am Panama, pp: 5-10.

4 Rodriguez R, Jimenez A, Fernández-Bolaños J, Guillén R, Heredia A (2006) Dietary fibre from vegetable products as source of functional ingredients. Trends Food Sci Technol 17: 3-15.

5 Schieber A, Stintzing FC, Carle R (2001) By-products of plant food processing as a source of functional compounds—recent developments. Trends Food Sci Technol 12: 401-413.

6 Murthy PS, Naidu MM (2012) Sustainable management of coffee industry by-products and value addition-A review. Resour Conserv Recycl 66: 45-58.

7 Baiano A (2014) Recovery of biomolecules from food wastes-a review. Molecules 19: 14821-14842.

8 Esquivel P, Jiménez VM (2012) Functional properties of coffee and coffee by-products. Food Res Int 46:488-495.

9 Borrelli RC, Esposito F, Napolitano A, Ritieni A, Fogliano V (2004) Characterization of a new potential functional ingredient: coffee silverskin. J Agric Food Chem 52: 1338-1343.

10 Murthy PS, Naidu MM (2012) Recovery of phenolic antioxidants and functional compounds from coffee industry by-products. Food Bioprocess Technol 5: 897-903.

11 Ravindran R, Jaiswal AK (2016) Exploitation of food industry waste for high-value products. Trends Biotechnol 34: 58-69.

12 Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, et al. (2011) Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food Chem 124: 411-421.

13 Redgwell RJ, Fischer M (2005) Dietary fiber as a versatile food component: an industrial perspective. Mol Nutr Food Res 49: 521-535.

14 Ötles S, Ozgoz S (2014) Health effects of dietary fiber. Acta Sci Pol Technol Aliment 13: 191-202.

15 Zhang H, Tsao R (2016) Dietary polyphenols, oxidative stress and antioxidant and anti-inflammatory effects. Curr Opin Food Sci 8: 33-42.

16 Brownlee IA (2011) The physiological roles of dietary fibre. Food Hydrocoll 25: 238-250.

17 Sangnark A, Noomhorm A (2004) Chemical, physical and baking properties of dietary fiber prepared from rice straw. Food Res Int 37: 66-74.

18 Canett RR, Ledesma OAI, Robles SRM, Morales CR, Leon-Martinez L, et al. (2004) Characterization of cookies made with deseeded grape pomace. Arch Latinoam Nutr 54: 93-99.

19 Pinto D, Castro I, Vicente A, Bourbon AI, Cerqueira MÂ (2014) Functional Bakery Products. Bak Prod Sci Technol 431-452.

20 O'Shea N, Arendt EK, Gallagher E (2012) Dietary fibre and phytochemical characteristics of fruit and vegetable by-products and their recent applications as novel ingredients in food products. Innov Food Sci Emerg Technol 16: 1-10.

21 Loebnitz N, Grunert KG (2017) Impact of self-health awareness and perceived product benefits on purchase intentions for hedonic and utilitarian foods with nutrition claims. Food Qual Prefer.

22 Larrauri JA (1999) New approaches in the preparation of high dietary fibre powders from fruit by-products. Trends Food Sci Technol 10: 3-8.

23 Vitaglione P, Napolitano A, Fogliano V (2008) Cereal dietary fibre: a natural functional ingredient to deliver phenolic compounds into the gut. Trends Food Sci Technol 19: 451-463.

24 Villanueva NDM, Petenate AJ, Da Silva MAAP (2005) Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. Food Qual Prefer 16: 691-703.

25 Assotiation Ofoac-A (1990) Official methods of analysis. Virginia: Arlington, p: 1117.

26 In: AOAC (2000) Official methods of analysis of AOAC International. AOAC: Arlington, VA.

27 In: AOAC (2005) Latimer JW, Horwitz W, editors. Official methods of analysis. Washington DC, AOAC International press.

28 DeVries JW, Rader JI (2005) Historical perspective as a guide for identifying and developing applicable methods for dietary fiber. J AOAC Int 88: 1349-1366.

29 Huang D, Ou B, Hampsch-Woodill M, Flanagan JA, Prior RL (2002) High-throughput assay of oxygen radical absorbance capacity (ORAC) using a multichannel liquid handling system coupled with a microplate fluorescence reader in 96-well format. J Agric Food Chem 50: 4437-4444.

