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Functional foods and bakery products: a review

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Abstract

The concept of functional foods is a highly topical one. Indeed, beyond their function of satisfying hunger, functional foods have health benefits for consumers. The aim of this study was not only to provide information on functional foods but also to review articles published over the last twenty years on functional bakery products. Firstly, this review looks at the history and concept of functional foods, their different types and the link between them and human health. secondly, some thirty articles were examined. From these articles, information on the nutrient intake and/or health benefits of functional foods was collected. It emerged that the formulation of functional bakery products is of interest to many authors. The product most often mentioned is the cookie, probably because it is loved by all, regardless of age, and because of its convenience. As far as nutritional intake is concerned, in most cases there is an improvement in the composition of total polyphenols, minerals, and fiber. As for the health benefits of these different products, we note a low glycemic index, which is a benefit for diabetics. Other products are gluten-free, which is recommended in cases of celiac disease. In addition to these benefits, there are products that, given their composition, have hypocholesterolemic effects, regulate heart rate and therefore blood pressure, are anti-diabetic, combat degenerative diseases, and many others. Functional bakery products are therefore of vital importance in today's world.

Keywords: Functional food, bakery products, health benefits, nutrition.

1. Introduction

As the world continues to evolve, public decision-makers, scientists and consumers are increasingly demanding healthy foods with improved nutritional characteristics, using non-conventional raw materials [1]. These improved foods, still known by the name of "functional foods", are like traditional foods and form part of normal consumption. But they are designed to provide, in addition to the nutritional elements they naturally contain, additional nutrients for better health [2].

In other words, they are foods that can provide health benefits beyond basic nutrition. They highlight the nutritional richness and bioactive potential for human health of certain plants and cereals, whose use in food presents dietary, social-economic, and environmental benefits [3]. Plant-based functional foods are generally derived from natural or unprocessed plant foods modified by a biotechnological process. They aim to meet nutritional requirements and provide effective and valuable bioactive compounds for the prevention of chronic diseases [4].

Socio-cultural evolution has led to a change in eating habits, with an increase in the consumption of processed food products. Consumption patterns have also changed, with a growing perception of the importance of a balanced diet for health. Socio-demographic changes, increased awareness of health and diet, interest in alternative medicine, and the quest for well-being all contribute to this trend. Nutritional science

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has evolved towards the concept of optimal nutrition, leading to the emergence of functional foods that contain natural nutritional elements as well as additional nutrients beneficial to health [2].

In recent years, a number of authors have focused on this topic, and in particular on the formulation of functional bakery products. This is because bakery products are of global importance in international nutrition, in that they are a staple food in many countries and are widely consumed. Thus, bakery products offer a promising approach and can thus constitute a carrier to be enriched with bioactive ingredients [5, 6].

The purpose of this study was to provide useful information for understanding the ins and outs of functional foods and to take stock of the various scientific studies that have been conducted on functional bakery products over the past 20 years.

1. A brief history

Functional foods have become increasingly popular in recent years, as people are now consuming them not just for their nutrients, but also to maintain well-being and reduce the risk of disease [7]. The concept of functional foods emerged in Japan in the 1980s in response to the increase in diet-related illnesses. The Japanese government-funded research to identify the physiological effects of food on health. Thus, a functional food was defined as a commonly consumed food that exhibits specific health benefits beyond those of ordinary foods. In Japan, functional foods include dietary fibers, polyalcohols, fatty acids, peptides, vitamins, etc. In 1991, Japan created the FOSHU (Foods for Specified Health Use) label to distinguish these foods on the market [8]. The concept of functional food also developed in Europe in the 1990s, where it is seen as a healthier alternative to traditional food. For European consumers, functional foods contribute to well-being, reduce the risk of disease, and go beyond basic nutritional requirements. According to the Belgian Federal Service for Scientific, Technical, and Cultural Affairs, functional food has a positive influence on the body's functions beyond its nutritional aspect [8].

