Journal of Health Care and Research
(ISSN: 2582-8967)
Commentary
DOI: https://doi.org/10.36502/2025/hcr.6250

Energy and Nutritional Aspects of Dietary Fiber in Human

Masahiro Bando[1], Hirohisa Urasaki[2], Hiroshi Bando[1,2iD*]
[1]*Tokushima University and Medical Research, Tokushima, Japan*
[2]*Yoshinogawa Hospital, Tokushima, Japan*

Corresponding Author: **Hiroshi Bando** ORCID iD
Address: Tokushima University /Medical Research, Nakashowa 1-61, Tokushima 770-0943, Japan; Email: pianomed@bronze.ocn.ne.jp

Received date: 11 October 2025; **Accepted date**: 19 November 2025; **Published date**: 25 November 2025

Citation: Bando M, Urasaki H, Bando H. Energy and Nutritional Aspects of Dietary Fiber in Human. J Health Care and Research. 2025 Nov 25;6(3):69-71.

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Abstract

Carbohydrates are defined as "sugars + dietary fiber," and dietary fiber has been considered indigestible and therefore provides no energy (0 kcal/g). Much dietary fiber is fermented by intestinal bacteria to produce short-chain fatty acids (SCFAs) such as acetic acid, propionic acid, and butyric acid. These SCFAs are partially absorbed by the host and used for metabolic energy, so dietary fiber contains "available energy". Consequently, dietary fiber is generally classified into 3 groups and converted into energy equivalents, which are non-absorbed fibers as 0 kcal/g, partially fermented fibers as 1 kcal/g, and fairly completely fermented fibers as 2 kcal/g.

Keywords

Short-Chain Fatty Acids, Dietary Fiber, Fermentation, Nordic Nutrition Recommendations

Abbreviations

SCFAs: Short-Chain Fatty Acids

Commentary

Human health depends on regular meals with a proper balance of nutrients. Currently, food research and development have led to the creation of a variety of beneficial foods [1]. Humans evolved from animals, and each organism metabolizes nutrients differently. Carbohydrates include sugars (narrow definition of carbohydrates) and dietary fiber, and this article will introduce topics in these areas.

Carbohydrates are generally defined as "sugars + dietary fiber," and dietary fiber has been considered indigestible and therefore provides no energy (0 kcal/g). However, recent findings have demonstrated that the simplification of categorizing all dietary fiber as "0 kcal/g" is inappropriate. Much dietary fiber is fermented by intestinal bacteria in the large intestine to produce short-chain fatty acids (SCFAs) such as acetic

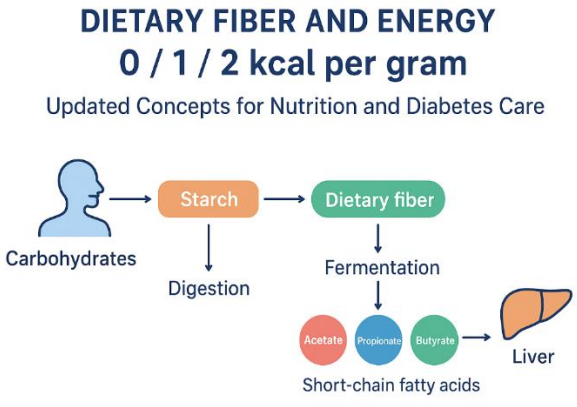

Fig-1: Nutritional mechanism for dietary fiber and energy

acid, propionic acid, and butyric acid [2]. These SCFAs are partially absorbed by the host and used for metabolic energy, so dietary fiber contains "available energy" (**Fig-1**). Furthermore, fermentability varies significantly depending on the type of dietary fiber (agar, cellulose, resistant dextrin, gums, etc.), molecular weight, and soluble/insoluble nature. Then, its actual energy contribution also varies depending on its metabolic or fermentation rate [3].

