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Acceptable low-phenylalanine foods and beverages can be made with glycomacropeptide from cheese whey for individuals with PKU

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Abstract

Glycomacropeptide (GMP) is a whey protein that contains no aromatic amino acids including phenylalanine (phe). The objective of this study was to make a variety of palatable, low-phe foods and beverages with GMP and to assess their acceptability by conducting consumer sensory studies in individuals with PKU. Results demonstrate acceptability of products made with GMP. GMP supplemented with limiting indispensable amino acids could provide an alternative protein source for individuals with PKU.

Introduction

Glycomacropeptide (GMP) is a whey protein produced during cheese making when bovine kappa (κ)-casein is cleaved by chymosin into para- κ -casein, which remains with the cheese curd, and GMP, which remains with the whey [1,2]. GMP, a 64 amino acid glycoposphopeptide, constitutes 15-20% of the protein in whey. Compared with typical dietary proteins, pure GMP has a unique amino acid profile with elevated amounts of threonine and isoleucine and no aromatic amino acids, including phenylalanine (phe), tyrosine and tryptophan [3]. Thus, GMP is ideally suited to the PKU diet as a potential substitute for phe-free amino acid based formulas [4]. The objective of this study was to make a variety of palatable, low-phe foods and beverages with GMP and to assess their acceptability by conducting consumer sensory studies in individuals with PKU.

Materials and Methods

Foods and beverages

Strawberry pudding, strawberry fruit leather, chocolate beverage, snack cracker and an orange sports beverage containing GMP were developed for this study in the Food Applications Laboratory at the Wisconsin Center for Dairy Research (CDR), University of Wisconsin-Madison (UW). The BioPURE-GMP™ (Davisco Foods International, Inc., LeSueur, MN) was used to formulate GMP products. The amino acid profile of BioPURE-GMP™ compared to

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casein is shown in Figure 1. A commercial amino acid-based chocolate beverage and low protein cracker were included in the taste testing to provide comparisons between GMP products and products currently used in the PKU diet. The nitrogen concentration of GMP and amino acid beverages was similar. The energy and protein content of all foods tested is provided in Table 1

Sensory studies to assess acceptability of foods and beverages

The protocol for sensory studies was approved by the Social and Behavioral Sciences Institutional Review Board, UW. Three sensory studies were performed with PKU subjects attending PKU Summer Camps in 2004 and 2005 and a PKU family conference in 2005 (n = 49; age range 12 to 42 years). The studies were conducted in the Sensory Analysis Laboratory, Department of Food Science, UW or at the Waisman Center. Test samples of 20-30 g were presented to subjects in balanced random order with three digit blind codes. Foods and beverages were rated using a five-point hedonic scale (1 = dislike very much, 2 = dislike, 3 = neither like nor dislike, 4 = like, 5 = like very much) to evaluate five sensory categories including appearance, odor, taste, texture and overall acceptability.

Statistical analysis

Dependent t-test was performed to analyze mean acceptability scores for GMP chocolate beverage and amino acid chocolate beverage. Group means were considered to be significantly different at $P \leq 0.05$, as determined by a two-tailed t-test using Statistical Analysis Software package (SAS Institutes Inc., Version 9.1.3, Cary, NC, USA). Acceptability scores for GMP snack crackers and low protein crackers were compared using general linear model procedure (PROC GLM) followed by Fisher's least square means for mean separation. Data are presented as means with standard deviations.

Results

PKU subjects tasted a total of 7 products during PKU events in 2004 and 2005 (Table 1). Among these foods and beverages, GMP strawberry pudding was the most acceptable (overall score of 4.2 ± 0.9) and other foods in order of overall acceptability were GMP snack crackers (3.6 ± 1.4), GMP strawberry fruit leather (3.4 ± 1.0), GMP chocolate beverage (3.3 ± 1.0), GMP orange sports beverage (3.3 ± 1.1), and low protein crackers (2.9 ± 1.3). An amino acid chocolate beverage was least acceptable (2.5 ± 1.4). A score of < 3 indicates that a food or beverage is unacceptable with respect to a specific category whereas a score of 3 indicates neutral acceptance. PKU subjects rated the appearance, odor, taste and overall acceptability of GMP chocolate beverage as significantly more acceptable compared to the amino acid based beverage ($p \leq 0.05$, Table 1B). Appearance, odor and taste of the GMP snack crackers were rated as significantly more acceptable compared to the low protein cracker ($p \leq 0.05$), but overall acceptability was not significantly different between the two types of crackers (Table 1C).

Discussion

New dietary approaches are needed to increase long-term compliance with the low-phe diet required for management of PKU [5,6]. The biggest obstacle to following the PKU diet is the need to consume the majority of dietary protein from a mixture of phe-free amino acids usually consumed as a liquid formula [7]. GMP, a natural protein in cheese whey, is uniquely suited to the PKU diet because pure GMP contains no phe. The feasibility of making a variety of palatable foods and beverages containing GMP was examined in this study.