2. Notion of functional foods

According to the Committee on the Environment, Agriculture and Local and Regional Affairs, the term "functional food" does not yet have a universal definition, and there are many possible interpretations. However, in recent literature, it is often defined as any food or ingredient that, in addition to the traditional nutrients it provides, has a beneficial effect on health. These functional foods are developed and marketed to inform consumers of their benefits. Recent Council of Europe guidelines specify that these foods must satisfactorily demonstrate that they have a beneficial effect on one or more functions of the body, over and above their nutritional effects. Functional foods may be natural, add or remove components, or have enhanced bioavailability. It's important to emphasize that functional foods are not pills or capsules, but elements of a healthy diet that deliver significant health benefits. For example, fermented dairy products may be considered healthy, but they are only functional if they contain probiotic cultures that offer additional health benefits [2].

The objectives of these foods are firstly to improve the general condition of the body, to prevent certain diseases and even to cure certain diseases [9].

3. Types of functional foods

According to the European Union's Committee on the Environment, Agriculture and Regional Affairs, there are currently five main types of functional food on the market, as shown in the table below.

Another categorization of functional products was made by [3]. According to this categorization, 4 types of functional products emerge, presented as follows:

- Fortified products: these are functional products in which the existing nutrient content is increased.
- Enriched products: these are functional products in which new nutrients or components not normally found in a given food are added.
- Altered products: these are products in which existing components are replaced by beneficial ones.
- Enhanced commodities: these are functional products in which the raw materials are

modified to change the nutrient composition.

Table 1: Types of functional food

Types of functional foods	Example of a related article
Products in which the quantity of a naturally or normally present ingredient is increased or decreased.	Utilization of butter and oleogel blends in sweet pan bread for saturated fat reduction: Dough rheology and baking performance. [10]
Products containing new ingredients	The use of moringa oleifera as value-added ingredient in bakery industry. [11]
Fermented dairy products such as yoghurts with active bacterial cultures	Probiotics bacteria in fermented dairy products. [12]
Sports or energy drinks to compensate for fluid and/or energy loss	Sports and energy drinks. [13]
Slow-release carbohydrate products for energy management.	Slow-release carbohydrates: growing evidence on metabolic responses and public health interest. Summary of the symposium held at the 12th European Nutrition Conference (FENS 2015). [14]

4. Links between functional foods and health

Functional foods are linked to the prevention and treatment of several common causes of death, such as cancer, diabetes, cardiovascular disease, and hypertension [2]. Many researchers have demonstrated this through their research, such as [15]. In their research entitled "Brewers spent grain protein hydrolysate as a functional ingredient for muffins: Antioxidant, antidiabetic, and sensory evaluation", they reported improved antidiabetic properties following the addition of 6% brewers spent grain protein hydrolysate to muffin formulations. Also, [16] in their study on the "In-vitro gastrointestinal digestion of functional cookies enriched with chestnut shells extract: Effects on phenolic composition, bio accessibility, bioactivity, and α-amylase inhibition", revealed that their realized functional cookies would have antioxidant/ antiradical and hypoglycemic effects.

Functional foods can also help treat other conditions, including neural tube defects, osteoporosis, digestive disorders and arthritis. Statistics reveal that diet is responsible for one in three cancer deaths, and that eight out of ten cancers are nutrition-related. Functional foods focus on two main areas: heart health, with cholesterol-lowering products, and bone health, with calcium- and mineral-rich foods. They also aim to promote a balanced digestive system through the consumption of products containing beneficial bacteria or rich in fiber, and to strengthen the immune system through the provision of vitamins, minerals and good bacteria [2].

5. Some articles published on functional bakery products over the last twenty 20 years

The table below presents some of the articles published on functional bakery products over the last twenty (20) years.

Analysis of the information in this table shows that authors are increasingly interested in improving the nutritional quality of bakery products. For most of them, the reason for turning bakery products into functional foods is, on the one hand, the desire to meet the expectations not only of consumers but also of executives The other reason is that the wheat flour used as a base in pastry products is less rich in minerals and contains gluten, which is an allergen for many people, particularly those suffering from celiac disease. It also shows that wheat flour has been partially replaced by functional ingredients such as cereals, pseudo-cereals, legumes, fruit, edible waste from the food industry, and even animal matter, such as cricket flour.

Table 2: Some of the articles published on functional bakery products over the last twenty (20) Years.

