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Sensory Analysis of Post-Exercise Coffee or Cocoa Milk Beverages for Endurance Athletes

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Received: 28 August 2020; Accepted: 10 October 2020; Published: 20 October 2020

Abstract: Beverage strategies with balanced carbohydrate and protein supply are important for athletes' recovery. Cow's milk with added bioactive compounds present in coffee and cocoa facilitates glucose metabolism and may help post-workout glycogen recovery. Home-prepared beverages are cost and nutritionally effective strategies. Thus, the objectives were: (1) To develop home-prepared beverages containing nonfat powdered milk and sugar combined with filtered coffee or cocoa powder in balanced amounts for recovery after endurance exercise; and (2) to perform sensory analysis. Sensory evaluation was conducted by an acceptance test, applying nine-point hedonic scale and descriptive analysis, using the check-all-that-apply method (CATA). McNemar's test and logistic regression with the proportional odds model were employed. The sample included 44 triathletes and 56 runners, of both sexes, 31–70 years old. Both beverages were well accepted by runners and triathletes, with higher acceptance of the coffee beverage (odds ratio coffee vs cocoa 5.232, $p = 0.0038$). There was no significant difference between acceptance of triathletes and runners for the two beverages. The descriptive sensory analysis (CATA) resulted in slightly different characterizations between the two beverages. Both beverages were well accepted and characterized by the athletes, who can supply different options of post-workout beverages according to individual tastes, composition, and characteristics.

Keywords: sports nutrition; recovery beverages; endurance training

1. Introduction

Endurance training entails extensive exercise that causes great physiological stress. The high metabolic demand significantly depletes the body's energy stores. Practitioners of endurance sports, such as triathlon and marathon, tend to have short recovery intervals between training sessions. Therefore, post-workout nutritional strategies are essential for proper muscle recovery and energy stores replenishment. The balanced supply of carbohydrate and protein in the 4 hours after training sessions are key to the athlete's recovery [1]. Recreational triathletes need to train for longer periods than recreational runners. Triathletes are exposed to sweet-base beverages during training and prone to accept sugar-sweetened beverages.

The most recent Brazilian Food Guidelines stated that unprocessed, minimally processed and home-made foods are advantageous to the population either economically and nutritionally [2]. Milk with added chocolate (roasted and ground cacao seeds) has been studied due to its nutritional composition, with carbohydrates and proteins in ideal quantities to assist in the resynthesis of muscle glycogen stores [3–7]. This home-made beverage is considered just as efficient as a ready to drink sports beverage in the recuperative response of athletes [8–11].

Cocoa is rich in polyphenols that can affect glucose homeostasis, mainly by modulating insulin secretion [12,13]. The administration of a post-workout beverage containing adequate carbohydrate and protein proportions with added cocoa may assist in reducing muscle pain after exhaustive aerobic exercise [14]. Coffee is also rich in bioactive compounds, which are associated with energy metabolism functions [15–17]. Chlorogenic acid, caffeic acid, and cafestol are related to increased insulin secretion and to favour glucose uptake by skeletal muscle [18,19]. When consumed in combination with carbohydrate beverages, caffeine facilitates energy recovery and a higher rate of muscle glycogen resynthesis after training sessions [20–22].

Thus, bioactive compounds present in beverages that contain cocoa or coffee may play a role in the post-workout recovery process [23].

This work aimed to develop home-prepared beverages with adequate proportions of nonfat cow's milk, sugar, and filtered coffee or cocoa powder for post-workout recovery. The hypothesis is that homemade beverages are well accepted by the athletes.

2. Materials and Methods

2.1. Beverage Preparation

The choice of beverage flavors came from a study conducted in our laboratory that tested the post-workout metabolic effects of coffee with milk. This sensory analysis was the first step of that experiment. Therefore, the objective was to evaluate the acceptance of the test beverage by athletes, comparing it with another beverage flavor. Cocoa was chosen as a component of the second beverage because it is a common flavor in post-workout ready to drink beverages. In addition, it has several bioactive compounds, as well as coffee. Both beverages were formulated to provide the carbohydrate and protein amounts according to the recommendations for post-exercise recovery [24,25].