For this reason, dietary fiber is generally classified into 3 groups and converted into energy equivalents: 1) almost non-absorbed fibers are considered 0 kcal/g; 2) partially fermented fibers are considered 1 kcal/g; and 3) fibers that are fairly completely fermented and some resistant carbohydrates are considered 2 kcal/g. Representative fibers are shown in **Table-1**. The Japanese Food Labeling Standards and the Standard Tables of Food Composition in Japan (8th Edition) indicate that dietary fiber may generally be calculated at 2 kcal/g, using appropriate energy conversion factors depending on the food components and ingredients. This is a convenient approach for labeling purposes. Furthermore, even with the latest revision of the Reference Intakes, there has been much discussion regarding the evaluation and conversion methods for dietary fiber [4]. Then, it is true that differences exist between the composition tables and labeling methods.

Table-1: Three-group classification of dietary fiber for 0, 1, 2 kcal/g

Group	Energy	Fermentation	Food Example	Main Ingredients
A	0 kcal/g	Non	Vegetables, konjac	Cellulose, agar, xanthan gum, gellan gum, polydextrose, low-molecular-weight sodium alginate, psyllium husk
B	1 kcal/g	Partially	Beverages, etc.	Gum arabic, resistant dextrin, indigestible dextrin, beet fiber
C	2 kcal/g	Highly	Fruits, beans	Pectin, guar gum, guar gum enzyme hydrolysate, pullulan, water-soluble soybean dietary fiber (WSSF), heat-moisture-treated starch (resistant starch), wheat germ, tamarind seed gum

From clinical and practical perspectives, the following three points are important. First, the "effective energy" of foods containing dietary fiber may differ from the simple calculation of available carbohydrates alone using the Atwater coefficients (4/9/4). Therefore, when managing diabetic diets and energy, it is necessary to clarify the version of the nutritional information table (7th to 8th revision in Japan nutritional standard table) and the conversion factor used (whether dietary fiber is treated as 0/1/2 kcal). In particular, the cumulative energy differences between oral nutrition, hospital meals, and food nutrition labeling cannot be ignored clinically [5].

Second, we consider the issue from the perspective of diabetes management. The metabolic benefits of dietary fiber, such as suppressing postprandial hyperglycemia (PPH), satiety, and improved insulin sensitivity, seem to be important [6]. However, these benefits should not be evaluated solely on the basis of their energy content. Highly fermentable fiber influences intestinal-hepatic metabolism and hormones (GLP-1, PYY, etc.) via short-chain fatty acids (SCFAs), potentially contributing to insulin sensitivity and appetite control. On the other hand, depending on the material, the energy contribution may be relatively large. Therefore, when using carbohydrate conversions or carbohydrate exchange tables, it is recommended to discuss with your team in advance. In practical use, it is beneficial to have a consistent understanding of available carbohydrates, dietary fiber, and the energy conversion method [7].

Third, the research and public health perspectives are crucial. Health benefits of dietary fiber, such as reduced risk of cardiovascular disease and type 2 diabetes, are supported by numerous epidemiological and intervention studies. As a result, the standard recommended intake for adults would generally be 20–25 grams/day or more. According to the Nordic Nutrition Recommendations 2012 (NNR2012), the ideal amount would be 25 g/d for females and 35 g/d for males [8]. However, the actual intake is remarkably lower, ranging from 16-22 g/d in females and

18-26 g/d in males. New NNR studies confirm the current view that advocating intakes will be at least 25 g/d.

In summary, the following 4 practical checkpoints are useful in practice:

i) Clearly indicate the version of the nutritional information table and the dietary fiber conversion coefficient used in nutrition calculations [9].

ii) When creating a food list for school lunches or outpatient nutritional guidance, note the "type of dietary fiber (soluble/insoluble/fermentable)."

iii) For diabetic patients, prioritize evaluation of "carbohydrates (available carbohydrates)," and treat the energy contribution of dietary fiber as secondary information.

iv) Clearly state the conversion method used in research and reports.

From the above-mentioned points, while dietary fiber cannot be uniformly treated as "0 kcal," a reasonable approach in practice is to treat it as 0 or 1 or 2 kcal/gram depending on the material and purpose.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

Funding

There was no funding received for this paper.

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