Searching for the Definition, Terminology and Classification of Dietary Fiber and the New Proposal from Japan

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The present review refers to the proposal for resolving the confusion on concept of dietary fiber in the world. The working committee established by Japanese Association for Dietary Fiber Research (JDF) in 1997 first overviewed the changes of discussions on the definition, terminology and classification of dietary fiber conducted in different countries since 1972. Further reviewing has been carried out concerning the physiological significance and classification of new indigestible substances appearing year by year with the proceedings of the researches in this field.

Based on the discussions, the committee members agreed that the term “dietary fiber” is inappropriate as a term which covers all indigestible components. The “luminacoids” was designed, as a comprehensive term that covers all such components, including dietary fiber in the conventional meaning. This comprehensive terminology should be classified into starch and non-starch components. Dietary fiber is a major component of non-starch substances and can be sub-classified into polysaccharides and lignin. Thus, the definition of “luminacoids” is proposed as follows: “dietary components which are not digested and/or absorbed in the human small intestine and which exert physiological effect that are useful in maintaining good health via the gastrointestinal tract”.

After presenting the proposal to the Annual Meeting of JDF in 1998 and 1999, it was finally approved at the 6th Annual Meeting in November 2000.

We further describe the significance of new proposal by JDF, and also compare and discuss about these advantages and drawbacks of each revised definition of dietary fiber proposed currently by five international organizations and other investigators.

Key words: luminacoids: dietary fiber: Japanese Association for Dietary Fiber Research

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1. Introduction

This report is published according to the definite policy of Japanese Association for Dietary Fiber Research. To avoid a misinterpretation of "double submission", we want to append the fact here.

Trowell\textsuperscript{1}) first proposed the term "dietary fiber" with physiological meaning for the first time. Although this term had already been used by Hipsley\textsuperscript{2}), Trowell distinguished "dietary fiber" from the term "fiber" which had been used without any clear definition, and the term "crude fiber" which had been conventionally used in analytical chemistry of the animal feeds. Substances covered by the term "dietary fiber" were thought to be the same as those called "unavailable carbohydrate" by McCance and Lawrence\textsuperscript{3}).

Trowell et al.\textsuperscript{4}) proposed that viscous polysaccharides such as pectin and guar gum should be classified as "dietary fiber" because of their physiological activities. They proposed the new definition that dietary fiber consists of the plant polysaccharides and lignin resisting to hydrolysis by digestive enzymes.

Further progress in research resulted in the discovery of many other indigestible ingredients with physiological activity, making it impossible to cover all these substances with such a definition proposed by the group of Trowell et al.\textsuperscript{4}). To deal with this situation, a number of new definitions and terms have been proposed by individuals and organizations including one which proposed that not only plant-derived substances but also animal-derived ones should be included; for example chitin and chitosan and one which proposed that partial hydrolysates of indigestible polysaccharides and synthetic polydextrose should also be included since they have a physiological activity. Furthermore, it has also been proposed to include resistant starch and indigestible dextrin and more recently oligosaccharides in dietary fiber.

Some researchers have proposed that dietary fiber should be defined on the basis of determination methods, while others have opposed to that proposal. Some have also proposed that the definition of dietary fiber should be expanded, but others have even questioned the use of the term "dietary fiber".

Thus, there is no general consensus about the definition or the term "dietary fiber" or the range of substances that are covered by this term.

The Japanese Association for Dietary Fiber Research (JDF) was organized in 1996, and the working group for reviewing the definition, terminology and classification of dietary fiber started its activity, to resolve global discrepancies associated with dietary fiber definition.

Almost in parallel with our work started in 1996, efforts to revise the definition of dietary fiber had been conducted in Australian-New Zealand Food Authority (ANZFA)\textsuperscript{5}), American Association of Cereal Chemists (AACC)\textsuperscript{6}) and National Academies of Science (NAS)\textsuperscript{7}) as well. These organizations proposed the revised definition from 2000 to 2002. The CODEX Committee on Nutrition and Foods for Special Dietary Uses (FAO/WHO)\textsuperscript{8}) is now discussing about the definition, quantitative analytical method and the labeling of dietary fiber to foods. Table 1 was summarized the history in dietary fiber definition.
Table 1 History of Dietary Fiber Definition

