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The effects of functional cereal rich in beta-glucan on cardiovascular health

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Abstract. The prevalence of cardiovascular and cerebrovascular diseases remains a global health concern. Lifestyle modifications, including dietary modifications, have been identified as viable risk reduction strategies. This study seeks to evaluate the potential benefits of beta-glucan-rich functional cereals, such as Uncle Toby's Oats, in reducing the risk of these diseases. Beta-glucan is a soluble fiber known for its cholesterol-lowering properties, and beta-glucan-rich functional cereals provide a convenient way to incorporate this healthful nutrient into daily diets. This study compares the nutritional profile of Uncle Toby's Oats, a representative beta-glucan-rich functional cereal, to that of other common breakfast options, such as Rice Bubbles cereal and Vegemite on toast, based on calorie content, macronutrient distribution, and the presence of essential vitamins and minerals. It is anticipated that the results of this study will contribute to public health recommendations for dietary interventions intended to reduce the risk of cardiovascular and cerebrovascular disease.

Keywords: functional cereals, beta-glucan, cardiovascular disease, cerebrovascular disease, dietary intervention oatmeal.

1. Introduction

In 2019, cardiovascular disease (CVD) caused 32% of global deaths, according to the WHO [1]. CVD includes atherosclerosis, coronary artery disease, cardiac arrhythmias, and stenosis. These conditions predominantly afflict individuals aged 65 and over [2]. The formation of unstable atherosclerotic plaques can lead to blood vessel occlusion, making atherosclerosis the most common cause of CVD [3]. Several risk factors contribute to the development of CVD; while some, such as age, gender, and genetic predisposition, are non-modifiable, others like tobacco usage, physical inactivity, excessive alcohol intake, hypertension, type 2 diabetes (T2D), dyslipidemia, and obesity, are modifiable [4]. These modifiable factors can elevate serum low-density lipoprotein cholesterol (LDL) and triglycerides, fasting glucose levels, and adiposity, thereby increasing the risk of CVD and T2D [3]. Research by Willeit et al. underscored the importance of controlling LDL-cholesterol for CVD prevention [5], while Ho suggested that oats, rich in beta-glucan, could effectively reduce LDL-cholesterol levels [6].

This study delves into the potential cardiovascular benefits of functional cereals abundant in beta-glucan, using Uncle Toby's Traditional Oats as a representative example. This cereal is composed of 100% whole grain oats and includes bioactive compounds such as beta-glucan and lupin, which are known for their potential effects on CVD [7]. In addition to evaluating the impact of this functional cereal, this study also compares its price and nutritional value with six non-functional breakfast

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alternatives (Kellogg's Rice Bubbles Puffed Rice Breakfast Cereal, Coles Rice Puffs, Cornflakes, Kellogg's Coco Pops Chocolatey Breakfast Cereal, Woolworths Crispy Rice Pops, and Coles I'M Free From Special Flakes), to offer realistic dietary advice to the general public.

2. Methodology

Two well-known Australian retailers, Woolworths and Coles, supplied nutritional data and price information for each product on their websites. The comparison revealed that six non-functional breakfast alternatives serve as potential substitutes for Uncle Toby's Traditional Oats. The selection of these six options was informed by factors including availability, cost, personal taste preferences, allergen considerations, and storage requirements. All the selected alternatives enjoy similar availability as Uncle Toby's Oats, being accessible at both Woolworths and Coles. For budget-conscious individuals, the Crispy Rice Pops, priced at $1.95 per 350 g pack, presents an affordable choice. The Coco Pops Chocolatey Cereal, with its higher sugar content, may appeal to those with a preference for sweeter tastes. For those with gluten sensitivities, the Breakfast Cereals Free From Gluten Cornflakes and Puffed Rice Breakfast Cereals are appropriate options. All these alternatives can be conveniently stored in a cool, dry environment.

3. Background of oats

Fiber-rich traditional oats include beta-glucan, which prevents cholesterol reabsorption and has health advantages.

3.1. Uncle Toby's traditional oats

Uncle Toby's traditional oats (or Uncle Toby's Oats), a popular breakfast choice made of 100% whole wheat oats. Uncle Toby's traditional oats were chosen as an example because they satisfy the criteria for claiming beta-glucan as a source: a minimum of 1 gram per serving and 3 grams per 100 grams of solids [8]. This product costs 4.5 Australian dollars per 500 grams, or 0.56 Australian dollars per 100 grams [7]. As shown in Table 1, each 100 g serving of Uncle Toby's Oats contains 1,600 kJ of energy, 12.8 g of protein, 9.2 g of total fat (including 1.7 g of saturated fat), 56.7 g of carbohydrates (including 1 g of sugar), 9.2 g of dietary fiber (4.5 g soluble, 4.7 g insoluble, and 4.0 g beta-glucan), and 6 mg of sodium. A 40-gram portion of grains provides 1.6 grams of beta-glucan [7]. At least 3 grams of beta-glucan, or 75 grams of Uncle Toby's Oats, each day reduces cholesterol reabsorption and costs 0.57 Australian dollars [5]. Additionally, increasing beta-glucan consumption to 5 g per day improves blood sugar management, feelings of fullness, and intestinal microbiota diversity [9].

