The Slow Rise of Sourdough: A Nutrition Audit of the Bread Category Highlights Whole Grain

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This is an Accepted Manuscript of an article published by Taylor & Francis in INTERNATIONAL JOURNAL OF FOOD SCIENCES AND NUTRITION on 22 May 2023, available at: *https://doi.org/10.1080/09637486.2023.2213858*

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The popularity of sourdough bread has increased, however traditional methods and ingredients may not always be used. This study compared the Australian bread category (October 2019 and 2021), examining nutrition and health issues with a specific focus on sourdough products. Data from Sydney supermarkets (Aldi, Coles, IGA, Woolworths) and a bakery franchise (Bakers Delight) collected ingredients, nutrition information and on-pack claims. Product numbers increased 20% between timepoints (n=669 v n=800), led by flatbread (+100%). Sourdough (14%) grew +50% ahead of traditional white wheat (+35%), gluten free (+12%), wholemeal (+5%) and multigrain breads (-31%). Half of all products (n=408) met the Healthy Food Partnership sodium reformulation targets. Fermentation claims increased 86% although products included non-traditional ingredients. Whole grain varieties (25%) remain the most nutritious choice within the category. Without a definition, fermentation claims may distract consumers, creating a 'health halo' for sourdough products although health benefits are yet to be substantiated.

Keywords: sourdough, bread, whole grain, fermentation, dietary fibre, claims

Introduction

Bread is a core food in the diet and considered a staple in many countries around the world. Although bread products are most often made from wheat, this often depends on the predominant cereal grain grown in a particular country, with rye bread dominating the northern European region and other cereal grains and pseudo-grains such as buckwheat, quinoa and amaranth also used. In Australia, bread is widely consumed and is utilised within the food system as a food vehicle for mandatory fortification of some key at-risk micronutrients. This includes thiamin (since 1991), folate and iodine (since 2009) (Food Standards Australia New Zealand 2016a). Although two thirds of Australians reported consuming regular bread in the last National Nutrition and Physical Activity Survey (NNPAS) in 2011-12, this was mostly white bread (58%) rather than

whole grain varieties (Australian Bureau of Statistics 2012).

Despite population-level declines in bread consumption, which are possibly due to negative media attention, beliefs about carbohydrate content and perceptions regarding processing (Grafenauer S and Curtain F 2018; Foster S et al. 2020; Estell ML et al. 2021; Krois N et al. 2022), there is innovation within the bread category, and interest in sourdough products. Sourdough is both a noun and a verb, and this type of bread making process is the oldest way of leavening bread. Traditional sourdough is characterised by a significant period of fermentation, using "starter", a mixture of flour, water and salt, spontaneously fermented through the synergistic effects of Lactic Acid bacteria and naturally occurring wild yeast populations, which leaven and acidify the product (Gobbetti M et al. 2019) producing carbon dioxide. Despite this, there is no consensus on the definition of sourdough and therefore no protection for consumers, with the largest differences in processing existing between artisan bakeries and large scale manufacturers (Brandt MJ 2019).

The process of making true sourdough is highly technical, and the conditions differ greatly from that used in standard bakery with baker's yeast which has dominated for 150 years. In yeast bakery, the protein in the cereal grain (particularly the prolamines) are not hydrolysed to any extent by proteases, compared with sourdough which degrades the gluten network impacting both the gliadin and glutenin proteins (Graça C et al. 2021). Although the lactic acid bacteria (LAB) *Lactobacillus Sanfranciscensis,* and the yeast *Candida Humilis* are typically present (Ribet L et al. 2023), the use of a sourdough culture (through 'backslopping'), means that the bacteria and yeasts present are highly variable. In particular, the precise species of bacteria present in the environment, the type and variety of flour (Shewry PR et al. 2022), the fermentation temperature and time and the pH achieved, may all vary, making it

difficult to translate results from the experimental setting to bakeries and the bread chosen by consumers (Ribet L et al. 2023). In the literature, there are calls to validate methods, ingredient inclusions, and authenticate the processes across the industry, in order to assist with regulatory frameworks (Brandt MJ 2019).

