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Maria Teresa Pedrosa Silva Clerici
Editor

Bread Consumption and Health

Food and Beverage Consumption and Health

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MARIA TERESA PEDROSA SILVA CLERICI
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PREFACE

Bread is a food of great acceptance worldwide. It is present in all continents and the habit of consuming it does not depend on social class, because it is produced with different formulations, shapes and sizes, which results in products with varying prices and attractive to the consumer.

Following the human evolution and resisting through the ages, bread can get into the category of products of high longevity, because as far as is known, it never stopped being consumed. The transformation of the baking area over time is one of the most successful commercially. The artisanal product, with low productivity and without quality forecast, became an industrial product produced by different processes, including the continuous process, which has a high production capacity.

Nowadays it is a product that has a high technological quality, with stringent control of raw materials and equipment, resulting in a forecast of quantity and quality of production, which are important for the baking industry and the consumer.

Bread has always shown great economic, political and religious relevance in history. The beginning of the wheat industry has occurred with the realization that this was a noble cereal, with special proteins, capable of forming breads and pastes appreciated for alimentary consumption. Countries from continents with long winter and favorable soil and climate conditions, have invested in wheat production and in the respective industrial applications of its flour. Thus, the excess production of wheat by these countries has led to strategies for extending the use of wheat flour in non-producing countries. The success of this strategy has led to the globally diffused habit of bread consumption, with non-producing countries importing wheat to meet the market demand and creating new businesses such as bakeries and milling industries. The price of wheat has a great influence in the global economy. Foreseeing an increasing dependence, many countries perform genetic research in order to adapt wheat to their conditions; other countries make programs for use of wheat flours mixed with other cereals or tubers.

The wheat industry hardly shows economic crisis, except for agronomic factors that are difficult to control, because it is one sector that always follows the growth of worldwide population and is highly structured to meet the global demand of these commodities.

With the easiness of globalization, bread obtained with wheat has become present in several meals every day. Nutritionally, it is considered a major source of carbohydrates. Because of the high consumption, the amount of protein ingested is important for the diet. The bread obtained from wheat provides fast-digesting carbohydrates for the diets, but it has limiting amino acids such as lysine and tryptophan. In light of such aspects, it is necessary the supplementation or even the formulation with other protein sources, aiming to promote the essential amino acids capable of complying with the requirements of FAO.

With the industrial expansion of fast-foods, snacks and other foods of easy consumption, and the decrease in high-fiber foods and foods with slow-digesting carbohydrates, there is a strong global trend to weight gain, with an increase in cases of morbid obesity whose consequences are increased risks to health and concomitant appearance of non-transmissible chronic diseases like diabetes, hypertension, heart diseases and cancer.

The researches and the market have focused on marketing of new products with benefits to health, i.e., in addition to nourishing, they must have ingredients that help in health promotion.

Taking advantage of this global trend and the fact that bread has great popular acceptance, a new frontier has opened for the baking industry; today bread is considered as a food capable of promoting the health of the population through small changes in its formulation and addition of functional ingredients. This has allowed for new types of bread to be obtained and marketed: with no addition of sugar and/or fat, with addition of fibers, proteins that improve the amino acid profile of bread, with the use of antioxidant ingredients, with vitamins and minerals and with a decrease or no additives.

Since baking industry has already high technological capacity, this book presents a collection of studies that gather the leading researches and trends concerning the binomial bread-health, namely:

Possibilities and trends of use of other ingredients for mixture with the flour aiming to improve the nutritional value and/or use by-products those are beneficial to health;

The use of fruits and their derivatives with high antioxidant capacity and as a source of fibers or resistant starch;

The use of whole wheat flour, obtained in a stone mill, returns to the past and appears as an option for high-fiber product, containing lower glycemic index carbohydrates; it focuses on an audience more concerned about health, as well as it shows the possibilities of replacing chemical additives by enzymes;

Presentation of the history of French-type bread in Brazil. Today, bread is a product widely used to improve the nutritional status of the population, with the use of flours fortified with iron and folic acid, in addition to the use of whole grain in its formulation;

The concern in developing methods to maintain the production of bread with the same characteristics and with a geographical identity has resulted in the creation of genetic methods to determine the origin of wheat flour, which must be used for bread production.

