

Optimising Nutritional Intake in Plant-Based Diets: A Functional Sourdough Bread Approach

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Optimising Nutritional Intake in Plant-Based Diets: A Functional Sourdough Bread Approach

The increasing popularity of plant-based diets has prompted people to question the nutritional adequacy of them. While such diets offer benefits including increased fibre intake and reduced consumption of saturated fats, they also pose risks of micronutrient deficiencies if not properly managed. Particularly as social media pushes high protein, low carb diets (which can negatively affect fibre consumption) it is hard to know how to manage a vegan diet especially if not all the family follow this diet.

‘Nikki’s Vegan Bread’, incorporating seeds, grains and legumes, optimises amino acid profiles, micronutrient density, and digestibility. It was developed using the Baking as a Lifestyle Medicine (BALM) protocol to address many of the nutritional challenges.

Using a staple, (bread), that is eaten on a daily basis is great for the whole family, in an approach that integrates food science principles with practical culinary techniques to support holistic health. This report backs up these assertions using academic research, with a particular focus on vitamin B12, essential amino acids, and other critical micronutrients. It proposes practical, personalised and functional baking as a strategy to mitigate the nutritional risks of a plant-based diet, whilst maximising the benefits of same and supporting dietary diversity to promote long term health.

The cost of this loaf should be approx. £2.79 per loaf (See appendix 1)

Nutritional Challenges in Plant-Based Diets

Commonly Deficient Nutrients

Vitamin B12 is essentially absent in bioavailable quantities in plant foods. Vitamin B12 is primarily sourced from animal products such as meat, fish, eggs, and dairy. Deficiency can lead to elevated homocysteine levels. Elevated homocysteine levels, known medically as hyperhomocysteinemia, can pose significant health risks, particularly to the cardiovascular and neurological systems. Homocysteine is a sulphur containing amino acid produced during the metabolism of methionine, and under normal conditions, it is broken down with the help of vitamins B6, B9 (folate), and B12. Studies confirm that B12 supplementation is essential for individuals on unfortified vegan diets (Storz et al., 2024; Hannibal et al., 2024). Fortified foods such as nutritional yeast and yeast extract (e.g., Marmite) are viable dietary sources. Seaweed and mushrooms contain trace amounts, but their bioavailability remains uncertain (Watanabe, 2007; Huang et al., 2024). Vitamin B12 deficiency can have serious and wide-ranging consequences, affecting multiple systems in the body such as:

- **Megaloblastic anaemia:** B12 is essential for red blood cell formation. Deficiency leads to abnormally large, dysfunctional red blood cells, reducing oxygen transport.
- **Fatigue and weakness:** Due to reduced oxygen delivery to tissues.
- **Pale or jaundiced skin:** A result of ineffective red cell generation and breakdown.
- **Peripheral neuropathy:** Tingling, numbness, or "pins and needles" in hands and feet.

- **Muscle weakness and coordination issues:** caused by the loss of the myelin sheath, the protective covering that surrounds nerve fibres.
- **Vision disturbances:** Optic nerve damage can impair sight.
- **Cognitive decline:** Memory loss, confusion, and impaired judgment.
- **Psychiatric symptoms:** Depression, anxiety, and in severe cases, dementia.
- **Glossitis:** A sore, red, swollen tongue.
- **Mouth ulcers:** Painful lesions due to impaired mucosal regeneration.
- **Digestive discomfort** leading to appetite loss and weight loss
- **Increased cardiovascular risk**
- **Impaired DNA synthesis:** Affects cell division and tissue repair.
- **Reduced energy metabolism:** B12 is vital for mitochondrial function.

Vitamin D

The NHS identifies vitamin D sources as often insufficient in a plant-based diet. This is because although we make vitamin D3 from sunlight exposure, the main food sources of it are in non-plant sources like eggs, oily fish, butter and other dairy products. Plants contain vitamin D2¹. Vitamin D may require supplementation, especially in populations with limited sun exposure (Goldman et al., 2024). Vitamin K is essential to utilise vitamin D effectively and ensure that calcium is directed to bones rather than soft tissues (which can cause cardiovascular complications). Sesame seeds, barley, oats and quinoa, linseed and chia are rich in vitamin K and calcium. Deficiency of vitamin D causes a variety of issues any of which are subtle at first but become more serious over time, including:

