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Nata as a source of dietary fiber with numerous health benefits

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ABSTRACT

In recent years, the general public's perception of modern diets and human health has shifted dramatically. Changes in lifestyle make people prefer fast food that is poor in nutrients, especially dietary fiber. Lack of dietary fiber is one of the contributions to the increasing prevalence of non-communicable diseases, such as hypercholesterolemia and cancer, among the public. For this reason, efforts to introduce fiber-rich functional foods need to be encouraged. Nata, which is a high-fiber food made from organic plant sources, can be used as an alternative source of fiber for the community. It is hoped that this article will provide some insight into alternative sources of dietary fiber that can be produced by members of the community on their own.

INTRODUCTION

Sustainable development goals (SDGs) number 2 is to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture [1]. Health care is a necessity so that the state can empower the potential of human resources. Currently, the modern food industry is being focused, among others, on various types of beverages and functional foods, which are aimed at increasing the nutritional value, and especially to obtain the health benefits of these products [2]. Diets high in fiber, such as cereals, nuts, fruits, and vegetables, are beneficial to health because their consumption has been linked to a lower incidence of several diseases [3].

One source of dietary fiber is nata. Nata in Spanish is literally defined as cream, such as nata de coco, which means the cream of coconut water. Nata was originally known as nata de coco, but it now comes in a variety depending on the source of the raw material. Nata de coco is composed of millions of fine cellulose threads, which eventually appear solid white to transparent and are referred to as nata. The dietary fiber content in nata de coco is beneficial to the body because it is required and important for digestion.

Nata is beneficial not only as a source of dietary fiber, but also as a wound healer. Nata de coco, for example, can be further processed into a new material that is very strong, heat resistant, as well as flexible and can even transmit light. In a study, one of the products that may be produced is the monitor screen [4]. Nata de coco is a conductive polymer with a conductivity of 553 S/cm that exhibits excellent mechanical stability [5]. In this review, we will focus exclusively on the health benefits of nata as a source of dietary fiber. Additionally, various natas derived from a variety of raw materials will be discussed.

HISTORY OF NATA

Nata was first introduced in the Philippines in 1973 as nata de coco in an attempt to utilize coconut water waste and preserve it as a jelly-like substance. Nata de coco (alternatively marketed as "coconut gel") is a chewy, translucent, jelly-like food made from coconut water that gels due to *Acetobacter xylinum* producing bacterial cellulose (BC). Nata de coco is primarily made from coconut water, and as a result, it has a low nutritional profile. However, because it is made of cellulose, it is high in dietary fiber. Cellulose (Figure 1), being the most important component of plant cell walls, is a polysaccharide with the formula $(C_6H_{10}O_5)m$ which is composed of thousands of (1→4) linked β-D-glucose units [6]. During the 1990s, nata de coco became very popular in Japan. Nowadays, it can be found in a variety of different flavors and shapes, and while it can be eaten raw, it is most often used to make refreshing fruit salads, yogurts, ice cream, and beverages as an ingredient.

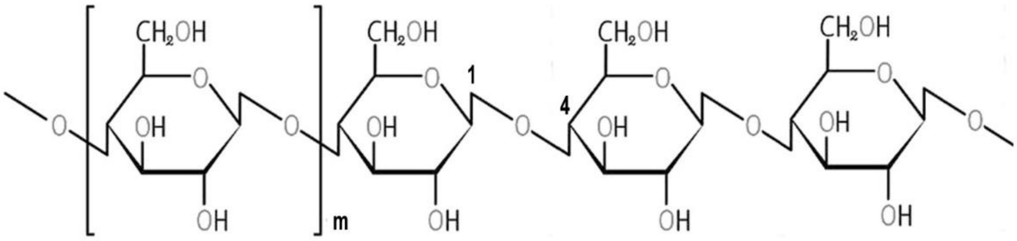

Figure 1. The structure of cellulose (m = 2,000 - 26,000). Each monomer unit is β-D-glucose, and each beta acetal link connects the carbon atom 1 of one glucose to the carbon atom 4 of the next glucose.

VARIOIUS TYPES OF NATA

Nata's main final product is cellulose. As is the case with other microbial products, carbon and nitrogen are the primary ingredient as a source of nutrients for microbes. Additionally, vitamins and minerals, collectively referred to as trace elements, are added in trace amounts to promote the growth of microbial cells and the formation of the desired product. *A. xylinum* is the microorganism responsible for converting these nutrients into BC.