<table>
<thead>
<tr>
<th>Personal / Country / Organization</th>
<th>Definition</th>
<th>Ref. No.</th>
</tr>
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<tbody>
<tr>
<td>Trowell HC (1972)</td>
<td>The remnants of the plants cell walls which are not hydrolyzed by digestive enzymes of man.</td>
<td>1</td>
</tr>
<tr>
<td>Trowell HC et al. (1976)</td>
<td>Dietary fiber consists of the plant polysaccharides and lignin which are resistant to hydrolysis by digestive enzymes of man.</td>
<td>4</td>
</tr>
<tr>
<td>Kiriyama S (1980)</td>
<td>All dietary ingredients that are not digested by digestive enzymes in humans.</td>
<td>9</td>
</tr>
<tr>
<td>New Zealand Food Regulations (1984)</td>
<td>Dietary fiber consists of edible plant components which are resistant to hydrolysis by endogenous enzymes of intestinal tract of human and is determined by AOAC method 985.29 (Prosky et al. 1985).</td>
<td>10</td>
</tr>
<tr>
<td>WHO/FAO (1985)</td>
<td>Dietary fiber is easily determined by consensus method and regarded as the constituents of edible animal and plant food being resistant to hydrolysis by proper enzyme in the gastrointestinal tract.</td>
<td>11</td>
</tr>
<tr>
<td>Prosky et al. (1985)</td>
<td>Besides the substances categorized by Trowell et al. (1976), resistant starch and other substances resistant to digestion during food processing are included in the applicable range of AOAC-Prosky method.</td>
<td>12</td>
</tr>
<tr>
<td>Trowell HC (1985)</td>
<td>Dietary fiber is mainly consisted of cellulose, hemicellulose, and pectin like substances, so called regarded as non-starch polysaccharides.</td>
<td>13</td>
</tr>
<tr>
<td>Health and Welfare Canada (1985)</td>
<td>Dietary fiber is the endogenous compounds of plant material in the diet which are resistant to digestion by enzymes produced by humans. They are predominantly non-starch polysaccharides and lignin and may include, in addition, associated substances.</td>
<td>14</td>
</tr>
<tr>
<td>FDA (1987)</td>
<td>Dietary fiber is material determined by AOAC method 985.29.</td>
<td>15</td>
</tr>
<tr>
<td>FDA (1987)</td>
<td>Final residues of plant substances in foods resistant to hydrolysis by human digestive enzyme.</td>
<td>16</td>
</tr>
<tr>
<td>Life Sciences Research Office (1987)</td>
<td>Dietary fiber is the endogenous components of plants materials in the diet which are resistant to digestion by enzymes produced by humans. They described that for analytical purpose, dietary fiber may be defined as non-starch polysaccharides in plant food. Lignin is not a carbohydrate and should not be measured analytically with NSP as dietary fiber. Lignin is quantitatively a minor component in the human diet and is difficult to determine.</td>
<td>17</td>
</tr>
<tr>
<td>Englyst HN and Cummings TH (1988)</td>
<td>A novel fiber source is a food that was manufactured to be a source of dietary fiber and that 1) had not traditionally been used or human consumption to any significant extent, or 2) had been chemically processed (oxidized) or physically processed (e.g., finely ground), so as to modify the properties of the fiber contained in the product, or 3) had been highly concentrated from its plant source.</td>
<td>18</td>
</tr>
<tr>
<td>Health Canada (1988)</td>
<td>Definition of dietary fiber was broadened to include resistant, Maillard reaction products and polydextrose in addition to the category of the Trowell’s definition, 1976.</td>
<td>19</td>
</tr>
<tr>
<td>Gordon DT (1989)</td>
<td>Dietary fiber is substances of plant origin, that cannot be broken down to resorbable components by the body’s own enzymes in the small intestine. Included are essentially soluble and insoluble non-</td>
<td>20</td>
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—13—
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<thead>
<tr>
<th>Author(s) and Year</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Englyst HN and Cummings TH (1990)</td>
<td>Starch polysaccharides (cellulose, pectin, hydrocolloids) and lignin and resistant starch. Substances like some sugar substitutes, organic acids, chitin and so on, which either are not or are incompletely absorbed in the small intestine, are not included. As starch contained as dietary fiber in the AOAC—Prosky method does not directly reflect an amount of starch resistant to digestion by human intestinal enzyme, the opposite opinion to include resistant starch was expressed.</td>
</tr>
<tr>
<td>British Nutrition Foundation (1990) WHO (1990)</td>
<td>The Foundation recommended that scientists should not use the term &quot;dietary fiber&quot; and instead use non-starch polysaccharide. The organization used the term of non-starch polysaccharide in a head concerning dietary fiber intake.</td>
</tr>
<tr>
<td>USDA and US Dept. of Health and Human Service (1990) Englyst HN (1991)</td>
<td>The organization did not use the term of fiber in the dietary guideline. If we do not agree at once the proper chemical definition, the term of dietary fiber would disappear.</td>
</tr>
<tr>
<td>Resources Council, Sciences and Technology Agency, Japan (1992) Belgium (1992) Italy (1993)</td>