Sourdough preparations are known to impact the rheological properties of baked goods, the sensory properties and shelf life, but also functional and nutritional properties, retarding starch digestibility, lowering the glycaemic index, enhancing mineral bioavailability, phytochemicals (antioxidants, phytochemicals), degrading gluten and masking low sodium content (Gobbetti M et al. 2019; Ribet L et al. 2023). Sourdough processes have been noted to decrease fructans, degrading them to fructose and sucrose and then to lactic acid (Menezes LAA et al. 2018). Prolonged sourdough fermentation has been shown to reduce Fermentable Oligosaccharides, Disaccharides, Monosaccharides and Polyols (FODMAPs) levels up to 90% (Ziegler JU et al. 2016) and assist with IBS symptoms compared to baker's yeast breads and those made with the now widely used Chorleywood process (Gobbetti M et al. 2019).

FODMAPs are a heterogeneous group of compounds which are generally good for bowel health and the microbiota. These include lactose, fructose, fructans, fructooliogosaccharides (FOS) and galacto-oligosaccharides (GOS), where the intake across a day is summative from a wide variety of food sources. Fructans and FOS are the main FODMAPs in wheat-based bread, and although wheat is relatively low in fructans, the amount of bread consumed means it is one of the largest dietary sources (Whelan et al. 2018). For those with suspected FODMAP issues, wheat-based bread may be removed from the diet alongside other key food sources until symptoms subside (Whelan et al. 2018).

The aim of this study was to review and compare the nutritional profile and on pack claims from the Australian bread category across two time points (October 2019 and 2021) with a specific focus on products categorised as sourdough and includes a review of pertinent nutrition issues for the category.

Materials and Methods

In October 2019, a survey of products using a recognised process (Dunford et al. 2012; Grafenauer S and Curtain F 2018) from four supermarkets and a bakery franchise (Bakers Delight™) in metropolitan Sydney (Woolworths, Neutral Bay; Independent Grocers of Australia (IGA), Cremorne; Coles, Neutral Bay; Aldi, North Sydney) collected ingredient lists, nutrition information and on pack claims for loaf breads, bread rolls, sandwich alternatives and flatbreads. Together, these supermarkets represented approximately 80% of the Australian market share in 2022 (Statista 2022). Bakers Delight™ is an Australian owned bakery franchise chain with over 700 stores across Australia, New Zealand, USA and Canada (Cobs Bread) (Bakers Delight 2023). Permission to visit each of the local supermarkets was sought prior to the audit process, and consent was requested from the store manager to proceed on the day of the audit. In supermarkets, photographs were taken with smartphones of all available products within each bread category. Researchers captured all sides of the food packaging and ensured inclusion of the ingredients list, the nutrition information panel (NIP) and presence of nutrition content and health claims. Only products available on supermarket shelves and in-store bakery products with nutrition information panels were included in the survey. Following in store data collection, all data was cross-checked and supplemented with information provided on manufacturer, brand and retailer websites (e.g., Coles and Woolworths online) and the Mintel Global New Products Database to ensure any missing products that were not available on supermarket shelves were recorded.

Nutrition data for Bakers Delight™ products were collected from their website as this information is not declared on the packaging that is supplied to consumers. The data collection process was replicated two years later in October 2021, however due to the impact of the COVID-19 pandemic, the data collection process from 2019 was reversed i.e. online searches of bread products from manufacturer, brand and retailer websites and the Mintel Global New Product Database were conducted first, and data was then supplemented by instore data collection methods.

Following data collection, bread products were assigned to one of four categories including bread loaves (sliced and unsliced); bread rolls (lunch and hot dog rolls); sandwich alternatives (wraps, tortillas, sandwich thins, Lebanese and pita bread) and flatbreads (pizza bases, focaccia, flat bread, Turkish and Indian bread). This categorisation of bread products has been used previously (Grafenauer S and Curtain F 2018). Products were further classified by bread/ flour type according to the product name (e.g., multigrain, gluten free, white, wholemeal/ whole grain and sourdough). For wholemeal/ whole grain breads, the Whole Grain Initiative definition of whole grain as a food ingredient was utilised: "whole grains shall consist of the intact, ground, cracked, flaked or otherwise processed kernel after the removal of inedible parts such as the hull and husk. All anatomical components, including the endosperm, germ, and bran must be present in the same relative proportions as in the intact kernel" (van der Kamp et al. 2021). In Australia, wholemeal is also considered whole grain (Food Standards Australia New Zealand 2016b). Products excluded from the study included bakery breakfast products (e.g., bagels, brioche, crumpets, English muffins, fruit bread, waffles fruit bread, pancakes/ pikelets), savoury flavoured products with toppings (e.g. cheese and bacon rolls), sweet breads including iced varieties, crispbreads, breadsticks / baguettes and bread mixes.