The final beverage recipe (Supplemental Material) has two stages. In the first stage, which occurred the day before each data collection, milk powder and sugar were weighed, coffee was filtered and frozen, and cocoa was diluted with water and then frozen. The coffee (Café Torrado e Moído Melitta Tradicional, São Paulo, SP, Brazil ®) was filtered with a paper filter (Melitta® 102, São Paulo, SP, Brazil) in a proportion of 25 g of ground coffee to 300 mL of mineral water at 90 °C. A greater volume of water was necessary to obtain a final volume of 250 mL of filtered coffee, considering the water retention in the filter. The filtered coffee was poured into ice cube tray and then frozen. Cocoa powder (Cacau empó Mãe Terra®, Osasco, SP, Brazil) was homogenized in a blender at the ratio of 25 g of cocoa to 250 mL of mineral water at 60 °C. This mixture was poured into an ice cube tray and then frozen. In the second stage of preparation, that occurred on the day of data collection, the beverages were homogenized. Powdered milk (Leite em Pó Desnatado Instantâneo Piracanjuba®, Bela Vista de Goiás, GO, Brazil) (60 g) and sugar (Cristalçúcar União®, São Paulo, SP, Brazil) (54 g) were blended for thirty seconds with cold mineral water (250 mL). Then, the 250 mL of frozen coffee (sample A) or cocoa (sample B) cubes were added. The beverages were homogenized for two more minutes and stored in thermoses. Thus, the total volume of each beverage was of 500 mL. After filled thermos bottles, the beverages were taken to the athletes' training sites for data collection and consumed within three hours.

2.2. Sampling and Inclusion Criteria

The study sample was non-probabilistic, and the sample size was stablished as 100 individuals testing each beverage, resulting in a total of 200 evaluations. Sensory acceptability studies on 100 tested consumers are considered an adequate number [26]. The athletes were recruited at the training sites, after agreement with the coaches. There were 10 days of data collection in parks, gyms and swimming clubs where athletes usually train. Participants answered questions about their socio-demographics characteristics, frequency of specific food consumption, health conditions, and training habits. Based on the questionnaires, eligible athletes were invited to participate in the study after their usual training session. The inclusion criteria were recreational triathletes or runners, of both genders, and over 18 years-old, who were habitual consumers of sweetened drinks containing milk, coffee and/or cocoa. Individuals who reported any health and/or allergy problems, intolerance, aversion, and incompatibility with beverage components were excluded.

2.3. Sensory Analysis

The athletes who met the inclusion criteria were invited to participate in the sensory evaluation of the beverages.

The evaluation was performed based on two independent tests arranged in a single form. First, the acceptance test was performed and then the descriptive analysis by the check-all-that-apply method (CATA) [27].

2.4. Acceptance Test

The athletes received a 50 mL samples of each beverage and completed the acceptance form evaluating their degree of like or dislike of the samples. For this, they rated the beverages using a structured 9-points hedonic scale, considering of: 1 dislike extremely, 2 dislike very much, 3 dislike moderately, 4 dislike slightly, 5 neither like nor dislike, 6 like slightly, 7 like moderately, 8 like very much, 9 like extremely. The beverages were coded, and the order offered was randomized.

Between each beverage sample tasting, the athletes drank mineral water and ate cracker to clean their palate and avoid the taste of one sample interfering with the other. Participants knew that the beverages could contain milk, coffee, or cocoa, but did not know the composition of the beverages during the acceptance test.

Statistical analysis of acceptance data was performed by fitting a proportional odds model [28] with PROC LOGISTIC using SAS® System for Windows (SAS Institute Inc., Cary, NC. USA).