Titre	Functional product	Nutritional particularity and health benefits	Reference
In-vitro gastrointestinal digestion of functional cookies enriched with chestnut shells extract: Effects on phenolic composition, bioaccessibility, bioactivity, and α-amylase inhibition	Functional cookies enriched with chestnut shells extract	Improved phenolic compound content, detection of phenolic acids, hydrolysable tannins, flavonoids and caffeine. Better antioxidant/anti-free radical and hypoglycemic effects after intestinal digestion.	[16]
Exploitation of Common Bean Flours with Low Antinutrient Content for Making Nutritionally Enhanced Biscuits	Biscuit with Common Bean Flours with Low Antinutrient Content	Higher nutritional quality (improved amino acid score, higher fibre content, lower predicted glycemic index and starch content).	[17]
Nutritional evaluation of biscuits enriched with cricket flour (Acheta domesticus)	Biscuits enriched with cricket flour	Improved nutritional intake, especially of protein. Low glycemic index.	[18]
Antioxidant Capacity, Mineral Content and Sensory Properties of Gluten-Free Rice and Buckwheat Cookies	Gluten-Free Rice and Buckwheat Cookies	High total phenolic and rutin content. Significantly high 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity, antioxidant activity, and reducing power.	[19]
Effect of peach puree incorportion on cookie quality and on simulated digestion of polyphenols and antioxidant properties	Peah pulp-cookies	Significant improvement in total polyphenol and antioxidant properties and polyphenol profile. Improved nutritional quality of cookies.	[20]
Tartary buckwheat malt as ingredient of gluten-free cookies	Gluten-free cookies with rice and tartary buckwheat malt	Functional cookies had significantly higher levels of total phenolic compounds and quercetin. They also had higher antioxidant activity and a lower glycemic index than the control.	[21]
Phenolic content and antioxidant activity of tortillas produced from pigmented maize processed by conventional nixtamalization or extrusion cooking	Tortillas produced from pigmented maize processed by conventional nixtamalizatio n or extrusion cooking	Improved levels of total phenolic compounds and total ferulic acid. Improved retention of total ferulic acids.	[22]
Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified	Sorghum and bread wheat biscuits fortified with defatted soy	Higher protein content, especially lysine. Increases in vitro protein digestibility.	[23]

with defatted soy flour	flour	Could help prevent protein-energy malnutrition affecting children.	
Antioxidant properties and heat damage of water biscuits enriched with sprouted wheat and barley	Biscuits enriched with sprouted wheat and barley	Enhanced nutritional quality (higher levels of carotenoids, tocols and phenolic compounds). High antioxidant capacity.	[24]
Physico-chemical, textural, sensory and antioxidant characteristics of gluten – Free cookies made from raw and germinated Chenopodium (Chenopodium album) flour	Cookies made from raw and germinated Chenopodium flour	Improved nutritional quality of cookies Increased antioxidant activity, total phenolic content and dietary fiber content of cookies.	[25]
Blackcurrant pomace from juice processing as partial flour substitute in savoury crackers: dough characteristics and product properties	Crackers with blackcurrant pomace from juice processing	High content of Marc de cassis in dietary fiber and bioactive compounds is likely to increase the nutritional value of the target food.	[26]
Effect of fortification of defatted soy flour on sensory and rheological properties of wheat bread	Bread fortified with defatted soy flour	Superior nutritional quality: increased ash and protein content.	[27]
Nutritional and sensory characteristics of gluten-free quinoa (Chenopodium quinoa Willd)-based cookies development using an experimental mixture design	Cookies with quinoa	Rich in dietary fiber, good source of essential amino acids, linolenic acid and minerals.	[28]
Total dietary fibre and antioxidant activity of gluten free cookies made from raw and germinated amaranth (Amaranthus spp.) flour	Gluten free cookies made from raw and germinated amaranth	Sprouting improved the antioxidant activity and functional properties of sprouted amaranth flour and sprouted amaranth flour cookies.	[29]
Effect of substitution of soy protein isolate on aroma volatiles, chemical composition and sensory quality of wheat cookies	Cookies with soy protein isolate	Improved nutritional composition and pyranone content.	[30]
Date seed flour and hydrolysates affect physicochemical properties of muffin	Muffins incorpored with date seed flour hydrolysate and date seed flour	Increased total dietary fiber and mineral content. Improved antioxidant activity of muffins Significant radical scavenging	[31]