30 Georgé S, Brat P, Alter P, Amiot MJ (2005) Rapid determination of polyphenols and vitamin C in plant-derived products. J Agric Food Chem 53: 1370-1373.

31 Feldsine P, Abeyta C, Andrews WH (2002) AOAC International methods committee guidelines for validation of qualitative and quantitative food microbiological official methods of analysis. J AOAC Int 85: 1187-1200.

32 Grigelmo-Miguel N, Carreras-Boladeras E, Martin-Belloso O (2001) Influence of the addition of peach dietary fiber in composition, physical properties and acceptability of reduced-fat muffins. Rev Agaroquimica y Tecnol Aliment 7: 425-431.

33 Soto-Mendívil EA, Vidal-Quintanar RL (2001) Evaluation of nixtamalized corn hulls as fiber source in baking products. Rev Agaroquimica y Tecnol Aliment 7: 355-361.

34 Becker FS, Damiani C, de Melo AAM, Borges PRS, de BV (2014) Incorporation of buriti endocarp flour in gluten-free whole cookies as potential source of dietary fiber. Plant foods Hum Nutr 69: 344-350.

35 Foschia M, Peressini D, Sensidoni A, Brennan CS (2013) The effects of dietary fibre addition on the quality of common cereal products. J Cereal Sci 58: 216-27.

36 Guillon F, Champ M (2000) Structural and physical properties of dietary fibres, and consequences of processing on human physiology. Food Res Int 33: 233-245.

37 Schneeman BO (1988) Handbook of Dietary Fiber: An Applied Approach Mark L. Dreher New York: Dekker. J Nutr 118: 915.

38 Sangnark A, Noomhorm A (2003) Effect of particle sizes on functional properties of dietary fibre prepared from sugarcane bagasse. Food Chem 80: 221-229.

39 Novak I, Janeiro P, Seruga M, Oliveira-Brett AM (2008) Ultrasound extracted flavonoids from four varieties of Portuguese red grape skins determined by reverse-phase high-performance liquid chromatography with electrochemical detection. Anal Chim Acta 630: 107-115.

40 Cui L, Pan Z, Yue T, Atungulu GG, Berrios J (2010) Effect of ultrasonic treatment of brown rice at different temperatures on cooking properties and quality. Cereal Chem 87:403-408.

41 Ajila CM, Leelavathi K, Rao UJSP (2008) Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. J Cereal Sci 48: 319-326.

42 Sajilata MG, Singhal RS, Kulkarni PR (2006) Resistant starch-a review. Compr Rev food Sci food Saf 5: 1-17.

43 Eerlingen RC, Delcour JA (1995) Formation, analysis, structure and properties of type III enzyme resistant starch. J Cereal Sci 22: 129-138.

44 de Simas KN, Vieira N, Podestá R, Vieira MA, Rockenbach II, et al. (2010) Microstructure, nutrient composition and antioxidant capacity of king palm flour: A new potential source of dietary fibre. Bioresour Technol 101: 5701-5707.

45 Leenhardt F, Lyan B, Rock E, Boussard A, Potus J, et al. (2006) Wheat lipoxygenase activity induces greater loss of carotenoids than vitamin E during bread making. J Agric Food Chem 54: 1710-1715.

46 Negesse T, Makkar HPS, Becker K (2009) Nutritive value of some non-conventional feed resources of Ethiopia determined by chemical analyses and an in vitro gas method. Anim Feed Sci Technol 154: 204-217.

47 Adams M, Ghaly AE (2007) Maximizing sustainability of the Costa Rican coffee industry. J Clean Prod 15: 1716-1729.

48 Quiles A, Campbell GM, Struck S, Rohm H, Hernando I (2016) Fiber from fruit pomace: A review of applications in cereal-based products. Food Rev Int, pp: 1-20.

49 Swanson KMJ, Petran RL, Hanlin JH (2001) Culture methods for enumeration of microorganisms. Compend methods Microbiol Exam foods (4th edn.), Am Public Heal Assoc Washington, DC, pp: 53-62.