<td>Standard Tables of Food Composition in Japan—Dietary Fiber—was published. Dietary fiber contents limited plant foods (227 items) was determined by Prosky—AOAC method (1987). The definition of dietary fiber proposed by Kiriya S (1980) was adopted. Dietary fiber is components of food that are not normally broken down by the body's own enzymes of humans. Dietary fiber is the edible substance of vegetable origin which normally is not hydrolyzed by the enzymes secreted by the human digestive system.</td>
</tr>
<tr>
<td>Lee SC and Prosky L (1994)</td>
<td>Based on the two international questionnaire surveys (144 professionals in 1992, 122 ones in 1993, the representing 30 countries each), expansion of the definition of dietary fiber was proposed to include resistant oligosaccharides, in addition to currently included nonstarch polysaccharides, resistant starch and lignin. However, a part of experts still insists that dietary fiber should include NSP and plant cell wall components only.</td>
</tr>
<tr>
<td>Denmark (1995) Codex Alimentarius Commission (1995)</td>
<td>Dietary fiber is the material isolated by AOAC method 985.29 and 997.08. Dietary fibre is edible plant or animal material not hydrolysed by the endogenous enzymes of the human digestive tract as determined by the agreed upon method/ Codex also approved AOAC method 985.29 and 991.43.</td>
</tr>
<tr>
<td>FAO / WHO (1997)</td>
<td>There are an opinions which the definition of dietary fiber should be regulated by a quantitative method, and non—digestible oligo— saccharide should also be added to dietary fiber. The organization members agreed with the point which NSP is the fundamental component of dietary fiber, but no consensus was obtained as to whether the other components should be categorized in the term of dietary fiber. Some member stated that not only the term of dietary fiber but also ones of soluble dietary fiber and indigestible dietary fiber would be phased out gradually. Dietary fiber is physiologically defined as plant polysaccharides and</td>
</tr>
<tr>
<td>Source</td>
<td>Description</td>
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<tr>
<td>-------------------------------</td>
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<tr>
<td>COMA (1998)</td>
<td>Dietary fibre is non-starch polysaccharide as measured by the Englyst method.</td>
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<tr>
<td>Finland (1998)</td>
<td>Dietary fiber is a part of the carbohydrate obtained when using AOAC 985.29 and AOAC 997.08.</td>
</tr>
<tr>
<td>Norway (1998)</td>
<td>Dietary fiber is the material isolated by AOAC method 985.29 and inulin and oligofructose.</td>
</tr>
<tr>
<td>Topping DL and Bird AR (1999)</td>
<td>&quot;Fiber Equivalent Theory&quot;: A new proposal was presented in place of dietary fiber definition. This new theory can be applied to carbohydrates (resistant starch, resistant oligosaccharides) from any source showing physiological role which are similar to dietary fiber action (fecal weight, improvement of constipation, blood cholesterol lowering, SCFA production, modification of large intestinal microflora).</td>
</tr>
<tr>
<td>Sweden (1999)</td>
<td>Dietary fiber is edible material that cannot be broken down by human endogenous enzymes. Dietary fiber is determined with AOAC 985.29. In addition, the fructan method AOAC 997.08 may be used.</td>
</tr>
<tr>
<td>Devries JW and Faubion JM (1999)</td>
<td>No consensus about the new dietary fiber definition was obtained in the workshop of Carbohydrate Technical Committee for AACC, ILSI and NA, but only the constituent components of dietary fiber was agreed.</td>
</tr>
<tr>
<td>United Kingdom (2000)</td>
<td>Dietary fibre is the material isolated by AOAC method 985.29 and the Englyst method for non-starch polysaccarides.</td>
</tr>
<tr>
<td>FAO / WHO (2000)</td>
<td>Food Design Committee could not agree with the inclusion of animal and other chemically characteristic substances in the dietary fiber definition.</td>
</tr>
<tr>
<td>Australia New Zealand Food Authority (2000)</td>
<td>Dietary fibre that fraction of the edible part of plants or their extracts, or analogous carbohydrates, that are resistant to digestion and absorption in the human small intestine, usually with complete or partial fermentation in the large intestine. The term includes polysaccharides, oligosaccharides (DP&lt;2), and lignin. Dietary fibre promotes one or more of these beneficial physiological effects: laxation, reduction in blood cholesterol, and/or modulation of blood glucose.</td>
</tr>
<tr>
<td>Japanese Association for Dietary Fiber Research (2000)</td>
<td>&quot;The luminacoids&quot; was designed as a new comprehensive term that covers all indigestible components, including dietary fiber in the conventional meaning. The definition of &quot;luminacoids&quot; is proposed as follows: &quot;dietary components which are not digested and/or absorbed in the human small intestine and which exert physiological effect that are useful in maintaining good health via the gastrointestinal tract&quot;.</td>
</tr>
<tr>
<td>AACC (2001)</td>
<td>Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine.</td>
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</table>
In this paper, we will review about the changes in opinions on the definition of dietary fiber in Japan, summary of our re-emerging definition proposed by the JDF and further the significance of the revised definition and the related matters. Finally, we will compare and discuss about the each revised definition of dietary fiber recently proposed by the four organizations.