2.5. Descriptive Beverage Analysis

The Check-all-that-apply method (CATA) was applied for the descriptive analysis of the beverages [27]. The terms used in the descriptive CATA analysis were previously elicited by the Repertory Grid method with 15 evaluators who received both samples for evaluation [29].

After taking the acceptance test, the athletes marked the terms on the CATA list of attributes that they deemed appropriate to describe each sample. The order of terms was randomized for each assessment to minimize psychological and fatigue errors [30]. The descriptive profile of the beverages was determined from the frequency data of the terms indicated by the athletes. The nine most frequent sensory attributes of each beverage were considered to describe them. The frequency between 40 and 60 checks were established as selection criterion.

The frequency data from the CATA test were analyzed by the McNemar's test to identify significant differences between pairs of matched samples, based on the frequency that each sensory term was marked by the athletes. The frequencies of each attribute were compared between beverages, considering each attribute independently. The p-value for the comparisons was 5%. Statistical analyzes were performed using the XLSTAT 2017 program (Addinsoft, Paris, France).

2.6. Ethics Declaration

The protocol was approved by the Human Research Ethics Committee of the Faculty of Health Sciences of the University of Brasilia (CEP/FS—CAAE 89893618.2.0000.0030) and all participants read and signed the informed consent form.

3. Results

The sample included 100 athletes—44 triathletes, and 56 runners. The majority were between 31 and 50 years old (74% of volunteers), with more men (65%) than women (35%).

3.1. Beverages Composition

The beverages prepared aimed to meet the macronutrient demands of a 70 kg endurance athlete. For this, 60 g of nonfat milk powder combined with 54 g of sugar were used, resulting in a portion of 84 g of carbohydrates (1.2 g/kg weight) and 21 g of proteins (0.3 g/kg weight). Sample A had 25 g of the ground and filtered coffee, which contains approximately 100 mg of caffeine (NDSR 2018 University of Minnesota, Nutrition Coordinating Center Food and Nutrient Database http://www.ncc.umn.edu/products/) and 530 mg of total polyphenols, including predominantly phenolic acids such as chlorogenic acid and caffeic acid [31]. Sample B had 25 g of cocoa, which contains approximately 5 mg of caffeine and 125 mg of total polyphenols, including mostly flavonoids such as catechins, epicatechins, and procyanidins [31]. The nutritional composition of beverage macronutrients and phenolic compounds is presented in Table1. Due to the characteristic lipid content of cocoa, the preparation with this food provided 5.5 Kcal/100 mL more than the coffee beverage. It is possible that the bioactive compounds from coffee and cocoa may be reduced in the milk-based preparation. The antioxidant capacity of different types of coffee was shown to be decreased with the addition of milk [32] and with cocoa products [33].

Table 1. Nutrient composition and bioactive compounds of beverages formulated for post-workout recovery.

	Coffe Based Beverage (500 mL)	Cocoa Based Beverage (500 mL)
Carbohydrates(g) [a]	85.5	90.0
Proteins(g) [a]	21.0	25.0
Lipids(g) [a]	0.5	3.0
Energy(kcal)	430	485
Caffeine(mg) [b]	100.0	5.0
Total Polyphenols(mg) [c]	530	125

[a] (IBGE, 2011), [b] (NSDR, 2018), [c] (Rothwell et al., 2013).

3.2. Athletes' Beverages Consumption Habits

Before sensory analysis, athletes filled out information about eating habits, reporting the frequency they drink certain beverages. Most participants (54%) reported consuming pure coffee more than once a day and 20% reported consuming it at least once a day. Almost half of the participants (47%) never consume pure milk and 32% rarely consume it. Many of the athletes never (42%) or rarely (42%) drink chocolate milk. However, only 31% of the participants never consume coffee with milk and 33% rarely consume it. Moreover, coffee with milk had the highest frequency of daily consumption (15%). The beverages consumption behavior of both runners and triathletes were similar. Thus, the surveyed athletes were considered high consumers of coffee and low consumers of cow's milk and milk with cocoa.