Statistics

The information obtained from the photographs and online sources was transcribed into a Microsoft® Excel® spreadsheet (Version 2302, Redmond, Washington, USA). For each product, the complete ingredients list, the nutrition information per serve and per 100g, and verbatim nutrition content and health claims were recorded. Following data collation, the information was independently checked by a second reviewer for any errors. All data were checked for normality using Shapiro–Wilks (IBM SPSS®, version 28.0.1, IBM Corp., Chicago, IL, USA) and the median and range for select nutrients were presented, including the energy, protein, carbohydrate, dietary fibre and sodium content. These nutrients were selected based on the results of the 2011-12 Australian Health Survey (Australian Bureau of Statistics 2012). In Australia, regular breads and bread rolls were the leading contributor to dietary fibre (12.7% of total intake) and carbohydrate (11.5%) intake for all persons aged 19 years and older (Australian Bureau of Statistics 2012). Likewise, regular breads and bread rolls were the second leading contributor to sodium intake (12.6%) and the fourth leading contributor to protein intake (7.1%). As bread and bread rolls contributed less than 3% of total fat and saturated fat intake, these nutrients were excluded from the analysis (Australian Bureau of Statistics 2012). A Kruskal-Wallis one-way ANOVA with Bonferroni correction for multiple tests (IBM SPSS®, version 28.0.1, IBM Corp., Chicago, IL, USA) was used to determine differences in the nutrition composition between four bread categories. Descriptive analysis was used to present the change in product type within the bread category over time, nutrition and health claims and proportion of products that met the Healthy Food Partnership sodium reformulation targets of less than or equal to 380 mg sodium per 100 g for leavened breads and less than or equal to 450 mg sodium per 100 g for flatbreads (Department of Health Australian Government 2023).

Results

Category Overview

Data from 800 bread products on the Australian market were collected in October 2021 including 359 loaf breads, 178 sandwich alternatives, 136 flatbreads and 127 bread rolls (Table 1). From 2019 (n=669) to 2021 (n=800), the total number of bread products had increased by 20%, with growth seen in all categories excepts for bread rolls which decreased slightly. Notably, the number of flatbread products had doubled from 2019 to 2021.

Table 1: Nutrition comparison (median and range) of all breads (n = 800) per 100g.

	Loaves (n = 359)	Sandwich Alternatives (n = 178)	Flatbreads (n = 136)	Rolls (n = 127)	p-value*
Energy (kJ)	1030 (632-1490)[bcd]	1185 (821-1420)	1130 (695-1969)[b]	1090 (848-1380)[b]	0.000
Protein (g)	9.0 (1.1-33.1)	9.0 (1.9-26.0)	8.2 (0.6-16.0)[abd]	9.0 (1.4-27.8)	<0.001
Carbohydrate (g)	42.0 (2.8-61.7)[bcd]	45.7 (5.7-59.2)	44.8 (18.3-71.0)	46.0 (4.0-58.0)	<0.001
Dietary Fibre (g)	5.6 (1.0-25.7)	4.3 (1.2-33.5)[a]	2.9 (0-19.6)[abd]	4.3 (2.3-25.7)	<0.001
Sodium (mg)	390 (178-1300)[c]	400 (38-1070)[c]	476 (36-1220)	392 (232-1300)[c]	<0.001

*Kruskal-Walis one-way ANOVA with Bonferroni correction 95% CI
Superscript letters indicate significant differences ($p < 0.05$) following paired comparisons with Bonferroni correction compared with: (a) loaves; (b) sandwich alternatives; (c) flatbreads; (d) rolls.

In 2021, half of all bread products were made from white wheat flour, followed by wholemeal/ whole grain varieties (20%), sourdough (14%), gluten free (10%) and multigrain breads (7%) (Table 2). A similar trend was noted in 2019, except the number of multigrain breads had since decreased by 31% and sourdough breads increased by

50%. Notably, the growth within the sourdough category was driven mostly by whole grain varieties which almost doubled in number (23 products in 2019 compared to 40 products in 2021) (Table 2).

Table 2: Classification of bread products in 2019 and 2021 (includes loaves, rolls, sandwich alternatives and flatbreads) and change over time.