### 2. Changes in opinions on the definition of dietary fiber in Japan

Before Trowell\(^1\) proposed the term “dietary fiber”, studies on a plasma cholesterol-normalizing effect of indigestible polysaccharides in the Japanese traditional foods such as konjac-mannan, sodium alginate and citrus pectin, had been conducted in Japan. Several researchers had reported that these polysaccharides showed a plasma cholesterol-normalizing effect in rats fed a high cholesterol diet. Thus, Kiriyama\(^3\) had proposed that the physiological effects of these unavailable carbohydrates should be unified under the concept of “nutrition of non-nutrients” in foods.

However, since Trowell\(^1\) proposed the term “dietary fiber”, Japanese researchers readily accepted this term and his definition, but confusion arose because the term was translated into a number of different terms in Japanese like in other countries where a number of synonyms were proposed for dietary fibre. In order to eliminate such confusion, Innami\(^9\) organized an academic conference to discuss on the definition of dietary fiber, as well as related terms and quantitative analytic methods under financial support of Yabuta Foundation. At that conference, he reviewed fiber-related terms used in various countries and reported that there was great confusion about these terms and translations, stressing the need for unifying the terminology. At the conference, Kiriyama (Innami 1980)\(^9\) at first proposed the use of the term “luminacoids” taking into consideration the global confusion at that time. He defined this term as follows, stressing the physiological significance of dietary indigestible components. The generic term “luminacoids” refers to a number of chemically unrelated, complex substances in diet which remain in intact or modified forms at every part of the digestive tract, where it provides pertinent consistencies to

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### Table of Dietary Fiber Definitions

<table>
<thead>
<tr>
<th>Organization</th>
<th>Definition</th>
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<tbody>
<tr>
<td>The national Academies (2001)</td>
<td>Dietary Fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fiber promote beneficial physiological effects including laxataiion, and/or blood cholesterol attenuation, and/or blood glucose attenuation. Dietary Fiber consists of non-digestible carbohydrates that lignin that are intrinsic and intact in plants. Added Fiber consists of isolated, non-digestible carbohydrates which have beneficial physiologic effects in humans. Total Fiber is the sum of Dietary Fiber and Added Fiber. A partial correction of the definition proposed in 2001. Dietary Fiber consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Functional Fiber consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans. Total fiber is sum of Dietary Fiber and Functional Fiber. Dietary fiber means carbohydrate polymers with a degree of polymerization (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerization not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fiber consists of one or more of: 1. edible carbohydrate polymers naturally occurring in the food as consumed, 2. carbohydrate polymers which have been obtained from food raw material by physical, enzymatic or chemical means, 3. synthetic carbohydrate polymers.</td>
</tr>
<tr>
<td>The National Academies (2002)</td>
<td>21</td>
</tr>
<tr>
<td>Codex Alimentarius Commission (2005)</td>
<td>7</td>
</tr>
</tbody>
</table>