Table 1. The nutrition information of Uncle Toby's traditional oats [10].

Nutritional Information	Per Serving (40g)	Per 100g
Energy (kj)	640	1600
Protein (g)	5.1	12.8
Fat, Total (g)	3.7	9.2
-Saturated (g)	- 0.7	- 1.7
Carbonhydrate (g)	22.7	56.7
-Sugar (g)	- 0.4	- 1.0
Dietary fibre (g)	3.7	9.2
-Insoluble (g)	- 1.9	- 4.7
-Soluble (g)	- 1.8	- 4.5
-Beta-glucan (g)	- 1.6	- 4.0
Sodium (mg)	2.0	6.0

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3.2. Mechanism of action

The primary bioactive compound in cereals contributing to the reduction of cardiovascular disease (CVD) risk is beta-glucan [11]. Meta-analyses have illustrated that the intake of beta-glucan fiber can manipulate risk factors of CVD by transforming the gut microbiome, modulating LDL-cholesterol, halting the progress of atherosclerosis, managing Body Mass Index (BMI), and mitigating inflammation [12]. Specifically, beta-glucan ingestion alters the gut microbiome, increasing bile salt hydrolase-producing Bifidobacterium, Bacteroides, and Lactobacillus species, which affects cholesterol metabolism and bile acid profiles. These modifications significantly lower serum LDL-cholesterol and CVD risk [13].

Figure 1 shows that beta-glucan, a dietary fiber, traps fatty acids aided by bile acid, interrupting the interaction between intestinal transporters and bile acid micelles [14]. Fat, bile acids, and cholesterol excretion rise due to this interaction, decreasing cholesterol levels and CVD risk. In an ApoE-deficient animal model, Han et al. found that oats supplemented with beta-glucan block atherosclerotic plaque formation and reduce chronic inflammation, decreasing CVD risk [15].

Oats high in beta-glucan delay gastric emptying and stimulate the gut-hypothalamic axis, increasing satiety and decreasing food intake. These adjustments reduce CVD risk by regulating BMI and central adiposity [16]. Since CVD is linked to chronic inflammation, beta-glucan-rich oats' anti-inflammatory characteristics help prevent it [16]. Cholesterol is converted into bile acid and eliminated when oat beta-glucan binds to bile acid.

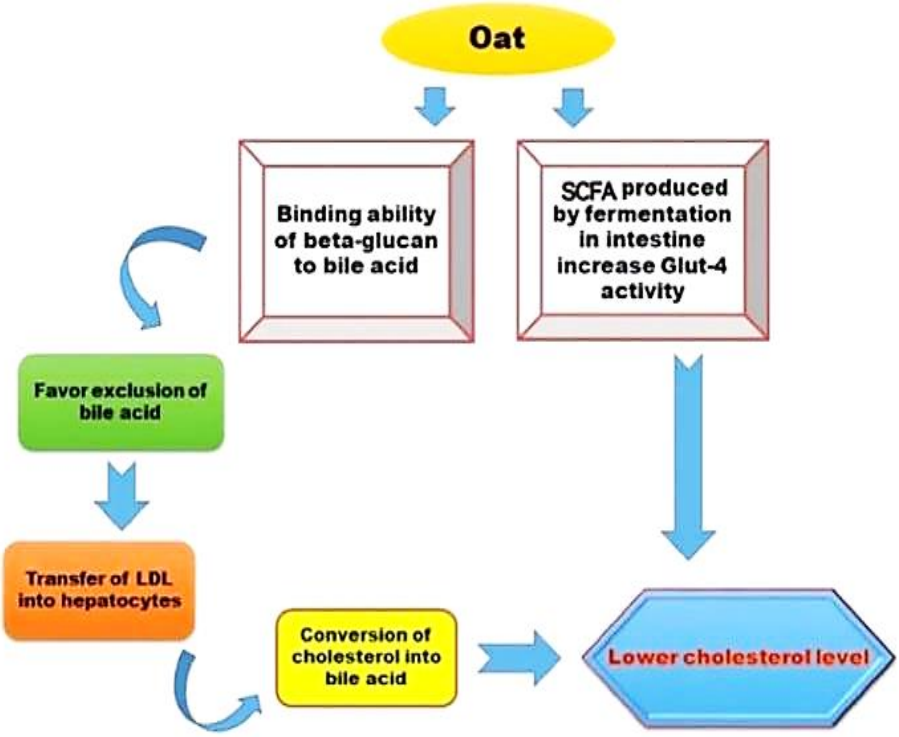

Figure 1. Cholesterol-reducing mechanism of oats [17].