	2019 n (% of total)	**2021 n (% of total)**	**Change 2019 - 2021**
Sourdough*	72 (11)	108 (14)	50%
Whole Grain Sourdough	23 (3)	40 (5)	74%
White Sourdough	34 (5)	55 (7)	62%
Multigrain Sourdough	15 (2)	13 (2)	-13%
White	294 (44)	397 (50)	35%
Gluten Free	73 (11)	82 (10)	12%
Wholemeal/ Whole Grain	153 (23)	160 (20)	5%
Multigrain	77 (12)	53 (7)	-31%
Grand Total	**669**	**800**	**20%**

Nutrient Comparison

A nutrient comparison of the bread category is presented in Appendix A. Given the aim of the paper, the analysis focused on the nutrient comparison between white and whole grain sourdough and regular loaf breads (Table 3). There were significant differences in the energy, protein, carbohydrate, dietary fibre and sodium content of sourdough and regular loaf breads (Table 3).

Table 3: Nutrition composition and comparison (median and range) of select loaf bread sub categories (n = 265) per 100g.

Nutrient per 100g	White Sourdough Loaves (n = 41)	Whole Grain Sourdough Loaves (n = 37)	Regular White Loaves (n = 102)	Regular Whole Grain Loaves (n = 85)	p-value*
Energy (kJ)	1020 (632-1140)	1020 (896-1300)	1050 (802-1320)	995 (781-1303)[c]	0.032
Protein (g)	8.5 (5.3-10.6)[bd]	10.0 (8.2-16.5)	8.5 (7.3-20.2)[bd]	10.6 (5.5-33.1)	< 0.001
Carbohydrate (g)	45.0 (29.0-49.9)	40.8 (30.7-50.1)[ac]	46.3 (9.6-56.0)	37.9 (5.4-49.4)[abc]	< 0.001
Dietary Fibre (g)	3.2 (1.0-5.9)[bd] (n = 27)	6.0 (3.8-11.3) (n = 31)	3.1 (2.1-25.7)[bd] (n = 78)	7.0 (2.9-17.0) (n = 74)	< 0.001
Sodium (mg)	480 (286-667)	350 (178-603)[a]	394 (274-628)[a]	379 (186-584)[a]	< 0.001

*Kruskal-Walis one-way ANOVA with Bonferroni correction 95% CI

Superscript letters indicate significant differences ($p < 0.05$) following paired comparisons with Bonferroni correction compared with: (a) white sourdough loaves; (b) whole grain sourdough loaves; (c) regular white loaves; (d) regular whole grain loaves.

Regular white loaves were the highest in energy (1050 kJ/100g), while regular whole grain loaves contained the lowest energy (995 kJ/100g) and were significantly lower than regular white loaf breads ($p = 0.026$).

Regular whole grain loaves were the highest in protein (10.6g/100g), closely followed by whole grain sourdough breads (10g/100g). White sourdough and regular white loaves were both significantly lower in protein compared to whole grain sourdough ($p = 0.001$ and $p = 0.001$, respectively) and regular whole grain loaf breads ($p = 0.000$ and $p = 0.000$, respectively).

Similar findings were observed for dietary fibre. Regular whole grain loaf breads were the highest in dietary fibre (7.0g/100g), followed by whole grain sourdough products (6.0g/100g). White sourdough breads were the lowest in dietary fibre (3.2g/100g) and contained significantly less dietary fibre compared to whole grain sourdough ($p = 0.000$) and regular whole grain loaves ($p = 0.000$).

White sourdough loaves were also the highest in sodium (480mg/100g), while whole grain sourdough breads contained the least amount of sodium per 100g (350mg/100g). Regular white loaf breads, whole grain sourdough and regular whole grain loaf breads were all significantly lower in sodium compared to white sourdough products ($p = 0.018$, $p = 0.001$ and $p = 0.000$, respectively).

Whole Grain Content

Overall, the median whole grain content of wholemeal/ whole grain breads (including sourdough varieties) (n = 200) was 44% or 28 grams of whole grain per serve (average serve size was 70g), with over half of products (54%) containing ≥25% whole grain and 32% containing ≥50% whole grain. Wholemeal bread rolls were the highest in whole grain, containing 61% whole grain (median), followed by loaves (44% whole grain, 32g/ serve), sandwich alternatives (39% whole grain, 18g/serve) and flatbreads (31% whole grain, 30g/serve).

Healthy Food Partnership Sodium Reformulation Targets

Half of all bread products overall (51%, n = 408) met the sodium reformulation targets of ≤380 mg/100g for leavened breads (n = 505) and ≤450 mg/100g for flatbreads (n = 295) (Table 4). For leavened breads specifically, 48% met the sodium reformulation target of ≤380 mg/100g, an improvement compared to 2019 where only 31% of leavened breads met the target. For sourdough leavened breads (n = 99), 42% met the target, the majority of which were whole grain varieties (55%), with only one quarter of white leavened sourdough products meeting the target.