GMP must be isolated from cheese whey and purified to reduce contamination from other whey proteins before it is useful in the PKU diet. Commercially available GMP contains approximately 4 mg phe per g GMP, a level acceptable in a moderately restricted PKU diet for individuals with a higher tolerance to phe, such as those with a variant form of classical PKU. For a strict low-phe diet (less than 500 mg/day), technology is available to purify GMP to contain a phe concentration less than 2 mg phe per g of GMP [2,8]. GMP contains low concentrations of several essential or indispensable amino acids. When used as the primary source of dietary protein for individuals with PKU, GMP must be supplemented with the following amino acids: leucine, histidine, tryptophan and tyrosine [9].

These data demonstrate that the functional properties of GMP are especially well suited for use in beverages and semi-solid foods such as pudding. For example, GMP is soluble in acid with an isoelectric point of 2.8, forms gels or foams, and has good heat stability. GMP actually enhanced the chocolate flavor used in the beverage with the added feature that the chocolate flavor helped to mask the dairy flavor of GMP. These data suggest that GMP can be used to make a beverage that is more palatable than the amino acid formulas currently required as the primary source of protein in the PKU diet. Additional studies utilizing a GMP beverage supplemented with limiting indispensable amino acids and micronutrients are underway to confirm this observation.

In summary, palatable, low-phe foods and beverages can be made with GMP to provide an alternative low-phe protein source in the PKU diet. The long-term goal of this research is to improve the palatability of the PKU diet to facilitate long-term dietary compliance and to ultimately improve quality of life and metabolic control for individuals with PKU. Preliminary studies in the PKU mouse model suggest that GMP provides for adequate growth and acceptable metabolic control [4]. Studies in individuals with PKU are ongoing in our research group to establish the safety and efficacy of GMP in the nutritional management of PKU.

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Figure 1 legend.

Amino acid profile of glycomacropeptide (BioPURE-GMP™; Davisco Foods International, Inc., LeSueur, MN) and casein (ALACID®; New Zealand Milk Products, Santa Rosa, CA) expressed as g amino acid per 100 g product..

Table 1

Mean Acceptability Ratings of Foods and Beverages made with GMP as tested in individuals with PKU

Product	No. of Subjects	Appearance	Odor	Taste	Texture	Overall
A. Acceptability ratings for GMP pudding, fruit leather, and sports beverage						
GMP ¹ Strawberry Pudding	31	4.0 ± 0.7 ²	3.6 ± 1.1	4.2 ± 1.0	4.1 ± 0.8	4.2 ± 0.9
GMP Strawberry Fruit Leather	31	3.4 ± 0.8	3.8 ± 0.9	3.4 ± 1.1	3.0 ± 0.9	3.4 ± 1.0
GMP Orange Sports Beverage	18	4.1 ± 0.6	3.6 ± 0.9	2.9 ± 1.2	3.8 ± 1.0	3.3 ± 1.1
B. Acceptability rating for GMP and amino acid-based chocolate beverage						
GMP Chocolate Beverage	32	3.8 ± 0.8 ^{a,3}	3.7 ± 1.0 ^a	3.2 ± 1.1 ^a	3.3 ± 1.0	3.3 ± 1.0 ^a
Amino Acid Chocolate Beverage	32	3.1 ± 1.1 ^b	2.8 ± 1.3 ^b	2.2 ± 1.3 ^b	3.1 ± 1.1	2.5 ± 1.4 ^b
C. Acceptability ratings for GMP and a low-protein snack cracker						
GMP Snack Crackers	18	3.8 ± 0.6 ^{a,3}	3.9 ± 0.8 ^a	3.7 ± 0.8 ^a	3.6 ± 0.9	3.6 ± 1.4
Low Protein Crackers	18	3.2 ± 0.9 ^b	3.2 ± 0.8 ^b	2.9 ± 1.1 ^b	3.2 ± 1.2	2.9 ± 1.3

The energy and protein content of the foods tested is as follows: GMP strawberry pudding, 213 kcal and 5.7 g protein per ½ cup serving (113 g); GMP fruit leather, 60 kcal and 0.7 g protein per 15 g; GMP orange sports beverage, 67 kcal and 7.9 g protein per 8 oz (234 g); GMP chocolate beverage, 148 kcal and 10.2 g protein per 8 oz (236 g); amino acid chocolate beverage, 187 kcal and 11.4 g protein per 8 oz (202 g); GMP snack crackers, 110 kcal and 1.3 g protein per 30 g; low protein crackers, 135 kcal and 0.1 g protein per 30 g.

¹ Glycomacropeptide: BioPURE-GMP™ (Davisco Foods International, Inc., Le Sueur, MN)

² Mean ± standard deviation (score reference: 1 – dislike very much, 2 – dislike, 3 – neither like nor dislike, 4 – like, 5 – like very much)

³ Means with different letter superscripts in the same column do significantly differ at $p \leq 0.05$