3.3. Acceptance Analysis

The acceptance test was conducted applying a nine-point hedonic scale, but it was observed that just 5% of all responses showed some kind of dislike (extremely to lightly) for the beverages (1% of evaluations for coffee and 4% for cocoa beverage). Moreover, from all responses, it was observed that 89% liked (lightly to extremely) the two beverages in some form (41% for cocoa and 48% for coffee beverages), and only 6% of all evaluations were indifferent (nor positive or negative) for acceptance (5% for cocoa and 1% for coffee). It is well known that when categories have few frequencies, statistical tests lose power or they are not applicable [34]. For this reason, it was considered a three-point hedonic scale for the proportional odds model, i.e., categories 1 to 4 were considered Disliked, 5 = Indifferent and categories 6 to 9 as Liked. (Supplemental Material shows the equivalence of original and new categories and observed frequencies).

Figure 1 illustrates the total agreement by runners and triathletes for each beverage (coffee and cocoa). A stepwise cumulative logistic model was performed considering sport, beverage, and its interaction as explanatory variables. The beverage was the effect selected with proportional odds test and goodness-of-fit statistics supporting the adequacy of the model with a significant effect for beverage and estimated odds ratio of 5.232 ($p = 0.0038$). It means that coffee beverage has more than 5 times higher odds of acceptance as those of cocoa beverage, both for liked evaluation versus indifferent or dislike acceptance, and for indifferent evaluation (acceptance) versus dislike evaluation. The respective 95% confidence interval was (1.705; 16.051), showing that acceptance of coffee beverage is at least 1.7 higher than a cocoa beverage.