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1. Trowell
2. Dietary Fiber
3. Konjac-mannan, sodium alginate and citrus pectin
4. Dietary Fiber
5. Added Fiber
6. Total Fiber
7. Functional Fiber
8. Dietary Fiber
9. Innami
10. “luminacoids”
the chyme and stool, makes site-specific interactions possible, and serves for normal digestive functions].

However, as Innami stressed the need for global standardization, the conference decided to adopt Trowell’s term “dietary fiber”, and also a direct Japanese translation of it, “Shokumotsu Sen-i” which Kiriyama had already proposed and personally used.

The discovery of serum cholesterol-lowering effects by chitosan, leads to a proposal that dietary fiber should not be limited to plant-derived substances. Kiriyama proposed the more broadened definition including animal-derived substances as well: “all dietary ingredients that are not digested by digestive enzymes in humans”. This definition has been generally accepted in Japan. In the Standard Tables of Food Composition in Japan edited by the Resources Council, the Science and Technology Agency, Japan used the modified method of Prosky et al. and adopted Kiriyama’s definition.

The first meeting of global scope in Japan, the Kellogg International Symposium on Dietary Fiber, Tokyo was held in Tokyo on August 18, 1989. This Symposium was organized by Chen S., Innami S. and Oku T. and chaired by Hosoya N. brought together over participants in the field including such internationally recognized authorities as Anderson JA., Cummings JH., Eastwood M., Kritchevsky D., Marlett JA., Oku T., Sugano M. and Kiriyama S.

In 1989, the Dietary Fiber Study Group was organized by Kiriyama S. and sponsored by Otsuka Pharmaceutical Co., Ltd. This group held annual meetings for 7 consecutive years from 1990 to 1996. Since this group had only a small number of researchers, it was pointed out that a larger number of researchers should be invited to join. JDF was formally launched in June 1996 (Japanese Association for Dietary Fiber Research).

Innami S. was elected as the first chairman. The JDF organizes a scientific meeting and an open lecture meeting once a year and issues both an association journal and newsletter twice a year. In addition, it operates the following working groups in order to review and resolve various problems related to research and technology in the field of dietary fiber: Committee for the Definition, Terminology and Classification of Dietary Fiber, Committee on Analytical Methods, and Committee on Project Groups.

3. Proposals by the Committee for the Definition, Terminology and Classification of Dietary Fiber

This committee summarized discussions on the definition, terminology, classification and physiological significance of dietary fiber conducted in different countries since 1972. As a result, members reached a consensus on the following:

1) The term “dietary fiber” should be retained because the tentative dietary goal in Japan has been set for dietary fiber which is a major component of indigestible ingredients and people are encouraged to take it daily.

2) Greater confusion will be caused if low molecular weight compounds such as sugar alcohols and indigestible oligosaccharides (degree of polymerization: 2 to 9) and substances such as resistant starches and proteins are classified into dietary fiber even if these substances have physiological functions similar to those of dietary fiber.

Sugar alcohols should be classified into poorly digested and/or absorbed groups.

3) It should not be defined based on a single analytical method. An analytical method that enables precise measurement should be applied to each substance according to the classification system; there is no single analytical method that can be applied to all components of dietary fiber.

4) The terms of “water-soluble”, “water-insoluble,” “fermentable” and “non-fermentable,” which describe the attributes of individual indigestible components, are inappropriate for use in general classification.