3.3. Product comparison

Tables 3-5 compare Uncle Toby's Oats with six alternatives' nutrient values and pricing. To enhance readability, the comparisons will use the abbreviated form for the seven cereal products as shown in Table 2.

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Table 2. Product name and abbreviation [18-22].

Full product name	Product name abbreviation
Uncle Toby's Traditionally Oats	UTO
Kellogg's Rice Bubbles Puffed Rice Breakfast Cereal	KRB
Coles Rice Puffs	CRP
Woolworths Free From Gluten Cereal Cornflakes	WFC
Kellogg's Coco Pops Chocolatey Breakfast Cereal	KCC
Woolworths Crispy Rice Pops	WCR
Coles I'M Free From Special Flakes	CSF

4. Nutritional comparison

Table 3. Comparative analysis of nutritional content per serving: Uncle Toby's Oats versus alternative food products [18-22].

Nutritional Content	**Samples**						
	UTO	**KRB**	**CRP**	**WFC**	**KCC**	**WCR**	**CSF**
The size per serving (g)	40.0	35.0	30.0	30.0	30.0	30.0	Approximate. 10
Energy (kj)	640.00	574.00	489.12	473.00	492.00	Approximate. 503	567.14
Protein (gram)	5.10	2.60	2.16	2.20	1.70	Approximate. 2.5	2.49
Fat Content, Total (gram)	3.70	0.50	0.42	0.20	0.40	Approximate. .0.4	0.47
- Saturated fat (gram)	- 0.70	-0.10	- 0.09	- <0.1	- 0.10	-Approximate. 0.2	- 0.18
Carbohydrates Content (gram)	22.70	29.80	25.50	24.40	26.20	Approximate 26.2	29.25
- Sugar (gram)	- 0.40	-2.90	- 2.52	-1.20	- 9.70	-Approximate.1.5	- 3.30
Dietary Fibre (gram)	3.70	0.80	NG*	1.50	0.50	<1	1.29
- soluble (gram)	- 1.80	-NG*		- NG*	- NG*	- NG*	- NG*
- beta-glucan (gram)	- 1.60	-NG*		- NG*	- NG*	- NG*	- NG*
- insoluble (gram)	- 0.90	-NG*		- NG*	- NG*	- NG*	- NG*
Sodium	2 mg	147.00 mg	117 mg	92 mg	99 mg	Approximate.105 mg	41.65 mg
Vitamin E Content	NG*	NG*	2.49mcg	NG*	NG*	NG*	NG*
Vitamin B6 Content	NG*	NG*	0.39 mcg	NG*	NG*	NG*	NG*

NG* stands for not given.

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As delineated in Table 3, Uncle Toby's Oats stands out as offering the highest energy per serving at 640 kJ, notably surpassing other options such as Cornflakes, which delivers the minimum energy per serving at 473 kJ. The oats also lead in cholesterol and protein content per serving, with 3.7 g and 5.1 g respectively, outpacing other compared products. In specific, Uncle Toby's Oats records the maximum amount of saturated fat at 0.7 grams, representing four to seven times the quantity seen in the other alternatives, whose saturated fat content ranges vaguely between 0.1 g and 0.2 g. Conversely, Cornflakes registers the least fat content at 0.2 g, while Chocolatey Cereals has the lowest protein content at 1.7 g. Considering dietary fiber, Uncle Toby's Oats once again tops the list with the highest content at 3.7 g per serving, in stark contrast to the other alternatives, which demonstrate remarkably low levels, around 1 g per serving. On the carbohydrate front, however, Uncle Toby's Oats contains the minimum amount at 22.7 g per serving, including the least sugar content at 0.4 g. Puffed Rice Cereals have 29.8 g of carbohydrate per serving, but Chocolatey Cereals have 9.7 g of sugar per serving, three to twenty-four times more than similar products. Puffed Rice Cereals have 147 mg of sodium, while Uncle Toby's Oats have 2 mg.

Table 4. Comparative analysis of nutritional content per 100 g: Uncle Toby's Oats versus alternative food products [18-22].