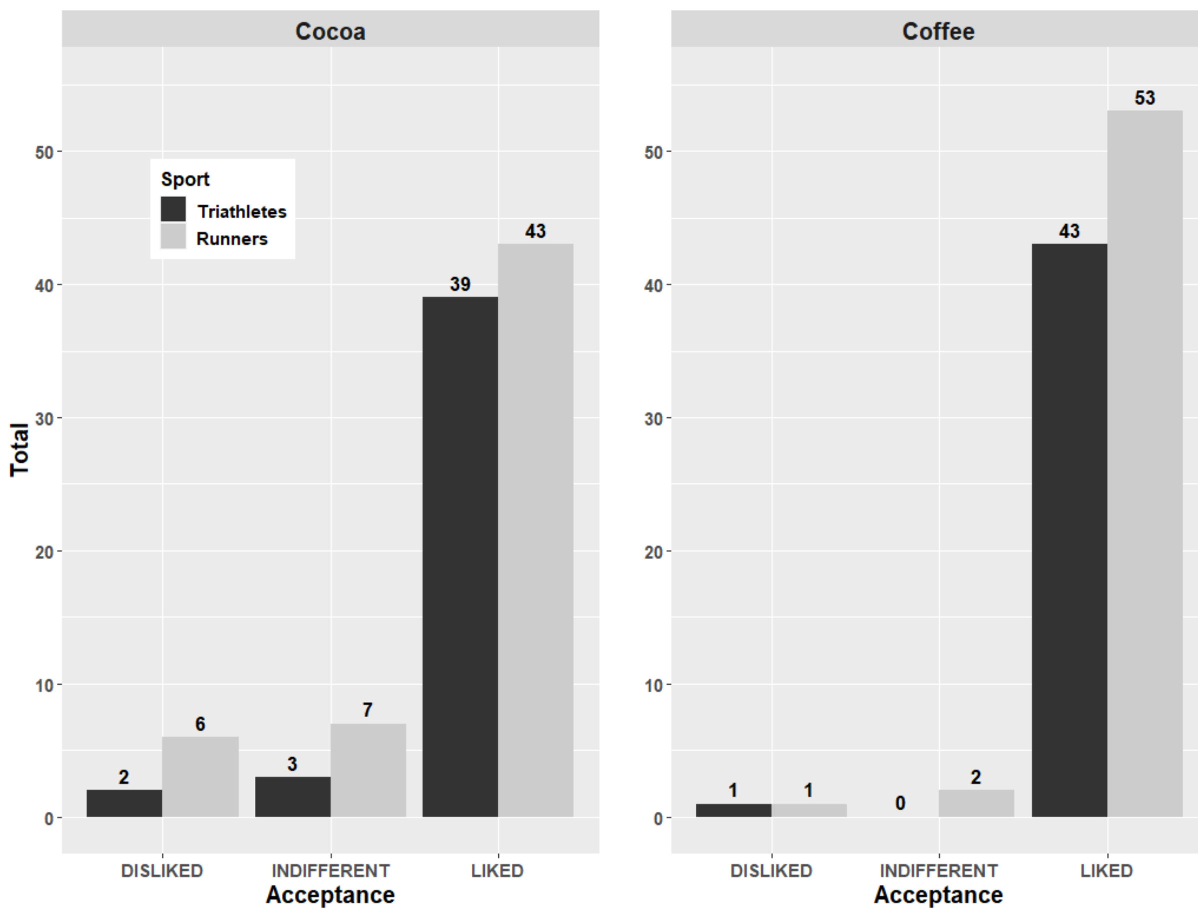

Figure 1. Total acceptance by triathletes and runners for cocoa and coffee beverages.

3.4. Descriptive Analysis

Table 2 presents information about the frequency on which the characteristics were attributed to coffee and cocoa beverages. The attributes with absolute frequencies between 40 and 60 percent (0.40 to 0.60) were considered characteristics of the samples. Coffee and cocoa beverage samples were characterized by the nine most frequently indicated attributes:

> The post-workout coffee milk beverage has a creamy and homogeneous appearance; coffee, cappuccino, and sweet aroma; sweet and tasty flavor; as well as a creamy texture.
>
> The post-workout cocoa milk beverage has a full-bodied, brown, and creamy appearance; chocolate and cocoa aroma and taste; as well as a full-bodied and creamy texture.

The five attributes placed at the end of the Table 2 (foamy appearance, creamy appearance, mild aroma, foamy texture, and creamy texture) resulted in non-significant differences in frequency reported by the athletes. The evaluation based on absolute frequencies (Table 2) agrees with most of the results of McNemar's test.

Table 2. Frequency of check-all-that-apply (CATA) attributes for post-workout beverages formulated with coffee or cocoa.

Atributes	Coffee	Cocoa	*p*-Value *
Homogeneous appearance	**0.460**	0.190	0.000
Coffee aroma	**0.580**	0.020	0.000
Sweet aroma	**0.410**	0.210	0.001
Pleasant aroma	**0.440**	0.250	0.003
Cappuccino aroma	**0.410**	0.020	0.000
Sweeter flavor	**0.510**	0.120	0.000
Tasty flavor	**0.580**	0.320	0.000
Full-bodied appearance	0.210	**0.520**	0.000
Brown appearance	0.280	**0.540**	0.000
Chocolate aroma	0.030	**0.530**	0.000
Cocoa aroma	0.030	**0.520**	0.000
Chocolate flavor	0.110	**0.500**	0.000
Cocoa flavor	0.050	**0.450**	0.000
Full-bodied texture	0.300	**0.470**	0.011
Attractive appearance	0.360	0.210	0.014
Cream color appearance	0.370	0.010	0.000
Ugly appearance	0.010	0.170	0.000
Strong aroma	0.020	0.270	0.000
Strong coffee flavor	0.180	0.020	0.000
Whey protein flavor	0.060	0.270	0.000
Mild flavor	0.360	0.080	0.000
More bitter taste	0.010	0.210	0.000
Chunky texture	0.000	0.140	0.000
Watery texture	0.190	0.040	0.001
Thick texture	0.090	0.340	0.000
Foamy Appearance	0.250	0.180	**0.223**
Creamy Appearance	**0.480**	**0.470**	**0.884**
Mild aroma	0.230	0.170	**0.239**
Foamy texture	0.220	0.140	**0.102**
Creamy texture	**0.570**	**0.550**	**0.763**
N = 100 athletes			

* MacNemar's Test.