Based on the discussions, the committee members agreed that indigestible ingredients are classified into starchy and non-starchy components from chemical viewpoints and that constituents are further sub-classified as shown in Fig.1. They also agreed that the use of the term “luminacoids” proposed personally once by Kiriyama would be useful in eliminating discrepancies associated with the term “dietary fiber”. A proposal prepared based on these discussions was presented to the Annual Meeting in 1998 and 1999 and modified based on active discussions by the participants and opinions and comments received from academic members of JDF. The final proposal was approved at the 6th Annual Meeting of JDF in November 2000.
The outline of the approved proposal is as follows:
1) The definition should cover all indigestible dietary components and be established as follows by modifying the proposal presented by Kiriyama: "dietary components which are not digested and/or absorbed in the human small intestine and which exert physiological effects that are useful in maintaining good health via the gastrointestinal tract."
2) As the term "dietary fiber" is inappropriate as a term that covers all indigestible components, "luminacoids" is proposed as a comprehensive term that covers all such components, including dietary fiber in the conventional meaning.
3) Components which are covered by this comprehensive terminology should be classified into starchy and non-starchy components. Dietary fiber is a major component of non-starchy substances and can be sub-classified into polysaccharides (plant-derived, animal-derived, microbial or chemically modified) and lignin.
4) The others correspond to the substances which were called "dietary fiber complexes" by Trowell et al. and dietary fiber-like food components by Southgate.

4. Significance of the JDF's revised definition

The definition and terminology by JDF have many advantages compared with others as follows.
a) "Luminacoids" is a new comprehensive terminology which covers dietary fiber and all other indigestible components with physiological effects and it is not a substitute for the term "dietary fiber".
b) The current confusion regarding the many other definitions after proposal of the concept of dietary fiber can be avoided.
c) It has been questioned whether the term "dietary fiber" should be used for low molecular weight components such as poorly digested or absorbed sugar alcohols or indigestible oligosaccharides. The proposal eliminates this question.
d) The description and/or expression on the food composition table and food labeling are not restricted by the new term "luminacoids" itself.

5. Involvement with food labeling

The Japanese Ministry of Health, Labor and Welfare (MHLW) enforced a system "Food for Specified Health Use (FOSHU)" based on the Nutrition Improvement Law in 1991. This was set up as the regulation system to approve statements contained on a label regarding the effects of foods on the human body.

The labeling on health claim of three physiological
functions is permitted under the present regulation system. The health claims on dietary fiber and related compounds are as follows: (1) improvement of gastrointestinal condition (dietary fiber, indigestible oligosaccharides, resistant dextrin and polydextrose), (2) suppression of blood cholesterol elevation (dietary fiber and resistant dextrin), (3) suppression of blood glucose elevation (dietary fiber and resistant dextrin).

The labeling of related compounds in FOSHU is obliged and put by the certified mark. While, to claim the functionality of indigestible oligosaccharides and dextrin, food manufactures are apt to distinct to original dietary fiber on the labeling.

Considering to the present situation of food labeling like this, it may not be adequate (reasonable) to involve all indigestible food compounds into the category of dietary fiber, because it is difficult to distinguish the function of dietary fiber from the specific compounds with lower molecular weight and to be fear to confuse the consumers.

Here, “luminacoids” was proposed as the classificatory term from an academic aspect, by that food labeling will not be restricted by this term.

6. Determination of “luminacoids” constituents

Among the luminacoid constituents, the main components which are necessary to be entered in the food composition table and the food labeling are determined by the following methods which have been already established.

1. Dietary fiber

Dietary fiber is a major compound which constitutes luminacoids and consists of non-starch polysaccharides and lignin. It can be principally determined by the AOAC method 991.43(45), with the exception of a part of components such as inulin and oligo-fructan from plant origin or polydextrose.

2. Oligo-fructan, inulin and fructo-oligosaccharides

Determined by AOAC method 997.08(47) and 999.03(48).

3. Polydextrose


4. Resistant starches

Determined by AOAC method 2002-02; AACC 37.42(50) showing consistent with in vivo data.

5. Resistant malto-dextrin

Determined by enzymatic-gravimetric method and liquid chromatography(6).

7. Comparison of the five new definitions and classifications

As mentioned above, four organizations presented the reports in relation to revisions of the definition and classification of dietary fiber almost at the same time. All of these proposals are intended to eliminate confusion due to the lack of a standard definition in each country and are based on the progress of research on dietary fiber and changes in its definition for the past 30 years. These proposals also reflect the results of discussions by their expert committee members.