Trends in the production of gluten free bread, which allow for the offer of new options for subjects with celiac disease;

Evaluations of mycotoxins, very dangerous to health, but that may be present in improperly stored cereals, which, if used for the production of bread, can pose risks to health;

Use of substitutes for fat to decrease the energy value of bread;

Gastrointestinal health promotion by bread consumption;

Use of wheat flours mixed with other flours from local countries with economic and nutritional purposes; and

Use of proteins from different origins, in order to complete the biological value of wheat protein. However, since many studies present the effect of protein supplementation and proposals regarding the sensory and technological qualities of bread, a proposal is being presented for in vitro and in vivo evaluation of proteins, with some examples focusing on bread.

Besides the use of new ingredients that are beneficial and promote health, the importance of using special packages destined to preserve the technological and nutritional characteristics of bread is also being presented.

Finally, as editor of this book, I thank Nova Publisher for enabling the accomplishment of this book and the collaboration of all authors and their respective institutions, because they made possible to prepare a material of excellent quality, with deep technical and scientific knowledge, but easy to read and understand by all those working in the field of Food Science, Technology, and Nutrition.

CONTENTS

In: Bread Consumption and Health
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Chapter 1

FUNCTIONAL BREADS ENHANCED WITH FRUIT-DERIVED POLYPHENOL ANTIOXIDANTS AND DIETARY FIBERS

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ABSTRACT

The current rapid growth of the functional food sector is stimulated by consumer awareness of the importance of a healthy diet, ageing demographics and escalating health-care costs. Foods targeting general well-being and personalised health are gaining increasingly market leverage. Consumers prefer the delivery of health-promoting bioactives through food products rather than medication-type pills, and in particular actively seek foodstuffs offering 'convenience', 'naturalness', 'familiarness' and 'well-being'. With the rise of superfruits in the health and wellness market, fruit-based functional foods are expected to establish a significant market share in the food sector. Vegetarianism and issues related to the consumption of dairy products, such as milk cholesterol content and lactose intolerance, also drive consumers to look to fresh fruits or vegetables and their derived products that are intrinsically rich in a broad spectrum of nutrients. Fruits contain health-promoting bioactive components such as polyphenols, vitamins, minerals, dietary fibre, and antioxidative colorants like anthocyanins and carotenoids. Fruit polyphenols, including those from apples, kiwifruits and berries have demonstrated anti-oxidant, anti-neurodegenerative, anti-carcinogenic, anti-mutagenic, anti-inflammatory and antimicrobial activity, brain wellness and enhance vision, muscle performance and immune responses. A high intake of dietary fibre has been associated with improved regulation of energy intake, satiety, digestive health, as well as reduction of cancer, heart, obesity and diabetes problems. The positive roles of these fruit components in health enhancement and disease prevention provide the necessary

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justification for their incorporation into bread which is a staple and convenient food consumed throughout the world. Numerous studies have been devoted to the various aspects of breadmaking. Breadmaking is a complex process consisting of ingredient mixing (typically wheat flour, water, salt, sugar and yeast), dough formation, fermentation, and baking, in which water evaporation, dough volume expansion, starch gelatinization, protein denaturation, and crust formation occur. This chapter showcases recent work aimed at the development of functional breads enhanced with fruit-derived ingredients and places emphasis on the impact of added polyphenols and/or fibre polysaccharides on dough properties and bread attributes. This chapter also describes the fate of these added bioactives and their involvement in the wheat protein cross-linking during bread dough development and baking. Technical challenges related to the stability of targeted bioactive components in breads, and the potential undesirable sensory attributes caused by added bioactive ingredients at high concentrations are addressed. It will be shown that careful manipulation of the beneficial synergies among added bioactive ingredients and bread components during dough development and baking is key to producing stable and appealing fruit-based functional breads. Finally, future prospects for functional breads are discussed.