Various fruit-based carbon sources can be used to make nata. Various natas have been developed successfully, including nata de piña. This nata can be made from pineapple juice or pineapple peel waste juice. Typically, pineapple peel waste is only used as animal feed. To add economic value to pineapple peel waste, it can be used as a raw material in the production of nata. Nata de coco piña is another nata product that we developed, which is made from coconut water waste and pineapple peel waste (Figure 2). Figure 3 illustrates the nata de coco piña processing. Essentially, the process of making nata is similar, as it utilizes *A. xylinum*, a cellulose-producing bacteria. The only difference is in the organic raw material sources and the amount of sugar and ammonium sulfate used. Table 1 shows the proximate analysis of nata de coco piña. When it comes to the proximate analysis, the sources of organic matter and the amount of sugar used as a starter are important factors to consider. These materials will also determine the thickness and organoleptic features of the resulting nata.

Nata de soya is made from liquid waste generated during the tofu manufacturing process. This waste is the primary by-product of the tofu manufacturing process and has the potential to pollute the environment. Nata de banana is made from banana peel waste. Cocoa bean pulp can be processed into nata de cacao. Nata de cassava is made from tapioca liquid waste. Nata de pinata is made from palm sap. Nata de cane is made from waste sugarcane stalks left over from bud chips which are often wasted, which actually contains a fairly high juice content. Nata de seaweed is made from any kind of seaweed, for example *Eucheuma cottonii*. With these examples, different types of nata can still be created from other organic wastes.

Table 1. The proximate analysis of nata de coco piña.

Parameter	Concentration (%)
Water content	96.71
Protein	0.33
Fat	1.53
Crude fiber	0.93
Carbohydrate	0.59
Calories	17.36
Phosphor (P)	0,01
Sucrose	0.44
Iron (Fe)	1.26 (ppm)
Calcium	153.95 (ppm)

Figure 2. Nata de coco piña.

Figure 3. The flowchart of nata de coco piña processing.

DIETARY FIBERS

Dietary fiber is a part of plants that can be eaten but cannot be digested by human digestion, but can only be digested or processed into simpler products by bacteria found in the large intestine. Dietary fiber is composed of cellulose, non-cellulosic polysaccharides such as hemicellulose, pectic substances, gums, and mucilages, and lignin, a non-carbohydrate component [3]. Fiber is classified into the following two types based on its solubility in water: insoluble fiber and water soluble fiber. Soluble and insoluble fiber content varies among plant foods, with different properties [7].

Soluble fiber is a type of fiber that dissolves easily in water and generates viscous gels. They are not digested in the small intestine but are readily fermented in the large intestine by the microbiota [8]. Soluble fibers can be found in plant cell walls; among others are arabinoxylans (AX), β-glucans, some hemicelluloses, pectins, gums, and inulin [9]. Soluble fiber is usually found in fruits.

Insoluble fibers do not dissolve in water in the human gastrointestinal tract, so they do not form gels, and are also rarely fermented by the intestinal microbiota [8]. Insoluble fiber is commonly found in tough plant cell walls. Among these are cellulose, hemicelluloses, lignin, and resistant starch [9]. Insoluble fiber is found in whole grains, fruit skins, cucumbers, tomatoes, rice husks (most commonly brown rice), legumes, and beans [10].

HEALTH BENEFITS OF DIETARY FIBERS

Dietary fiber is essential for human health. However, current intake levels of fibre and fiber-rich foods are still far below recommended levels in the majority of countries around the world [11]. Increasing the intake of dietary fiber has been recommended by a number of health organizations, with specific recommendations of 25-30 grams per day. In recent years, there has been an increase in interest in functional foods that can adjust body function and prevent civilizational lifestyle diseases [12]. Dietary fiber is essential for maintaining a healthy digestive system. The deficiency of fiber is especially relevant in light of the astonishingly high incidence rates of colon cancer in urban societies [13,14].

Dietary administration of fiber changes the niche environment in the gut by providing nutrients and substrates for microbiota growth, which allows microbiota that are able to utilize these nutrients to multiply and spread throughout the body [15]. The low administration of dietary fiber not only suppresses the diversity of microbiota in the digestive tract, but also shifts the metabolic pattern of the microbiota towards the use of substrates that are not in accordance with the benefits of these microbiota (16). This event will in turn disrupt the host's metabolism, which will lead to metabolic disorders that have an impact on host health disorders.