The revised definitions of ANZFA(5) and AACC(6) include the same food components as those included in the historical definition that has been used over the past 30 years and is based on plant origin fiber. The AACC(6) classified dietary fiber into 4 groups and included indigestible oligosaccharides and non-starch polysaccharides in the same group (Group 1). AACC(6) proposed the term “analogous carbohydrates” to the group: indigestible dextrins, synthesized carbohydrate compounds and resistant starches (Group 2). The AACC(6) also listed lignin (Group 3) and substances associated with the non-starch polysaccharides and lignin complex in plants (Group 4).

NAS(7) proposed the new definition that dietary fiber consists of natural indigestible carbohydrate and lignin in plants, and that functional fiber (former name, added fiber) consists of indigestible carbohydrate isolated from plant- and animal-derived foods, modified or synthetic polysaccharides and oligosaccharides (degree of polymerization:3 to 9). The “total dietary fiber” is assigned to the sum of the dietary fiber and the functional fiber.

In contrast, the JDF(37) did not agree to expand the definition of dietary fiber to include oligosaccharides and decided to limit the range of dietary fiber to animal- and plant-derived and microbial polysaccharides, and modified or synthetic polysaccharides, and lignin. Thus, the JDF(37) proposed the new comprehensive term “luminacoids” to include all oligosaccharides (degree of polymerization:2 to 9 ), sugar alcohols, resistant starches, indigestible dextrins,
resistant proteins and other components in addition to dietary fiber above described.

In the definitions by ANZFA\textsuperscript{5} and AACC\textsuperscript{6}, physiological functions were limited to, 1) suppression of blood glucose elevation, 2) decrease in blood cholesterol levels and 3) improvement of constipation. One of the main characteristics of the new definitions by both the organizations was that it specified groups of substances which are classified as dietary fiber and clearly described their physiological functions. Further, NAS\textsuperscript{7} also picked up the three physiological functions based on the scientific evidence in humans, which are similar to those of the revised definitions by ANZFA\textsuperscript{5} and AACC\textsuperscript{6}. However, JDF (2003)\textsuperscript{3} did not limit the physiological functions.

All of the four definitions accord with the point covering food components which are resistant to human digestive enzyme and which have beneficial effects on human health. However, the four definitions differ from each other in term of the range of indigestible components classified as dietary fiber and their physiological effects. Three organizations except for JDF\textsuperscript{3} selected to expand the definition of dietary fiber in order to more effectively deal with problems related to food labeling. In contrast, JDF\textsuperscript{3} decided to abandon its conventional definition that included all indigestible components and to adopt a more restrictive definition. In addition, NAS\textsuperscript{7} and JDF\textsuperscript{3} stated that dietary fiber should not be classified into water-soluble and insoluble ones and that the definition should not be based on a single quantitative method. Whereas, the ANZFA\textsuperscript{5} and AACC\textsuperscript{6} recommended the AOAC\textsuperscript{46)-certified method and its modifications saying that they are fully applicable to the analysis of dietary fiber. This means that the ANZFA\textsuperscript{5} and AACC\textsuperscript{6} accept the water-soluble and insoluble classification, and their attitude differs from that of NAS\textsuperscript{7} and JDF\textsuperscript{3} in this respect.

The four organizations' views differ slightly from each other regarding the degree of polymerization of oligosaccharides which are necessary for them to be classified into dietary fiber. Furthermore, JDF\textsuperscript{3} only classify poorly absorbed or digested sugar alcohol into the definition "luminacoids", but all three of the other organizations do not classify into dietary fiber.

Differences and similarities of the definition, terminology and classification of dietary fiber recently proposed by four (essentially three) organizations are summarized above. As shown in the above comparison, a consensus had not been reached among different countries in many aspects even in 2002. It goes without saying that the definition of dietary fiber should be standardized in order to ensure greater international harmonization regarding nutrition labeling. It is also necessary to establish standardized quantitative methods for components classified as dietary fiber in order to establish useful databases for food composition.

The term proposed by NAS\textsuperscript{3}, "functional fiber", is questionable. Originally, the term "dietary fiber" itself was proposed to indicate substances with functional characteristics. The term "functional fiber", which refers to only isolated or purified substances, neglects or weakens the functionality of dietary fiber, and is inappropriate and self-contradictory. It also presents problems from the viewpoint of food labeling.

The term proposed by JDF\textsuperscript{3}, luminacoids, also required further discussions. The question is whether the definition is flexible enough to allow major food components required to be labeled to fully exert their characteristics. Further discussions are necessary from this viewpoint.