INTRODUCTION

Views and perceptions about the positive or negative effects on health of particular dietary compounds can profoundly influence the consumption of foods. Consumers are becoming increasingly aware of the relationships between diet and disease, and demand for foods with health benefits beyond simple nutrition is increasing rapidly [1,2]. A more mobile society, combined with busier and less physically active modern lifestyles and changes in age demographics, has led to strong consumer demand for ready-to-eat, easy-to-use products. Moreover, consumers actively seek foodstuffs featured in the "naturalness" and "wellbeing" categories. Consumers are also increasingly more interested in "natural" rather than "synthetic" medications, preferring the delivery of health beneficial bioactives through a food product [3].

Consumer perceptions and demands motivate food manufacturers to develop new high value functional food products with high consumer acceptance or popularity. The most popular functional foods are those that are similar in appearance and price to a conventional food, familiar to the consumer and possess health-promoting properties [4,5]. Bread in its many forms has been a principal component of Western diets for over 12,000 years. The basic leavened bread recipe contains ingredients such as wheat flour, water, yeast, sugar, oil and salt. It has always been of interest to add some extra ingredients to enhance dough development and bread quality, nutritional value and consumer acceptability. Bread is a convenient food format to carry bioactive ingredients to consumers. This chapter focuses on the breads fortified with fruit fibre and fruit polyphenol antioxidants.

FRUIT-DERIVED POLYPHENOL ANTIOXIDANTS AND DIETARY FIBRES

The positive roles of active plant-derived ingredients or plant-based foods in disease prevention and health enhancement have widely been examined [6,7,8,9]. Fruits and vegetables are popular foods because of their perceived "naturalness", availability and diverse nutrient composition [10]. Fruits and vegetables contain a wide range of nutrients and health-promoting bioactive components such as polyphenols, vitamin A, vitamin C, minerals and dietary fibre [9,10,11,12,13]. Dietary fibres and phytochemicals (including polyphenols) have long been recognized as the active nutrients responsible for the health benefits of fruits and vegetables to humans. However, people today do not consume sufficient fruits and vegetables, e.g. on average, an American consumer eats only about three servings of fruits and vegetables per day (the US National Cancer Institute, http:// progressreport.cancer.gov/). Therefore, introduction of fruit-/vegetable-derived bioactives via different food formats, especially the food formats of high consumer familiarity and convenience can help to increase the total consumption of fruits and vegetables.

Fruits of high consumer demand and acceptability include cranberry, blueberry, pomegranate, apple, blackcurrant, acai, acerola, guarana, mango, bilberries, grapes, cherries, kiwifruits, strawberries, feijoa, peach and plums [10,13,14,15,16]. Considerable opportunities exist in the functional fruit product category for expansion and innovation.

Polyphenols are secondary metabolites synthesized by plants, ranging from simple molecules such as phenolic acids (with a single phenolic ring), to biphenyls and flavonoids (with two or three phenolic rings), and polyphenols (with many phenolic groups) [17,18]. Proanthocyanidins, tannins and their derivatives are often referred to as polyphenols [18]. Polyphenols possess different chemical structures and polarity, containing multiple hydroxyl groups that can act as sites for conjugation to sugars, acids or alkyl groups [17] (Figure 1 shows the chemical structure of some common polyphenols). Polyphenols can act as antioxidants by scavenging free radicals in biological systems [19]. Free radicals derived from a wide range of biological reactions in the body can damage biomolecules including DNA. An excess of free radicals cause ill health and disease, for example, reactive oxygen species (ROS) including superoxide ($O_2^{\cdot-}$), hydroxyl radical (OH), hydrogen peroxide (H_2O_2) and lipid peroxide radicals have been associated with chronic degenerative diseases such as cancer, inflammatory, aging, cardiovascular and neurodegenerative disease [20,21]. The modes of antioxidant action include direct scavenging (for primary antioxidants e.g. α-tocopherol) and indirect scavenging (for secondary antioxidants e.g. dilauryl thiodipropionate and thiodipropionic acid) [20,22]. Later in this chapter, functional breads containing kiwifruit, blackcurrant and apple polyphenol extracts and/or apple pectin fibre are described. Fruit polyphenols, including those from kiwifruits, berries and apples have demonstrated antioxidant capacity, anti-neurodegenerative effect, anti-ulcer activity, anti-carcinogenic effect, anti-mutagenic activity, anti-inflammatory activity, anti-microbial effects, and also assist brain wellness, vision, muscle performance and immune responses [14,21,23,24,25,26]. Kiwifruit polyphenols are mainly small and highly polar phenolic acids such as protocatechuric acid and caffeic acid derivatives [27,28,29,30]. Blackcurrants have various polyphenols including flavanoids, phenolic acids and anthocyanins [31], with a high anthocyanin content of cyanidin-3-*o*-glucoside, cyanidin-3-*o*-rutinoside, delphinidin-3-*o*-