Increased insoluble cereal fiber intake resulted in a considerable improvement in whole-body glucose elimination, leading to an 8% increase in insulin sensitivity [17]. Additionally, insoluble fiber may result in a decrease in appetite and food intake [18]. Insoluble fiber speeds up the flow of food through the digestive tract, resulting in smoother bowel movements [19]. In large prospective cohort studies, ingestion of insoluble cereal dietary fibre has been linked to a lower risk of type 2 diabetes mellitus development (20). Increased whole-grain intake is associated with a decreased risk of various diseases, including coronary heart disease, cardiovascular disease, stroke, respiratory disease, and infectious disease, according to a meta-analysis of prospective cohorts [21-23].

HEALTH BENEFITS OF NATA DE COCO

Nata is a source of insoluble dietary fiber due to its cellulose content. Nata de coco contains about 98% water, 0.2% fat, 0.012% calcium, 0.002% phosphorus, 0.0017% vitamin B3, 51 mg/g sodium, potassium 280 mg/100 g, and 2.46 mg/100g vitamin C. This product has a high fiber content, including cellulose (2.5%), hemicellulose, lignin, and soluble fiber [24,25]. Components of chemical compounds contained in nata de coco include: hexadecanoic acid (7.58%), benzeneacetic acid (7.73%), 22-hydroxyhopane (3.96%), tetradecanoic acid (3.84%), 9-octadecenoic acid (3.65%), ϱ-cresol (3.50%), 9-octadecenamide, (Z) (3.00%), phenol, 4-(2-aminoethyl) (2.73%), dodecanoic acid (2.21%), pentadecanoic acid (1.79%), 1-heptadecanecarboxylic acid (1.64%), indole (1.79%), hydrocinnamic acid (1.60%), heptadecanoic acid (1.54%), dan cyclohexanecarboxylic acid (1.47%) [26].

A functional food refers to a food product that contains nutrients but also has the potential to provide additional health benefits, either an improvement in one's health and well-being or a decrease in the risk of contracting disease [27]. With regards to this definition, nata can be classified as a functional food. The following describes the health benefits of nata as a functional food.

Control of biological functions

Hexadecanoic acid (palmitic acid) is a 16-carbon long-chain saturated fatty acid. It is the most abundant saturated fatty acid in the human body, accounting for between 20% and 30% of total fatty acids. At the cellular and tissue level, palmitic acid performs a variety of fundamental biological functions [28]. In a study, BC inhibits α-amylase significantly in an in vitro chyme model. Additionally, it is capable of adsorbing significant amounts of glucose via its binding to glucose molecules. Thus, BC has the ability to regulate blood sugar levels and can be used as a dietary supplement for patients with hyperglycaemia [29]. BC also plays an important role in increasing cellular adhesion, hence contributes to tissue re-epihelialisation [30].

Antifungal and antimicrobial properties

Nata is rich in a variety of fatty acids (FAs). FAs have been shown to be extremely promising for development as next-generation antibacterial agents for the treatment of a broad spectrum of bacterial infections [31]. Benzeneacetic acid (phenylacetic acid) is well-known for its antifungal properties [32-34]. This compound possesses a broad antimicrobial spectrum and inhibited the growth of several soil-borne phytopathogenic fungi completely [33]. Tetradecanoic acid and hexadecanoic acid have antimicrobial activities against multidrug-resistant bacteria [35].

Wound dressing

Bacterial cellulose, a naturally occurring gelly-like substance produced by *A. xylinum*, is widely used in wound dressings due to its high water-holding capacity and mechanical strength [36]. Wound dressings can help to speed up the healing process of the wound by increasing the permeability and protection of the new tissue [37]. Bacterial cellulose has also been used as an alternative carrier of C_{60} (an effective photosensitizer for photodynamic therapy) in the form of a multifunctional wound dressing in the treatment of skin cancer [38].

Contribution to the control of plasma cholesterol levels

Tetradecanoic acid (myristic acid) is a long-chain saturated fatty acid composed of 14 C atoms. This acid is first extracted from the nutmeg plant. It is related to low plasma HDL cholesterol levels in the Mediterranean population [39]. In hypercholesterolemic women, nata de coco consumption can lower total cholesterol levels in the blood [40].

