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REDEFINING THE PKU DIET: NOVEL FUNCTIONAL FOODS WITH LOW PHENYLALANINE AND HIGH NUTRITIONAL VALUE

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Abstract: Phenylketonuria (PKU) is an inherited metabolic disorder that is defined as the deficiency of phenylalanine hydroxylase, which requires lifelong dietary management to avoid neurotoxicity and metabolic imbalances. PKU diet is semi-synthetic with managed consumption of natural low-protein foods, and phenylalanine-free protein replacement options and specialized dietetic products. The aim of this study is to identify potential new sources of low-phenylalanine (low-Phe) products, that are rich in copper, providing an optimized and sustainable PKU diet and supply all the essential nutrients.

Introduction

PKU treatment's main focus is to balance phenylalanine and tyrosine levels between safe limit and optimal protein for growth and development. In individuals with classical PKU, daily tolerance typically ranges between 220 and 240 mg of Phe, equivalent to an intake of approximately 4–5 grams of natural protein per day.

The cornerstone of treatment remains lifelong low-protein diet with phenylalanine-free amino acids. Fruits and vegetables are an essential part of the PKU diet as they have relatively low protein content, 1–1.5% in fruits, and 3–8% in vegetables. However, some varieties—such as spinach, peas, kale, and sweetcorn—have a higher amount of phenylalanine, which needs moderation of portions.

The Phe-restricted diet commonly results in increased carbohydrate intake, along with a build-up of visceral fat, which increase cardiovascular risk, type 2 diabetes and obesity. Moreover, an association between reduced vitamin B12 intakes and reduced serum cobalamin concentrations was found, supporting the idea that nutritional intake and supplementation needs to be monitored as well to avoid such deficiencies.

The study aims to answer one main question: what plant-based food products could correct or prevent copper and cobalamin deficit in individuals suffering from phenylketonuria (PKU)?

Material and method

Articles were selected according to amino acid profiling importance and micronutrient composition. Significant attention has been paid to foods rich in essential vitamins such as vitamin C, E, K, folic acid, minerals such as copper, iron, zinc, potassium and bioactive compounds with antioxidant activity and metabolic benefits. In order to address the main research question, a comprehensive table was developed using data extracted from the reviewed scientific literature and relevant nutrition databases. The graphical fingerprint of data was created using MVSP program, version 3.22.

Results and discussions

Figure 1 helps to identify the main foods able to contribute with higher content of copper and /or other nutritional components in order to answer the main question regarding the deficit of copper and cobalamin in individuals suffering from phenylketonuria (PKU).

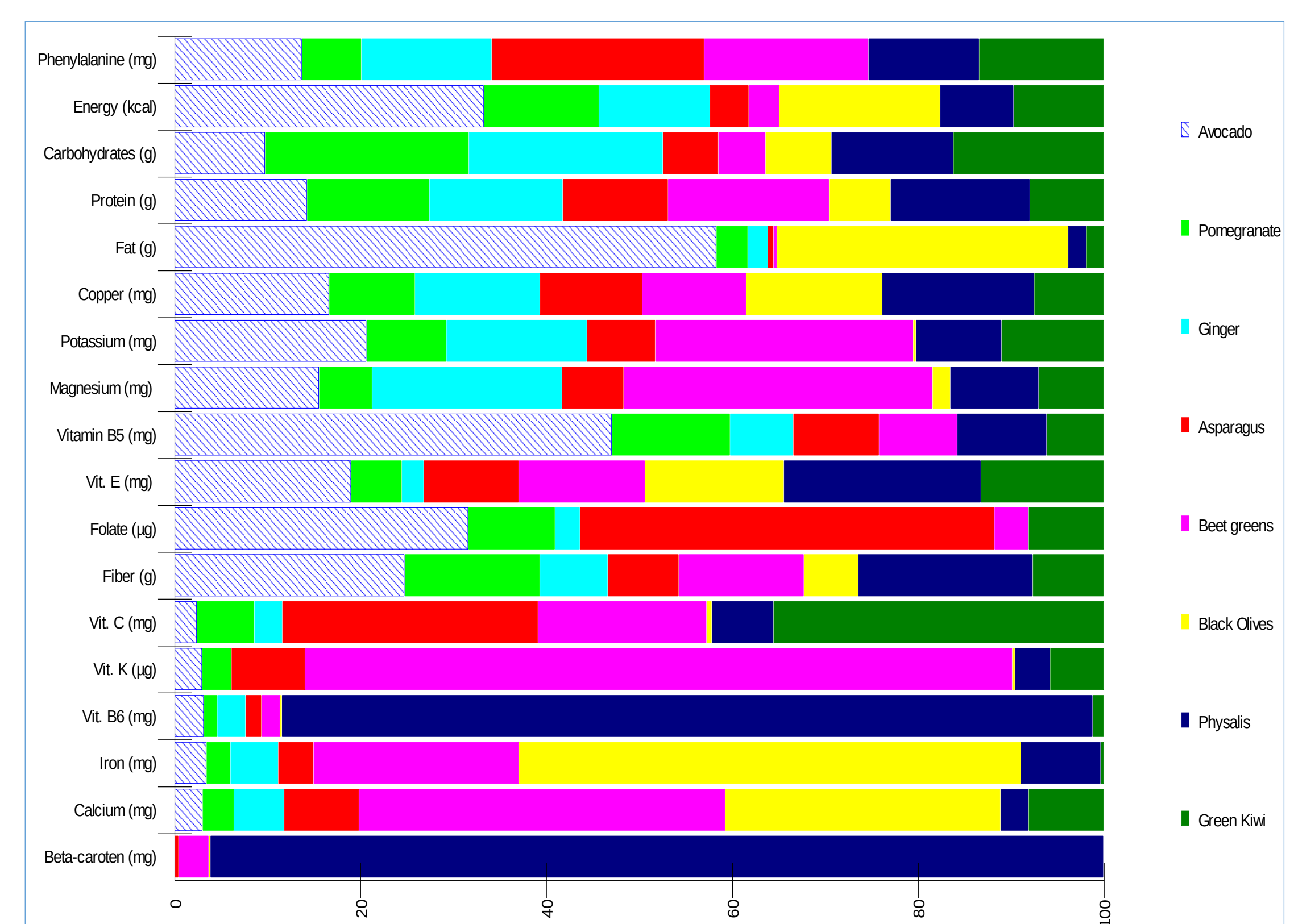


Figure 1. Graphical Fingerprint of Normalized Standardized Data

Copper was identified as the most important micronutrient in this study, and the highest contents were reported for avocado and black olives. For a significant dietary source of copper with comparatively lower lipid content, physalis and ginger represent suitable plant-based options. Although copper and vitamin B12 act through separate metabolic pathways, both are essential for red blood cell formation and neurological function. Maintaining appropriate copper intake can enhance enzymatic activity in response to nutritional imbalances that arise from decreased cobalamin concentration.

Conclusions

The identification of low-phenylalanine plant-based foods (< 75 mg/100 g), such as black olives, avocado, beet greens, asparagus, pomegranate, physalis, and green kiwi, expands safe natural options for individuals with PKU while providing essential micronutrients and bioactive compounds that support metabolic control and antioxidant defense. Based on multiple research studies by combining these foods with fortified medical substitutes can ensure both metabolic stability and nutritional adequacy, reducing common deficiencies and supporting gut and cardiovascular health.