glucoside and delphinidin-3-*o*-rutinoside [31]. Apple polyphenols include procyanidin, catechin, epicatechin, chlorogenic acid, phloridzin, quercetin and their conjugates [32,33].

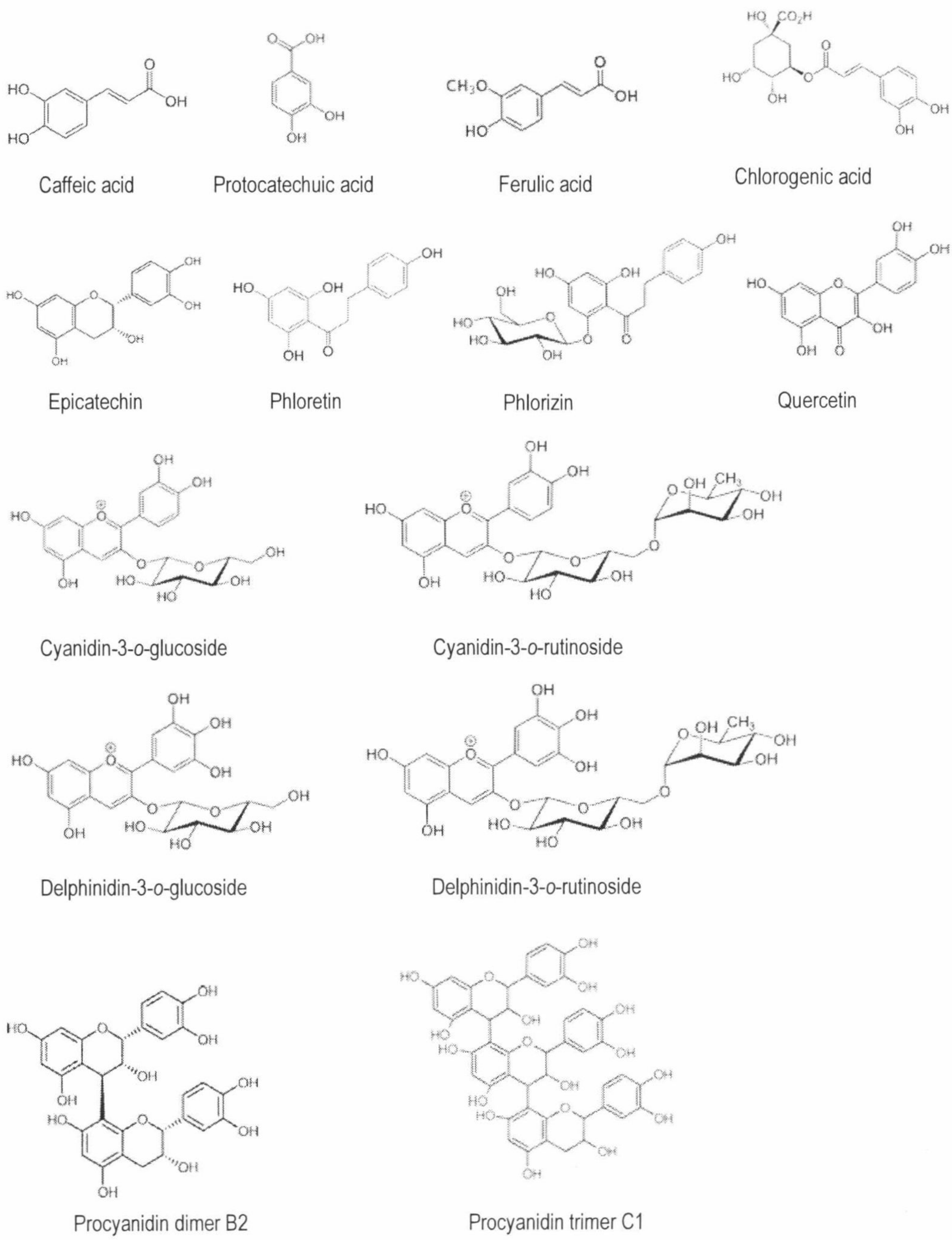

Figure 1. Some polyphenols in fruits.

The definition of dietary fibres has been debated and re-written several times since 1976 [34,35,36,37]. Currently dietary fibre is defined as carbohydrate polymers with 10 or more monomeric units, which are not hydrolysed by the endogenous enzymes in the small intestine of humans [38]. Dietary fibres can reduce intestinal transit time, increase stool bulk, slow down the rate of gastric emptying, decrease the total and LDL cholesterol level in blood, lower postprandial blood glucose and insulin level and prevent constipation [39,40,41,42]. Low dietary fibre intake is believed to result in high risks of health problems such as diverticular disease, diabetes, obesity, coronary heart disease and colorectal cancer [43,44,45]. Thus, there has been a lot of work done to add dietary fibre into popular foods to develop products that satisfy the requirements of The *Code of Federal Regulations* [46], which allows "good source of fibre" and "excellent source of fibre" claims to be made for a product. This also applies to the incorporation of fibre into bread to raise the health profile of the final products, because the endogenous fibre content in wheat flour is only 2–4% [47,48]. Cereals, fruit and vegetables are major sources of dietary fibres, with their cell wall polysaccharides being the main components. Pectic polysaccharides (pectins) are one of the important polysaccharide classes of dicotyledons and some monocotyledons, containing a distinct monosaccharide composition (Figure 2), 'smooth' (homogalacturonan) and 'hairy' (rhamnogalacturonans) blocks (Figure 3), and different degrees of methyl esterification and acetylation (Figure 4) [49]. The degree of esterification influences the solubility and functionality of pectins [50], and the hydroxyl and carboxyl groups can participate in various chemical reactions [51]. Pectins with high and low methoxyl content (HM and LM,