Contribution to cancer cure and prevention

According to the findings of a large number of epidemiological and experimental studies, dietary fiber may play an important role in colon cancer prevention [41]. In several studies it is said that BC is a suitable material in treating various cancers due to its ability to absorb and deliver drugs [42]. Furthermore, according to the findings of a study, BC-*Garcinia mangostana* extract has the potential to be used as an anti-breast cancer biofilm candidate in the future [43]. As a result, there is still room for advancement of nata in terms of its potential contribution to cancer cure and prevention.

CONCLUSIONS AND FUTURE PROSPECTS

Nata, a jelly-like substance, is a product of fermentation by the bacterium *A. xylinum*. Nata is primarily composed of cellulose, an insoluble fiber. Insoluble fiber has many health benefits, including facilitating bowel movements, reducing the risk of heart disease, cancer, and diabetes, and lowering cholesterol levels in the blood. This nutritious food can be utilized as a functional food, and it is simple to make in the community by repurposing organic waste resources. Nata can be fortified with the addition of vitamins and a variety of other key nutrients, enhancing its potential as a functional food by providing additional health advantages (Figure 4).

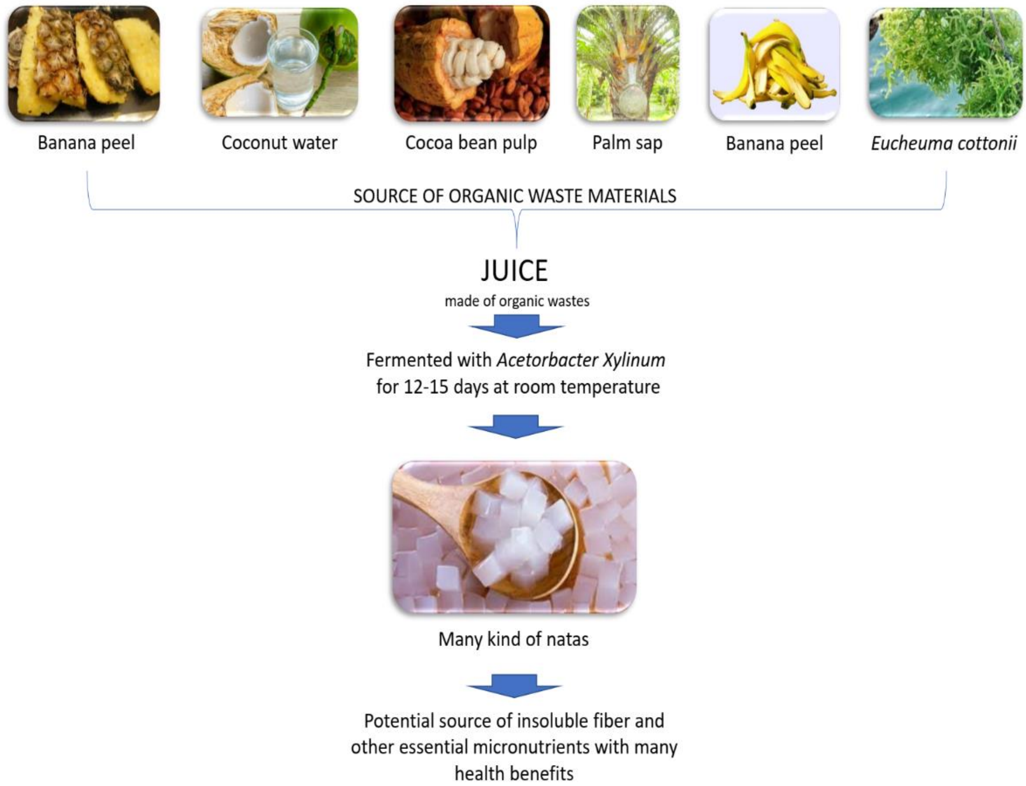

Figure 4. Schematic diagram of summary of the study. Juice made of organic wastes is subjected for fermentation with *A. xylinum.* These provide various kinds of natas. These natas are the potential sources of insoluble fiber and other essential micronutrients with many health benefits.

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AUTHOR CONTRIBUTIONS

TET, F and ASS were involved in conception and design of the experiments. AHA, AADPA, NP, PSA and SM contributed to perform the experiments. TET, F, ASS and

TBE contributed to drafting the article. TET and TBE contributed to revising it critically for important intellectual content. TET and TBE made the final approval of the version to be published.

CONFLICTS OF INTEREST

There is no conflict of interest among the authors.

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