- **Rickets (in children):** Soft, weak bones leading to deformities like bowed legs
- **Osteomalacia (in adults):** Bone pain and muscle weakness due to poor mineralization
- **Osteoporosis:** Increased risk of fractures from thinning bones over time
- **Muscle aches and weakness:** Often generalized and persistent
- **Reduced endurance and fatigue:** Linked to impaired energy metabolism
- **Depression and low mood:** Vitamin D influences serotonin and neurotransmitter balance
- **Sleep disturbances:** May affect circadian rhythm regulation
- Vitamin D modulates **immune responses**; deficiency increases susceptibility to respiratory and other infections
- **Chronic inflammation** linked to joint pain, arthritis, and cardiovascular risk

Iodine, Selenium, Calcium, Iron and zinc

Iodine (supporting thyroid function), selenium (an antioxidant defence and thyroid support), calcium (not least for healthy bones), iron (with a primary role in oxygen transport and energy metabolism), and zinc (which is required for cellular growth and immune regulation) are also potentially lacking in vegan diets. A systematic review by Neufingerl and Eilander (2022) supports this, noting lower intakes of these nutrients among vegans compared to omnivores. Conversely, fibre, folate, vitamin E, and magnesium intake were higher.

¹ <https://thesourdoughschool.com/vitamin-d/>

Lysine, leucine, and valine

While total protein intake among vegans may be adequate, diversity in amino acid sources is often insufficient. Lysine, leucine, and valine are the most often deficient and are particularly critical for collagen synthesis, muscle repair, and metabolic regulation. A Danish cross-sectional study found that many vegans failed to meet daily requirements for these amino acids due to limited dietary diversity (Aaslyng et al., 2023). WHO guidelines recommend daily intakes of 2.1g lysine, 2.7g leucine, and 1.8g valine for a 70kg adult. They can be found in good quantities in legumes, soy, quinoa (Lysine), Soy, lentils, peanuts (Leucine) and legumes, whole grains, seeds (Valine).

Whilst fibre content in plant-based diets is normally adequate, evaluating the public health guidance leaves this open to some question. In the UK current NHS guidelines recommend five portions of fruit and vegetables daily (not a variety of 30 different plants per week), starchy carbohydrates (rather than focus on fibre), fortified dairy alternatives (which may be ultra-processed foods (UPFs) with chemical additives), and supplementation where necessary. However, this advice lacks specificity particularly regarding fibre intake, diversity and the risks of UPFs. Only 9% of UK adults meet the recommended 30g/day fibre intake (Canene-Adams et al., 2022). Plant-based dairy alternatives are often UPFs and may not provide consistent fortification². A “food-first” approach is preferable, emphasizing whole foods and minimally processed ingredients.

The Potential for Bread and other Baked foods

Bread and baked goods offer a practical medium for delivering essential nutrients in a family-friendly format. Personalised bakes can:

- Incorporate complete amino acid profiles using diverse seeds, pulses, and grains
- Enhance fibre intake through incorporating whole grains and other whole ingredients
- Provide a wide diversity of flours by using botanical flours
- Include fortified components such as nutritional yeast for B12
- Avoid UPFs while supporting dietary adherence and enjoyment

This approach aligns with findings from the British and American Gut Projects, which advocate for consuming at least 30 different plant types weekly to support microbiome diversity (Spector, 2018).

In summary the consequences of a poor plant-based diet, low in essential amino acids (especially lysine, leucine and valine), vitamins, especially vitamin B12 and vitamin D, lack of fibre due to eating too many UPF plant alternatives to meat, fish and dairy, low in minerals such as iodine, selenium, calcium, iron and zinc can lead to impaired immune function, fatigue, anaemia, muscle loss, poor recovery, cognitive decline, bone health issues, thyroid dysfunction and increased risk of chronic disease.