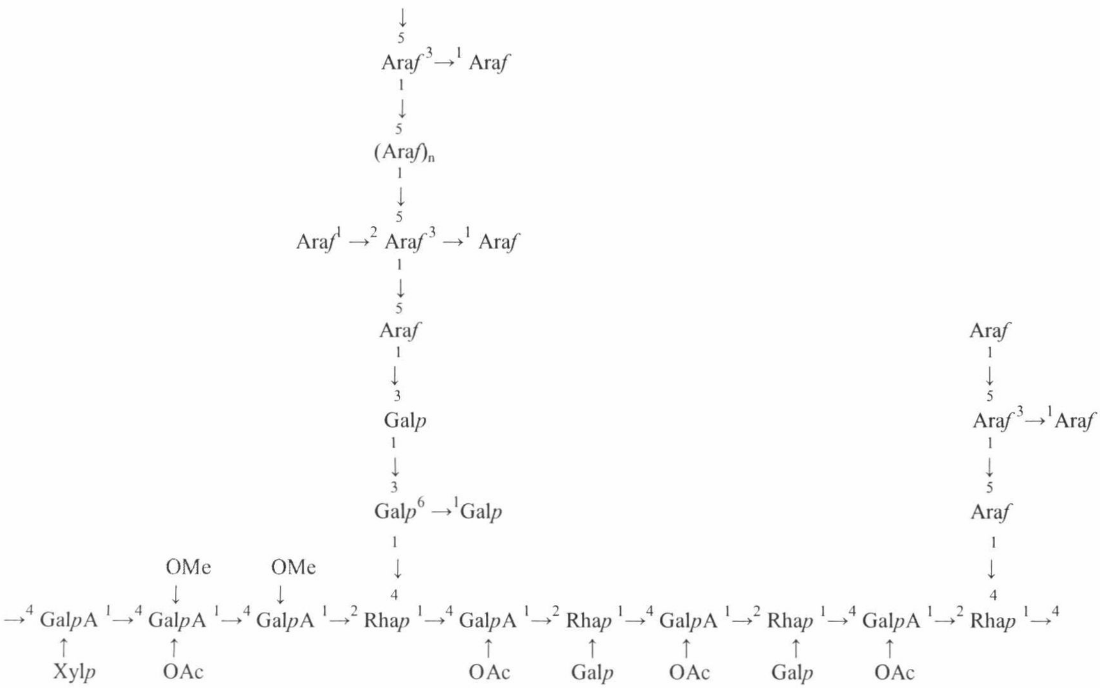

Figure 2. Possible structure of modified hairy regions of pectic fraction (rhamnogalacturonan) [54]. Araf = arabinofuranosyl, Galp = galactopyranosyl, GalpA = galactosyluronic acid [pyranose], Rhap = rhamnopyranosyl, Xylp = xylopyranosyl, OMe = methyl ester, OAc = ethyl ester.

respectively) differ in charge densities and gel setting behaviour [52,53]. HM pectins can gel according to slow-, medium- or rapid-set, but require high concentrations of soluble solids (> 55%w/w) and a low pH (< 3.5). HM pectins form low water activity gels or sugar-acid-pectin gels, in which water and the co-solutes sugar and acid are immobilised. The resultant gels resist deformation, due to the formation of junction zones where chain associations are stabilised by hydrogen bonding interactions between undissociated carboxyl and secondary alcohol groups and by hydrophobic interactions between methyl esters [50]. LM pectins gel via the same mechanisms as HM pectins over a wide range of soluble solid contents and pH, but require sufficient divalent cations such as Ca^{2+} for gelation [53].

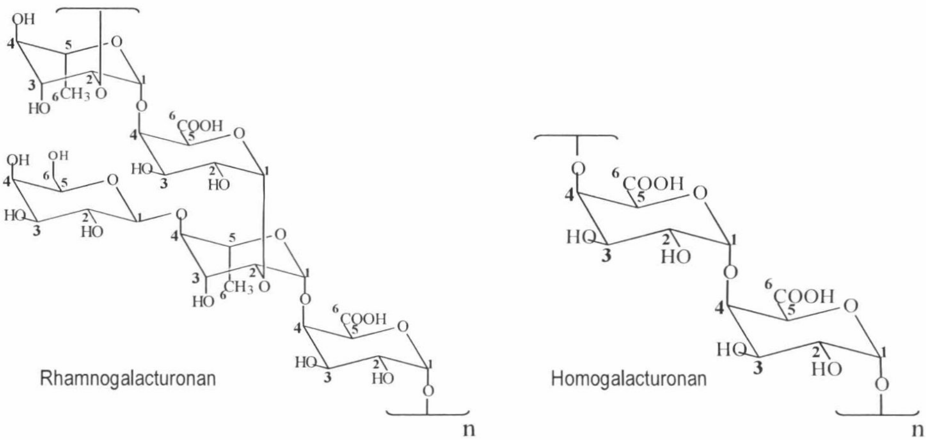

Fig. 3 Structures of some galacturonans (49).

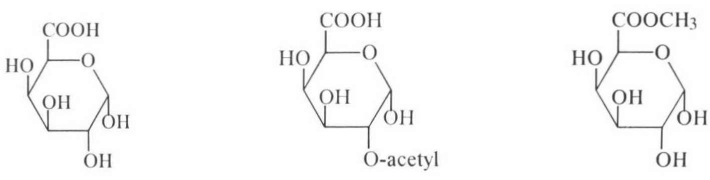

Figure 4. Structures of galacturonic acid, acetylated galacturonic acid, and methyl galacturonate [49].