From 2019 to 2021, the proportion of flatbreads that met the sodium target of ≤450 mg/100g had increased from 47% (n = 90) to 57% (n = 168). The majority of wholemeal/ whole grain flatbreads (77%) and sourdough flatbreads (56%) met the

target, while less than one quarter of gluten free and multigrain flatbreads contained ≤450 mg of sodium per 100g (Table 4).

Table 4: Sodium content (mg) per 100g (median and range) and compliance with the Healthy Food Partnership Sodium Reformulation Targets for 2021 data.

	Products that met the HFP Targets **n (% of subcategory)**	**Products that did not meet the HFP Targets** **n (% of subcategory)**	**Sodium content (mg) per 100g**
Leavened Breads (≤380mg/100g) (n = 505)	**240 (48)**	**265 (52)**	**390 (178 - 1300)**
Multigrain (n = 47)	29 (62)	18 (38)	380 (296 – 530)
Wholemeal/ Whole Grain (n = 107)	58 (54)	49 (46)	379 (186 – 728)
White (n = 186)	84 (45)	102 (55)	392 (273 – 1220)
Sourdough* (n = 99)	42 (42)	57 (58)	392 (178 – 840)
Gluten Free (n = 66)	27 (41)	39 (59)	400 (232 – 1300)
Flat Breads (≤450mg/100g) (n = 295)	**168 (57)**	**127 (43)**	**430 (36 – 1210)**
Wholemeal/ Whole Grain (n = 53)	41 (77)	12 (23)	400 (145 – 978)
Sourdough* (n = 9)	5 (56)	4 (44)	428 (372 – 656)
White (n = 211)	115 (55)	96 (45)	440 (38 – 1210)
Gluten Free (n = 16)	6 (38)	10 (63)	485 (36 – 860)
Multigrain (n = 6)	1 (17)	5 (83)	502 (400 – 1070)

*Includes both wholemeal/ whole grain, multigrain and white wheat products.

Ingredients in Sourdough Bread

From this analysis, 83% of sourdough breads (n = 90) contained a range of additional ingredients not traditionally used in sourdough methods including added yeast (44% of sourdough products), wheat malt flour (49%), wheat gluten (30%), emulsifiers (24%), vinegar (15%), lecithin (7%), raising agents/ baking powder (6%), acidity regulators (3%), preservatives (3%), bread improver (3%), humectant (2%) and stabilisers (1%).

Nutrition Content and Health Claims

Most bread products displayed at least one nutrition content or health claim (85%, n = 684). Between 2019 and 2021, the top three nutrition content claims remained the same and included plant-based, dietary fibre and protein related claims (Table 5). The largest

increase in nutrition claims on bread products were carbohydrate related claims (e.g., low carb, 'x% reduced carbohydrates') which increased from 17 to 54 claims (threefold increase). The number of products displaying a general level health claim related to vitamins or minerals doubled from 2019 (n = 11) to 2021 (n = 23) (e.g., Naturally enriched with essential vitamins and minerals to promote health and well-being, iron & zinc to support normal immune function, magnesium to support nerve and muscle function). Similarly, general health claims promoting dietary fibre for digestive health were found more frequently in 2021.

Table 5: Nutrition content and health claims displayed on all bread products in 2019 (n = 669) and 2021 (n = 800).

	2019 n (% of total products)	**2021 n (% of total products)**	**Change 2019 - 2021 (%)**
Nutrition Content Claim			
Carbohydrate	17 (3)	54 (7)	218%
Energy	11 (2)	20 (3)	82%
Salt	22 (3)	39 (5)	77%
Sugar	78 (12)	134 (17)	72%
FODMAP	16 (2)	24 (3)	50%
Fat	83 (12)	124 (16)	49%
Plant-Based*	279 (42)	410 (51)	47%
Gluten Free	81 (12)	113 (14)	40%
Protein	125 (19)	173 (22)	38%
Dietary Fibre	203 (30)	275 (34)	35%
Vitamins & Minerals	45 (7)	49 (6)	9%
Whole Grain	108 (16)	104 (13)	-4%
General Level Health Claims			
Vitamins & Minerals	11 (2)	23 (3)	109%
Dietary Fibre and Digestive Health	20 (3)	36 (5)	80%
Low Glycemic Index	29 (4)	43 (5)	48%
Protein and Muscle Growth and/or Repair	9 (1)	11 (1)	22%
Beta Glucan and Cholesterol Lowering	2 (0)	2 (0)	-

*Includes the terms 'plant-based', 'plant protein' and suitable for vegetarians and vegans claims.