4. Discussion

The developed sports beverages have an adequate nutritional composition for post-workout recovery of endurance athletes, referencing the current guidelines [24,25]. The beverages provide 1.2 g of carbohydrate combined with 0.3 g of protein per kilogram of body weight, which can contribute to muscle glycogen resynthesis, metabolic adaptation, repair and remodeling [25,35]. In addition to an adequate post-workout macronutrient composition, the coffee or cocoa bioactive compounds may contribute to energy metabolism and muscle glycogen resynthesis. In sensory evaluation, the beverages were well accepted confirming the hypothesis of the study.

The predominance of men training for a triathlon is not a surprising feature of the sample. The USA Triathlon Membership Survey Report had similar sex distribution with a predominance of men (65%) participating in triathlon races [36]. Triathletes and runners accepted equally the two beverages. Athletes are used to sweet foods and supplements to meet the high-energy demand that these individuals require.

The results obtained on the food frequency questionnaire about the consumption of beverages confirmed that participants frequently consume coffee but rarely consume cow's milk. A study that evaluated the foods most frequently consumed by Brazil's, using data from the National Food Survey (INA), contained similar data. In Brazil, coffee is the first most-consumed food, with a prevalence of 78, 1% of consumption, whereas milk is consumed less frequently (6.5% for whole milk and 1% for nonfat milk [37]. Another study that investigated the most used coffee preparation methods, also found high coffee consumption by Brazilians [38]. That study found that filtered or instant (71%) coffee was the most common, followed by the preparation of coffee with milk (53%), which reflects the consumption behavior of coffee and milk observed in our sample.

The higher frequency of coffee consumption reported by athletes may have influenced their greater acceptance of the coffee beverage compared to the cocoa beverage. This high acceptability of the coffee beverage among athletes confirms our hypothesis. The polyphenol content of coffee, which may add a high astringent potential to the beverage, [39], was not a factor for rejection among evaluators. On the contrary, the variety of bioactive compounds may have been a factor favoring greater acceptance by providing unique sensory characteristics to the beverage [40,41]. In addition, coffee is associated with improved cognitive processes related to mood and well-being [17]. Due mainly to the caffeine, coffee also acts on psychoactive mechanisms that directly influence sports performance, such as increased concentration and alertness [42,43]. All these attributes and effects are potentially appealing to athletes.

The bioactive compounds in the cocoa beverage may play a role in the post-workout recovery process [4]. Polyphenols present in cocoa can significantly influence energy metabolism. These compounds affect insulin modulation, increasing glucose uptake in skeletal muscle and favoring muscle glycogen resynthesis [12,13]. In addition, cocoa polyphenols can stimulate the nervous system, but less than caffeine [44]. Thus, the consumption of polyphenol-rich foods such as post-workout cocoa may induce desirable metabolic responses. The cocoa beverage also provides more energy intake than the coffee beverage due to the higher amount of carbohydrate, protein, and especially lipids. The energy input of 97 Kcal/100 mL of the cocoa beverage is approximately 12% higher than the 86 Kcal/100 mL of the coffee beverage.

The descriptive sensory evaluation indicated statistically significant differences in most sensory attributes, demonstrating that each beverage had unique characteristics chosen by the participants. As they are essentially different beverages, they were expected to have distinct characteristics, such as appearance, aroma and texture. The texture was different not only because of the composition but also because of the form of preparation. Thus, the cocoa beverage had a fuller, more chunky and dense texture, while the coffee beverage had a more homogeneous and creamy texture.