The Use of Fruit-derived Polyphenol or Fibre Ingredients for Food Applications

Knowledge of the health benefits associated with increased consumption of polyphenols and dietary fibre has led to the inclusion of these active ingredients into popular consumer foods like bread [28,30,42,55,56,57]. Polyphenols and fibre polysaccharides possess a broad range of chemical structures and contain different functional groups that may react differently during food formulation and processing [17,21].

Fruit polyphenol and fibre preparations have been generated in both research and commercial sectors. Commercial suppliers include Berryfruit New Zealand, Just the Berries New Zealand, GNT International The Netherlands, Penglai Marine BioTech China, Herbstreith & Fox Germany. Furthermore, the polyphenol or fibre ingredients can be produced from different parts of whole fruits or fruit wastes, using different extraction media such as water, ethanol or their mixtures, which may lead to different bioactive composition and food functionality [28,58]. Table 1 shows that the composition and amount of individual polyphenols, as well as the amount of pectic polysaccharides, in the extracts from green kiwifruit by-products, varied with the extraction medium and the type of fruit by-product [28].

There exist various forms of dietary fibre in the market; including

- a natural component of a complex ingredient e.g. fruit, vegetable and cereal materials, or
- processed fibre ingredients containing both soluble and insoluble fibres e.g. Herbacel Classic apple fibre from Herbstreith & Fox KG of Switzerland, or
- fibre polysaccharides used as a food ingredient e.g. CM203 citrus pectin from Herbstreith & Fox KG of Switzerland.

Table 1. Total polyphenol and uronic acid contents in the ethanolic or aqueous extracts of kiwifruit skin, residue and pulp [28]*

Extraction Medium (Final %v/v of ethanol)	Total Polyphenols (Catechin Equivalent mg/g)			Uronic Acid Content (% w/w)		
	Skin	Pulp	Residue	Skin	Pulp	Residue
96.0	1.54 ± 0.15^{a}	1.09 ± 0.06^{a}	0.95 ± 0.09^{a}	1.70 ± 0.20^{a}	0.68 ± 0.19^{b}	0.62 ± 0.13^{b}
73.8	1.06 ± 0.04^{a}	0.81 ± 0.04^{a}	0.74 ± 0.01^{a}	0.63 ± 0.21^{b}	0.64 ± 0.32^{b}	0.65 ± 0.17^{b}
49.5	0.55 ± 0.04^{b}	0.41 ± 0.01^{b}	0.57 ± 0.05^{b}	0.74 ± 0.25^{b}	0.83 ± 0.21^{b}	0.86 ± 0.23^{b}
29.5	1.34 ± 0.11^{a}	0.40 ± 0.08^{b}	0.48 ± 0.06^{b}	1.69 ± 0.05^{a}	1.02 ± 0.43^{ab}	0.90 ± 0.20^{ab}
0.0	1.06 ± 0.10^{a}	0.62 ± 0.08^{b}	0.60 ± 0.01^{b}	1.85 ± 0.36^{a}	1.87 ± 0.38^{a}	1.63 ± 0.36^{a}

* Values are expressed as mean ± standard deviation. Different superscript letters in the horizontal rows of total polyphenol or uronic acid content, indicate significant differences at $P < 0.05$.

Different preparation methods have been used for the production of these fibres. Sun-Waterhouse *et al.* [58] compared aqueous and ethanolic methods for fibre preparation from fruits, and reported that the aqueous method appeared to be advantageous in terms of the retention and profiles of health-beneficial components such as pectic polysaccharides and bound polyphenols as well as cost-effectiveness for industrial scale-up. Table 2 shows the difference in pectin content and Figure 5 demonstrates the differences in fibre morphology, thickness and constituents when different fibre preparation methods are applied to the same