Sourdough On-Pack Claims

In 2021, twenty-eight products made at least one on-pack claim related to sourdough fermentation, an increase of 86% compared to 2019. The majority of which displayed a claim related to long fermentation (n = 21), highlighting the time taken for the sourdough to leaven, ranging from 8 hours (n = 1) to 30 hours (n = 9), 36 hours (n = 3), 48 hours (n = 2) and 72 hours (n = 2) (e.g. 30-hour dough fermentation, fermented for 48 hours, 8-hour recipe). Eleven products made a claim about the natural process of making sourdough (e.g. naturally leavened for 36 hours, naturally fermented sourdough, natural sourdough, 40% Natural Culture) and six products referred to a traditional sourdough recipe/ fermentation process (e.g. slowly & traditionally fermented, …. allow the dough to rise slowly and naturally without using yeast, the way it always did before there were additives and industrial processing, crafted using traditional sourdough fermentation method).

Discussion

Bread may appear a homogenous food category, however this analysis of the nutritional profile clearly points to whole grain product varieties across both sourdough and mainstream loaves as higher in dietary fibre and protein and lower in sodium. The increase in sourdough product numbers within the bread category seems to indicate increasing acceptability of sourdough products among consumers with loaves, rolls and flat bread products now available, most of which were whole grain. The growth was independently validated by MINTEL, with a doubling of product numbers between 2019 and 2020 (Mintel Global New Product Database 2021). In consideration of the global burden of disease data consistently indicating low whole grain intakes as problematic in driving morbidity and mortality (Afshin et al. 2019), a potential strategy to assist more Australians in meeting the whole grain target intakes may be to further

promote whole grain sourdough products, perceived as ‘natural’ (Ribet L et al. 2023). Bread and breakfast cereals already contribute the largest source of whole grain in Australian diets, with bread providing 20%, cereals 40% and a further 19% from ‘other breads’ like tortillas (Grafenauer S and Curtain F 2018). Swapping to whole grain is a key communication message for organisations like the Grains & Legumes Nutrition Council in Australia, the Whole Grain Council in the US and the Global Whole Grain Initiative, with evidence supporting healthcare cost savings based on data from Australia (Abdullah MMH et al. 2021a, 2021b), the US (Murphy MM and Schmier JK 2020) and Finland (Martikainen et al. 2021) across a range of disease areas. Fortunately, the growth in this sub-category was driven by a greater number of whole grain products with an average of 44% whole grain content, equivalent to 28g/serve, just short of 60% of the 48 g whole grain Daily Target Intake (Griffiths T 2007).

Diets high in sodium consistently rank as the number one issue in terms of the global burden of disease (Afshin et al. 2019), and bread makes a contribution to this within dietary patterns, 12.8% in Australia (Australian Bureau of Statistics 2012). However, sodium, in the form of sodium chloride or salt, plays an important functional role in bread. Sodium plays role in controlling yeast and stabilising gluten (O’Connor Á 2012) and is important for managing bread dough as it moves through modern production lines. Sodium also assists with shelf life, the final texture and flavour of the bread (Trevena H et al. 2014). However, there is scope for sodium reduction, and as little as 300 mg/100 g has been trailed in acceptance testing in a remote Indigenous community in the Northern Territory of Australia (McMahon E et al. 2016; McMahon E et al. 2017). Over time, sodium has been gradually reduced with a mean of 434mg/100g (n=94 sliced loaves) and 435mg/100g (n=99 sliced loaves) reported in 2007 and 2010, respectively (Dunford EK et al. 2011), 415mg/100g (n=177) in 2013 (Trevena H et al.

2014), and in 2017 the median was 400mg/100g (n=456) (Grafenauer S and Curtain F 2018). From this most recent analysis, the sodium level across all breads examined was maintained, at 394mg/100g in white sliced loaves, 379mg/100g in regular whole grain loaves and 350mg/100g in whole grain sourdough varieties. In this analysis, greater than 50% of breads complied with the sodium reformulation guidelines set by the Healthy Food Partnership.