The CATA methodology is an efficient way to describe products and is advantageous mainly for the simplicity and speed of the analysis. In addition, products can be described based on the frequency of the most commonly used terms, which are directly related to consumer perception [45]. Therefore, the acceptance and description data of the beverages provided relevant information, indicating striking characteristics of both beverages, which may help to choose a beverage preparation. A relevant aspect of our research is that the beverages were evaluated immediately after athletes finished a training session, reproducing actual sensations right after physical exhaustion, such as hunger and thirst. This permitted a sensory evaluation of the beverages with greater specificity, obtaining more realistic information about acceptance and description of the beverages for post-workout.

In addition to the high acceptance by athletes, another possible determining factor in choosing a post-workout beverage is its economic value. The dairy sports beverages in the present study were evaluated for their costs on the Brazilian market. Estimated values were US$0.79 (corresponding to R$3.30 Brazilian Reais) for one serving (500 mL) of the coffee beverage and US$1.00 (R$4.20) for one serving (500 mL) of the cocoa beverage. A commercial post-workout recovery product with similar nutritional composition (Endurox®) costs approximately US$3.60 (R$15.00) per serving (75 g) of the supplement diluted in 200 mL of water. Thus, the studied beverages cost 4 to 5 times less than a comparable commercial supplement.

The sample size of this study can be considered sufficient for statistical relevance in sensory evaluation studies [45], especially in the case of a very specific target audience, which is endurance athlete. A limitation of the study is the experimental design with only two treatments used, reducing the statistical power because multivariate analyzes cannot be performed. However, due to the fixed nutritional composition combined with the athletic benefits, the treatments did not have a wide margin of variation in the composition of the samples. The beverages have fixed carbohydrate and protein concentrations and varying amounts of bioactive compounds, including caffeine and other glycolytic pathway stimulants to function in the post-workout recovery process. In addition, coffee and cocoa are consumed beverages among the surveyed athletes so that they could be viable options according to their individual preferences. Additionally, we did not find in the literature sensory evaluation of homemade preparations with milk, coffee, and cocoa for athletes.

5. Conclusions

The beverages prepared with nonfat cow's milk with sugar and added coffee or cocoa for post-workout consumption obtained a high acceptance. A comparison of the overall acceptance showed triathletes and runners did not differ in acceptance of both beverages, and the coffee beverage was more accepted by athletes in both sports compared to cocoa. The descriptive evaluation of the two beverages concluded that they have distinct characteristics, mainly in texture. Nevertheless, both beverages have positive characteristics and can be options for athletes according to their individual preferences, prescribed diet, and training demands. Thus, both beverages can be considered viable resources in the routine of endurance athletes who do not have dietary restrictions for these beverage components.

Supplementary Materials: The following are available online at http://www.mdpi.com/2306-5710/6/4/61/s1. Table S1. Acceptance Correspondence of 9 point and 3 point-hedonic scales*. Table S2. Sample A (Coffee Milk Beverage). Table S3. PREPARATION NAME: Sample B (Cocoa Milk Beverage).

Author Contributions: Conceptualization, methodology, investigation: R.M.T., L.d.L.d.O., and T.H.M.d.C.; dietary formulation and calculations L.M.R.L., R.M.T., and T.H.M.d.C.; data interpretation and analysis, R.M.T., L.d.L.d.O., G.v.B., and T.H.M.d.C.; resources and supervision: L.d.L.d.O. and T.H.M.d.C.; data curation: R.M.T. and T.H.M.d.C.; writing original draft preparation: R.M.T.; writing review and editing: R.M.T., L.d.L.d.O., L.M.R.L., G.v.B., and T.H.M.d.C. All authors have read and agreed to the published version of the manuscript.

Funding: This work was partially supported by CAPES (Coordination for the Improvement of Higher Education Personnel, Ministry of Education) under Grant PROAP 001 for R.T.M. This research did not receive any direct support grant from agencies in the commercial and non-profit sectors.

Acknowledgments: THMC received a personal scientific grant (number 308630/2017-3) from CNPq (Brazilian National Technological and Scientific Development Council). SAS was used through academic partnership with Department of Statistics from University of Brasília.

Conflicts of Interest: The authors declare no conflict of interest.

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