		activity against DPPH and hydroxyl radicals Inhibition of angiotensin I-converting enzyme	
Potential antidiabetic effect of muffins formulated with different protein hydrolysates: Role of bioactive peptides formed during digestion	Muffins formulated with hydrolysates of casein, soybean protein, pea protein, and rice protein	Reduced glycemic index of muffins containing hydrolyzed pea and rice proteins. Release of bioactive peptides during in vitro digestion, with potential health benefits.	[32]
Production of functional biscuits for lowering blood lipids	Functional biscuits with barley, mustard, defatted mustard, flaxseed meal and flaxseed oil	Improved nutritional profile. Rich source of alpha-linolenic acid. Low linoleic acid levels. Reduced degree of cardiac and liver tissue damage in hypercholesterolemic rats Significant reduction in serum total cholesterol, triglycerides, low-density lipoproteins, very-low-density lipoproteins, total cholesterol/high-density lipoprotein, low-density lipoprotein/high-density lipoprotein ratios and atherogenic index in hypercholesterolemic rats. Increase in high-density lipoproteins in hypercholesterolemic rats	[33]
Exploitation of alfalfa seed (Medicago sativa L.) flour into gluten-free rice cookies: Nutritional, antioxidant and quality characteristics	Gluten-free rice cookies with alfalfa seed	Increased crude protein, total dietary fiber, total polyunsaturated fatty acids and total fatty acids. Total phenolic content, in vitro antioxidant capacity and resistant starch increased. Lower starch hydrolysis indexes were found.	[34]
In vivo study of medical and biological properties of functional bakery products with the addition of pumpkin flour	Functional muffins and cookies with the addition of pumpkin flour	Bakery products with pumpkin powder are a source of bioactive components in the diet. Bakery products with pumpkin powder showed in vivo antioxidant, hypocholesterolemic, hepatoprotective and prebiotic effects. The bioactive components of pumpkin and dietary fiber determine the preventive properties of pumpkin bakery products.	[35]

Antioxidative, sensory and volatile profiles of cookies enriched with freeze-dried Japanese quince (Chaenomeles japonica) fruits	Cookies with Japanese quince fruits	High antioxidative potential. Microbiological safety of stored cookies enhanced. Radical scavenging activity 2 to 3.5 times higher.	[36]
Functional, physicochemical and sensory properties of novel cookies produced by utilizing underutilized jering (Pithecellobium jiringa Jack.) legume flour	Cookies produced by utilizing underutilized jering legume flour	Increased protein, fiber and ash content in composite cookies.	[37]
Brewers spent grain protein hydrolysate as a functional ingredient for muffins: Antioxidant, antidiabetic, and sensory evaluation	Muffin with Brewers spent grain protein hydrolysate	Significant improvement in antioxidant activity of muffins Improved anti-diabetic properties. Improved oxidative stability.	[15]
Composites flour formulation made from yellow pumpkin, purple sweet potato, corn, and wolf-herring flour for replacement of wheat flour on low- and high- moisture foods part I: Cookies and muffin	Cookies and muffin with yellow pumpkin, purple sweet potato, corn, and wolf-herring flour	Improved nutritional quality in general, and mineral and amino acid composition in particular.	[38]
Comparison of nutritional quality and sensory acceptability of biscuits obtained from native, fermented, and malted pearl millet (*Pennisetum glaucum*) flour	Biscuit with fermented, and malted pearl millet	Increased nutritional value of flour and biscuit. Increased content of essential amino acids in flour and biscuit.	[39]
Physicochemical, rheological, bioactive and consumer acceptance analyses of concha-type Mexican sweet bread containing Lima bean or cowpea hydrolysates	Concha-type Mexican sweet bread with Lima bean or cowpea hydrolysates	Increased protein and mineral content. . Improved angiotensin I inhibitory activity and antioxidant capacity equivalent to Trolox.	[40]
Effect of fermentation and malting on the microstructure and selected physicochemical properties of pearl millet (*Pennisetum glaucum*) flour and biscuit.	Biscuit with pearl millet	Fermentation and malting have modified and improved the physical-chemical and possibly nutritional properties of the flour and biscuit obtained.	[41]
Improvement of dietary fiber content and antioxidant properties	Biscuits with the incorporation	Increased polyphenol and antioxidant content.	[42]