Due to the multiple functions of sodium in bread, a new focus, on exchanging sodium chloride (NaCl) for potassium chloride (KCl) has commenced, championed by The George Institute for Global Health (Huang L et al. 2020; Neal B et al. 2021). Although a range of cations have been considered (Reißner AM et al. 2019), potassium (K+) is the most similar cation to Sodium (Na+) when considering its physicochemical properties (Marco ER et al. 2022) as it is a naturally occurring mineral salt, obtained in a manner similar to NaCl extracted from rock and sea salts. In addition to the salt taste, K+ plays a role in blood pressure regulation which makes it a suitable replacement ingredient (Neal B et al. 2021). However, in moist products, at very high levels, KCl can induce bitterness and metallic-taste (Saavedra-Garcia L et al. 2015). Research with bread has shown it was possible to reduce the salt content by about one third (Salovaara H 1982) with no detectable difference in taste and KCl could replace up to 20% of the NaCl normally utilised in baking without detracting from flavour. By replacing NaCl in with KCl in whole grain and white bread, research has found that up to 30% of the NaCl could be replaced with similar acceptability scores to the standard product (Charlton KE et al. 2007) and others up to 50% (Marco ER et al. 2022).

It is worth noting that the change to KCL would also need to be tested with the addition of iodine as mandatory fortification of iodised salt is a key public health measure in the Australian market and the change may impact cost of goods.

Breads/bread rolls were the largest contributor of iodine (38.1 - 31.8 mcg/day, 72%), followed by English-style muffins, flat breads and savoury and sweet breads (5.1 -12.2 mcg/day, 10%) in the Australian diet. Findings demonstrated that those consuming ≥100 g/day (approximately 2.5 slices) were five times more likely to be achieving an adequate iodine intake (OR 5.0, 95% CI 4.96–5.13; $p < 0.001$) compared to lower bread consumption in women and 12 times in children (OR 12.34, 95% CI 1.71–89.26; $p < 0.001$) (Charlton K et al. 2016). The level of iodine required by mandatory fortification to be added to salt used in the bread-making process was modelled using bread consumption patterns of 100 g/day, equating to approximately three slices and 45mcg/100g bread (Grafenauer S and Curtain F 2018). However, only 8%–9% of Australian women and children were consuming bread at the level modelled by Food Standards Australia New Zealand when the fortification standard was put in place.

Sourdough bread products may be considered unique within the bread category, perceived as natural and have a 'health halo'. Consumers may believe these products are better for health, regardless of whether this can be validated through the claims or other labelling information. To date, research has not established a clear health benefit for sourdough in comparison to normal yeast breads (Ribet L et al. 2023). Systematic reviews regarding improved glycaemic control and satiety from sourdough consumption compared with normally produced bread have not demonstrated distinct favourability (Rolim ME et al. 2022), although whole wheat products perform better than refined flour products in terms of postprandial glycaemia. As such, there are no endorsed health claims in the US nor a standard of identity for artisan or sourdough bread (Carson 2023; Food and Drug Administration 2023). In Australia, manufacturers are using claims indicating fermentation time, although other ingredients known to influence raising are often added. In Europe there are differences between countries regarding ingredients

permitted, for example in Austria and Germany no yeast can be added, whereas in the Czech Republic yeast is allowed. In Spain, the quality standard for bread and speciality bread products including sourdough, states that the 'mother mass' is equal or greater than 15% of dough and the preparation takes more than 15 hours without interruption. Within this decree, baker's yeast is permitted and the claim, 'with long fermentation sourdough' can be used on product labelling (European Commission 2018). In the UK there are movements by the 'Real Bread Campaign', a collaboration of five trade bodies, to legitimise a definition for sourdough lobbying the Department for Environment, Food and Rural Affairs for an Honest Crust Act since 2009 (Mehmet S 2019).

Sourdough bread is not safe for those with coeliac disease to consume (unless gluten free flours are used), it may however be better tolerated by those with intolerances. Reportedly, 70% of IBS patients respond to a low FODMAP diet (Seal CJ et al. 2021), ideally with the guidance of a health professional. Tolerance may be due to reductions in fructans where bread is made from wheat (Ziegler JU et al. 2016) and rye (Graça C et al. 2021), however there may be specific strains of yeasts that are more effective at producing inulinases, enzymes that are better at degrading fructans compared with invertases (Graça C et al. 2021; Seal CJ et al. 2021). Proofing time of as little as 4.5hrs appeared to be sufficient to reduce fructans by 90% in wheat bread, 77% in spelt bread (Ziegler JU et al. 2016), and 62% decrease in rye bread (Nyyssölä A et al. 2020). Similarly, the acidic conditions during sourdough processes are essential to encourage the proteolytic breakdown of prolamin and up to 95% is possible, lowering gluten content (Graça C et al. 2021). Refining and translation of this experimental work may be an opportunity for the bakery industry. However, there are marked differences between experimental conditions versus loaves produced in bakeries, and there are

complexities when comparing sourdough to breads produced using commercial yeasts and chemical leavening (Arora et al. 2021; Ribet L et al. 2023).