On the other hand, Champ et al.\textsuperscript{52} in EU area (France, Sweden, Belgium and Netherlands) recently published their own review in relation to the adequate labeling of dietary fiber on foods and the quantitative analysis of dietary fiber to guarantee that. Since the term dietary fiber has been generally accepted to be synonymous as "indigestible carbohydrates" or "non-digestible carbohydrates", they considered that the term "indigestible carbohydrates" or "non-digestible carbohydrates" is much preferable and the term is more scientific than the popular term "dietary fiber", and also may be less confuse for consumers who image dietary fiber as fibrous components in cereal bran and plant foods. Considering recent expansion of dietary fiber definition, they suggested that the three components of non-starch polysaccharides (NSP), resistant starches and resistant oligosaccharides are included in this category and the sum of them could be regarded as the total amount of dietary fiber. And also they stated that the measurement of three compounds is performed by an each different adequate method or AOAC method (AOAC 985.29, 991.43)\textsuperscript{45,46} of dietary fiber and by simultaneously adding
the analytical data of different non-digestible oligosaccharides. Thus, this procedure may be able to present the more detailed constituent of non-digestible carbohydrates for food labeling. EU group is likely to have a tendency still to hold the limited definition of dietary fiber.

Since the 24th session of Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU), the working group on dietary fiber of CODEX Committee was requested to draft a working document including proposals for definition, method of analysis and conditions for nutritional claims on fiber content, in order to facilitate the discussion. The 27th session on Nov. 2005\(^5\) has discussed in detail the definition of dietary fiber. The definition of dietary fiber proposed at the session was as follows: Dietary fiber means carbohydrate polymers with a degree of polymerization (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerization not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fiber consists of one or more of:

- Edible carbohydrate polymer naturally occurring in the food as consumed,
- Carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means,
- Synthetic carbohydrate polymers.

Dietary fiber generally has properties such as:

- Decrease intestinal transit time and increase stool bulk
- Fermentable by colonic microflora
- Reduce blood total and/or LDL cholesterol levels
- Reduce post-prandial glucose and/or insulin levels

With the exception of non-digestible edible carbohydrate polymers naturally occurring in foods as consumed where a declaration or claim is made with respect to dietary fiber, a physiological effect should be scientifically demonstrated by clinical studies and other studies as appropriate. The establishment of criteria to quantify physiological effects is left to national authorities.

The Committee listed up and discussed the AOAC 991.43 method\(^4\) and the other methods for the dietary fiber determination. The Committee is now discussing, though not yet being agreed, about the definition, terminology and classification proposed from each country.

In summary, we think that our JDF (2003)\(^3\) proposal may largely attribute to give a great help for the theoretical readjustment of the contents discussed in the Committee.

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食物繊維の定義・用語・分類の探索と日本からの新たな提案

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和文要旨

本論文は国際的な食物繊維の概念をめぐる混乱を解決するための提案に関するものである。日本食物繊維研究会では1997年に検討部会を発足させ、1972年以降に外国で採用されてきた食物繊維に関する定義、用語、分類に関する誤識の変遷についてまとめた。さらに、この分野における研究の発展に合わせて、新たな不消化成分の生理的意義や分類に関しても検討を行ってきた。

こうした議論を踏まえて、部会メンバーは食物繊維という言葉は全ての不消化成分を包括する言葉としては適切ではないという考えで一致した。ルミナコイド（luminaoids）は、これまで使われてきた食物繊維も含めてすべての不消化成分を含むする包括的な言葉として捉えられたものである。この包括的用語はさらにでんぷんと非でんぷん成分に分類される。食物繊維は非でんぷん物質の主要な成分であり、さらに多糖類とトグニンに細分される。最終的に、ルミナコイドの定義は次のように提案する：ヒトの小腸内で消化・吸収されにくく、消化管を介して健康の維持に役立つ生理作用を発現する食物成分。

1998，1999年の日本食物繊維研究会学術集会において提案され、2000年11月の第6回学術集会において最終的に合意された。我々はさらに日本食物繊維研究会に新たな提案の意義を検討し、最近5つの国際的組織や他の研究者から提案されている食物繊維の定義の利点や問題点について比較検討した。