in soft dough biscuits with the incorporation of mango peel powder	of mango peel powder	Improved antioxidant properties. Probable health benefits, including protection against cardiovascular disease, cancer, and other degenerative diseases thanks to the presence of bioactive compounds.	
Nutritional, Physico-Chemical, Phytochemical, and Rheological Characteristics of Composite Flour Substituted by Baobab Pulp Flour (*Adansonia digitata* L.) for Bread Making	Bread fortified with Baobab Pulp Flour	Improved nutritional composition Improved total polyphenol and flavonoid composition Probable antimalarial and antidiarrheal effect due to the presence of baobab pulp.	[43]
Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract	Biscuits enriched with grape marc extract	High phenolic content and good antioxidant activity. High levels of Maillard and lipid oxidation volatiles.	[44]
Gluten-Free Cookies Enriched with Baobab Flour (*Adansonia digitata* L.) and Buckwheat Flour (*Fagopyrum esculentum*)	Cookies Enriched with Baobab Flour and Buckwheat Flour	Improved nutritional profile High source of polyphenol and flavonoids Gluten-free, a benefit for those suffering from celiac disease.	[45]
Strategies to Formulate Value-Added Pastry Products from Composite Flours Based on Spelt Flour and Grape Pomace Powder	Biscuits, cakes and rolls with Spelt Flour and Grape Pomace Powder	Significant improvements in total polyphenol and flavonoid composition. Improved nutritional composition.	[46]
Mature green plantain-amaranth flour inclusion improved wheat bread nutrients, antioxidant activities, glycemic index/load and carbohydrate hydrolyzing enzyme inhibitory activities	Wheat bread with Mature green plantain-amaranth flour	Appreciable amount of crude protein, potassium and high antioxidant activities potential. High inhibitory activities against carbohydrate hydrolyzing enzymes, and low in glycemic index/load. May be advantageous in the management and treatment of diabetes mellitus.	[47]

These ingredients have been tested on several bakery products, including cookies, muffins, breads, tortillas, crackers, and more.
The various products studied in the table below were not only a good source of bioactive compounds, but also of nutritional composition. There was an improvement in the composition of polyphenols, dietary fiber, minerals, vitamins and other substances. These different products also offered enormous health benefits, especially in the prevention of chronic diseases. While most studies

have addressed the nutritional aspect of functional foods, few have carried out clinical studies to prove the beneficial effects of these different products on human health. Nevertheless, some of these products have been shown to have anti-diabetic effects [47], regulate cardiac pressure [42], regulate cholesteromia [33], prevent protein malnutrition in children [23], and to be effective against malaria and diarrhea [43]. There are also probable effects against cancer and degenerative diseases [42].

1. Conclusion and Prospects

All this information shows that the notion of functional foods is a topical one, even though it dates back to the 1980s. It's an approach that aims to treat and/or prevent certain diseases through food. It involves enriching or improving an existing food that is poor or not very rich from a nutritional point of view. It also involves modifying the composition of food by replacing, for example, an ingredient with components deemed toxic. In this way, these foods are beneficial to consumers' health. This study also presented several articles on functional bakery products. It shows the growing interest of scientific players in improving and meeting the expectations of public decision-makers and consumers alike. This study revealed that many functional ingredients can be used in baked goods to make them functional while improving nutritional quality and health benefits. Although a multitude of studies exist, humanity is still a long way from achieving the United Nations' sustainable development goals in terms of eliminating malnutrition. It is therefore essential that leaders invest more in promoting these products while putting in place a legal framework to control what is being done. Scientists are urged to conduct more clinical studies on the health benefits of these products. Finally, industrial authors are invited to join forces with consumers to learn more about what is being done to offer them healthy, nutritious products with health benefit.

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