Nutritional Content	**Samples**						
	UTO	**KRB**	**CRP**	**WFC**	**KCC**	**WCR**	**CSF**
Energy (kj)	1600.0	1640.0	1630.0	1580.0	1640.0	Approximate.1680	1620.4
Protein (gram)	12.80	7.40	7.20	7.40	5.70	Approximate. 8.2	7.11
Fat Content, Total (gram) - Saturated fat (gram)	9.20 - 1.70	1.30 -0.20	1.40 - 0.30	0.70 -0.20	1.20 - 0.30	Approximate. 1.4 -Approximate. 0.5	1.34 - 0.51
Carbohydrates Content (g) - Sugar (g)	56.70 - 1.00	85.00 -8.40	85.00 - 8.40	81.5 - 4.00	87.40 - 32.40	Approximate. 87.3 -Approximate.5	83.56 - 9.44
Dietary Fibre (gram) - Soluble (gram) - Beta-glucan (gram) - Insoluble (gram)	9.20 - 4.50 - 4.00 - 4.70	2.30 -NG* -NG* -NG*	NG*	5.00 -NG* -NG* -NG*	1.70 - NG* - NG* - NG*	<1 - NG* - NG* - NG*	3.68 - NG* - NG* - NG*
Sodium	6mg	420mg	390.00mg	308mg	330mg	Approximate. 350mg	119.00 mg
Vitamin E Content	NG*	NG*	8.30mcg	NG*	NG*	NG*	NG*
Vitamin B6 Content	NG*	NG*	1.30 mcg	NG*	NG*	NG*	NG*

NG* stands for not given

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Table 4 shows that all products average 1,600 kJ per 100 g. Among these, Uncle Toby's Oats distinctly stands out for its superior protein, fat, and dietary fiber content per 100 g serving, even though it registers lower carbohydrate and salt values in comparison to its counterparts. The sodium content differs greatly. Kellogg's Rice cereal has the greatest sodium content (420 mg per 100g), then comes Rice Puffs (390 mg per 100 g) and Rice Pops (350 mg per 100 g). Uncle Toby's Oats has the lowest sodium amount.

Further, Uncle Toby's Oats manifestly features the most significant fiber content (9.2g per 100 g), including soluble fiber (4.5 g per 100 g), beta-glucan (4.0 per 100 g), and insoluble fiber (4.7 g per 100 g). In contrast, other products merely provided an aggregate fiber content, with Cornflakes registering 5 g per 100 g and Special Flakes showing 3.68 g per 100 g. An exception is seen with Rice Puff, which failed to present a specific fiber content. Moreover, Rice Puff includes 8.30 mcg per 100 g of Vitamin E and 1.30 mcg per 100 g of Vitamin B6, whereas the nutritional composition table of other alternatives does not include this information.

Table 5. Comparative analysis of price per package and serving: Uncle Toby's Oats versus alternative food products [18-22].

Samples	Price per each package	Price per 100g	Servings Numbers	Price per each serving	Daily Price
UTO ($)	4.50	0.90	12	0.38	0.38
KRB ($)	5.00	2.00	7	0.71	0.71
CRP ($)	2.90	0.61	16	0.18	0.18
WFC ($)	3.00	0.80	12	0.25	0.25
KCC ($)	4.75	0.73	21	0.23	0.23
WCR($)	1.95	0.56	11	0.18	0.18
CSF ($)	4.50	1.20	35	0.13	0.13

As demonstrated in Table 5, a price comparison of the packages reveals that Puffed Rice Cereals are the most expensive (5 dollars), while Rice Pops stand as the most economical option (1.95 dollars). Therefore, Uncle Toby's Oats falls in the median range of pricing. When evaluated on a per day cost basis, Puffed Rice Cereals command the highest price (0.71 dollars), whereas Special Flakes come out as the most affordable (0.13 dollars). Despite having the same package price (4.5 dollars), Uncle Toby's Oats costs 0.38 dollars each serving, while Special Flakes costs 0.13 dollars. This discrepancy arises because Special Flakes accommodate more servings in each package. In conclusion, from the standpoint of per-day pricing, Uncle Toby's Oats does not present a price benefit over its competitors.

5. Discussion

Uncle Toby's Oats has pros and cons, though the general populace would then receive recommendations for this functional product based on its benefits and drawbacks.