There are limitations to providing an absolute overview of this food category due to the contribution of small, local bakeries to bread consumption. Regarding the nutrition information collected, it is not mandatory to report the dietary fibre in the NIP unless there is an on-pack claim related to dietary fibre. Similarly, reporting whole grain is voluntary, so whole grain content (as a percentage) may not always be declared and as such, there may be missing data. The products in the white loaves category also include those with added dietary fibre, so figures for dietary fibre may be inflated. We did not conduct our own analysis of nutrient content and were reliant on the data declared by the manufacturer, and this is an unavoidable limitation, but at the same time, presents what is available to the consumer. All care was taken to ensure the quality of the data and limit error in tabulation through quality checking by an independent reviewer and packaging photographs assisted with this process.

Conclusion

Sourdough bread is growing within the bread category between the time points examined, alongside very strong growth in the usage of fermentation claims. There are some reported benefits of traditional sourdough processing for gut health, reducing FODMAPS due to the prolonged fermentation processes in the presence of lactic acid bacteria and wild yeasts. For food industry, creating sourdough breads that are intentionally lower in fructans may be an opportunity. However, there are some concerns regarding claims promoting fermentation time without guidance about permitted ingredients. The addition of ingredients such as commercial baker's yeasts, improvers and other raising agents are commonly added to products indicating they are not produced specifically utilising the traditional methods of the sourdough process.

The compelling fermentation claims may influence consumers to purchase products without realising this lack of authenticity. In any case, the analysis of nutritional profile supports selection of whole grain products – either sourdough or normally manufactured whole grain bread in preference to refined varieties due to higher dietary fibre, protein and lower sodium. Further research considering both the industrial and artisan environment should aim to more precisely determine optimal bacterial species and yeasts, with a view to identifying health benefits.

Funding

This research received no external funding, however the data was provided without charge by the Grains & Legumes Nutrition Council, a not-for-profit charity. The Grains & Legumes Nutrition Council had no role in the design, execution, interpretation and writing of the study or in the decision to publish the results.

Disclosure Statement

Jaimee Hughes has no conflicts of interest to declare; Sara Grafenauer is a member of the governing board for the Whole Grain Initiative and a board member of Oat Australia.

Data Availability Statement

All data for this study are contained within the article.

Acknowledgments

The authors would like to acknowledge the Grains & Legumes Nutrition Council for the supply of the data base utilised in this research without charge.

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Appendix A

Table A1: Nutrition comparison (median and range) of all breads (n = 800) per 100g.

	Loaves (n = 359)	Sandwich Alternatives (n = 178)	Flatbreads (n = 136)	Rolls (n = 127)	p-value*
Energy (kJ)	1030 (632-1490)[bcd]	1185 (821-1420)	1130 (695-1969)[b]	1090 (848-1380)[b]	0.000
Protein (g)	9.0 (1.1-33.1)	9.0 (1.9-26.0)	8.2 (0.6-16.0)[abd]	9.0 (1.4-27.8)	<0.001
Carbohydrate (g)	42.0 (2.8-61.7)[bcd]	45.7 (5.7-59.2)	44.8 (18.3-71.0)	46.0 (4.0-58.0)	<0.001
Dietary Fibre (g)	5.6 (1.0-25.7)	4.3 (1.2-33.5)[a]	2.9 (0-19.6)[abd]	4.3 (2.3-25.7)	<0.001
Sodium (mg)	390 (178-1300)[c]	400 (38-1070)[c]	476 (36-1220)	392 (232-1300)[c]	<0.001

*Kruskal-Walis one-way ANOVA with Bonferroni correction 95% CI

Superscript letters indicate significant differences ($p < 0.05$) following paired comparisons with Bonferroni correction compared with: (a) loaves; (b) sandwich alternatives; (c) flatbreads; (d) rolls.