5.1. Benefits

Oat beta-glucan modulated bile acid metabolism to reduce LDL-cholesterol, non-HDL-cholesterol, and apoB in a 6-week dietary intervention, according to a meta-analysis [23]. Oats also reduce lipid buildup,

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plasma cholesterol, cholesterol efflux, and cholesterol absorption to treat CVD [24]. Microorganisms can ferment oat-derived beta-glucan to create SCFAs. SCFAs benefit health, which reduce obesity and cardiovascular disease (CVD) by modifying energy metabolism and preventing lipid buildup. They also increase glucose transporter type 4 function, which improves glucose uptake and reduces the incidence of type 2 diabetes (T2D) [25-26]. Uncle Toby's Oats' soluble fiber reduces total serum cholesterol and LDL-cholesterol and improves insulin sensitivity, which lowers cardiovascular disease risk [7]. According to a study, oat -glucan reduces glycemic response and prevents cardiovascular disease by maintaining glucose-insulin homeostasis. Oat beta-glucan improved health with antioxidant and antibacterial properties [26].

Uncle Toby's Oats has the least sodium. Sodium reduction could lower blood pressure and cardiovascular disease risk [17]. Uncle Toby's Oats might have lupin, which slows platelet aggregation and reduces CVD risk [3].

5.2. Limitations

The product's elevated level of saturated fat is a drawback of Uncle Toby's Oats. Research indicates that saturated fat can potentially influence the function of blood vessels. Saturated fatty acids (SFA) raise LDL-cholesterol, a major risk factor for cardiovascular disease. [3]. LDL-derived lipids in the artery wall may lead to atherosclerotic plaques and CVD [11]. Researchers advise lowering saturated fat consumption to lower CVD risk [14]. Uncle Toby's Oats contains gluten, avenin, rye, wheat, lupin, and barley, which may cause allergic responses [7]. Oats' dietary fiber may slow metabolism and exacerbate persistent indigestion [27]. CVD prevention requires 75g of Uncle Toby's Oats because beta-glucan, its active ingredient, requires 3 g [6]. Since Uncle Toby's Oats has 40 g per serving, the average person cannot get the right dose unless they measure it.

5.3. Recommendation

beta-glucan-rich oats provide benefits for a number of chronic diseases, as described in the preceding section. Particularly, beta-glucan can reduce the risk of cardiovascular disease by inhibiting the absorption of cholesterol from the diet [28]. Besides, vegans can get high-quality plant protein from cereal lupin [27]. In contrast, abruptly switching from a diet low in fiber to one high in oats can cause gastrointestinal discomfort [29]. Oat components like lupin and gluten can induce chronic dyspepsia in certain people [27]. These concerns can be resolved by progressively raising oats to a suitable dosage as the digestive flora adapts. For the general population, oats reduce cardiovascular disease, however intolerant and allergic people should either avoid or eat small amounts.

6. Conclusion

Uncle Toby's Oats, as an example of functional cereal, are enriched with beta-glucan, an active compound that aids in averting atherosclerosis, reducing LDL-cholesterol levels, and managing weight, thereby mitigating the risk of cardiovascular disease (CVD). A daily intake of 75 grams of Uncle Toby's Oats is advised for optimal health benefits. The selection of the six alternatives was influenced by factors such as availability, cost, personal predilections, allergen considerations, and storage convenience. In comparison to its counterparts, Uncle Toby's Oats offers reasonable pricing. Uncle Toby's Oats have the highest concentration of saturated fats, yet low levels of carbohydrates and sodium per serving, making them a suitable choice for individuals focusing on weight management and those with elevated LDL cholesterol levels. Due to its nutritional profile and health-enhancing properties, Uncle Toby's Oats offers a range of potential benefits, although achieving the active dose can be challenging. It is advisable for the general populace to incorporate functional cereal rich in beta-glucan into their diet to decrease their CVD risk.

This study contrasts the nutritional profiles of Uncle Toby's Oats and other popular breakfast cereals. Individual dietary needs and reactions can vary considerably. While the benefits of beta-glucan and functional cereals are well-documented, individual responses to these dietary modifications may vary. In addition, our research does not account for other lifestyle factors that may influence the risk of

cardiovascular and cerebrovascular disease, such as physical activity, smoking, and total calorie intake. To better comprehend the long-term effects of beta-glucan-rich functional cereals on the risk of cardiovascular and cerebrovascular disease, additional research is required. It would be advantageous to conduct research involving diverse populations and additional dietary and lifestyle variables. In addition, the development of standard measurements for the beta-glucan content of functional cereals could significantly contribute to the establishment of more precise dietary recommendations. In addition, ongoing research is examining the potential benefits of beta-glucan beyond cardiovascular health, such as its impact on gastrointestinal health and role in blood sugar regulation, which may further emphasize the significance of functional cereals in a healthy diet.

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