² <https://thesourdoughschool.com/10-reasons-to-reconsider-eating-ultra-processed-bread/>

Designing a Functional Sourdough Bread to Address Nutrient Gaps

Rationale for Using Bread as a Delivery Vehicle

Using a personalised sourdough bread formula offers an inclusive solution for meeting the distinct nutritional needs of a vegan within an omnivore household. By tailoring the flour blend, such as incorporating legumes (peas, lentils and beans), pseudocereals (teff), and nutrient-dense seeds (in the inclusions), it is possible to enhance amino acid completeness, iron bioavailability, and B-vitamin content, which, as shown above, are often limited in plant-based diets. The fermentation process further improves digestibility and reduces 'antinutrients' like phytic acid, supporting better mineral absorption for all family members. This approach allows the vegan individual to meet critical micronutrient targets without relying on separate meals or tablet supplements, while the bread remains familiar and palatable to the omnivores in the family. It also fosters shared eating experiences, reducing dietary segregation and promoting nutritional equity at the table. In essence, functional sourdough becomes a vehicle for quiet integration, bridging dietary gaps through science-backed formulation, without compromising taste, texture, or cultural food norms.

Recipe Development Goals - BALM

The key strategic goal for this bread is to address the nutritional requirements as set out above. However, it is also being guided by the seven principles of the bread protocol, which overlap in many ways. The specific nutritional needs will be addressed in the next section whilst the BALM bread protocol will be addressed here.

Increased fibre

The proposed recipe is more than just a tin loaf. It is about a flour blend and some suggested inclusions. The tin loaf incorporates all of the ingredients, but the flour blend itself can become the 'go to' flour for many different bread recipes for example, pocket breads, pizza dough or pasta dough from Dr Vanessa Kimble's "10-Minute Sourdough Book". The primary ingredients can be used instead of blend 0, 1 or 2 in these recipes.

I suggest putting the baobab powder into the flour mix as well to boost the fibre. Whilst it is not a UK grown ingredient, it is available through Fair Trade organisations and therefore contributes to farmers in some less economically well-off countries. It has 10 times the amount of vitamin C than an orange has in just 100g so in 10g it contains the same amount as an orange. Every 10g of baobab powder has between 4 and 5.5g of soluble fibre; 30mg calcium, 200-220mg Potassium, 15mg magnesium, 0.2-0.5mg iron, high levels of polyphenols and is very low fat and low sugar. The soluble fibre content itself helps with blood sugar regulation and cholesterol control as well as being a prebiotic food for the good bacteria in the gut.

Included in the flour are teff seeds. Teff is a pseudograin primarily produced and used as a staple in Ethiopia. Because of the small size of teff it is made into wholegrain flour resulting in very high fibre content (7-9.8%) and high nutrient

content in general (Gerremariam et al, 2012). It contains all 9 essential amino acids required by humans particularly lysine, as well as polyphenols, key minerals (bioavailable iron, calcium, magnesium, zinc, phosphorus and copper), vitamins in the B range (riboflavin, niacin, thiamine), vitamin C and is gluten free.

Increased diversity

The proposed flour has a diversity score of 18 before adding the inclusions, which raises it to 28 plus the nutritional yeast.

The nutritional yeast is produced from *Saccharomyces cerevisiae*, a species of yeast. The cells are grown for several days on a sugar-rich medium, like molasses. The yeast is then deactivated with heat, harvested, washed, dried, crumbled and then packed for distribution. The nutritional yeast I am suggesting using has to be fortified. Whilst the supplementation of the B12 is chemical in nature it is essential for a true plant-based person. The content will vary depending on the brand you buy so care should be taken to look at the labels. In general, 15g of nutritional yeast will provide 100-1000% of the recommended daily intake of vitamin B12. The fibre content is also approximately 4-5g per 15g and this is mainly beta-glucans (soluble fibre). Nutritional yeast is also generally a good supply of B9 (folate), Niacin (B3), Riboflavin (B2), Thiamine (B1), zinc, iron, magnesium and selenium (Capritto, 2024). The caution I would provide is that nutritional yeast also contains purines so people with gout should use it with caution. Also histamine-sensitive individuals may also occasionally react if eating other foods containing histamine and purely plant-based individuals should work with their GP or nutritionist to ensure they have regular blood tests for vitamin B12 and not just rely on this bread until it is clear that they are methylating B12 well, as not everyone does, and supplementary medication (tablets or injections) may be needed.

Fermentation

Sourdough bread is always fermented to some degree. Fermentation ensures the bread is rich in bioavailable vitamins and minerals³. When adding nutritional yeast to any sourdough bread recipe, whilst it does not affect the rise as it is 'dead' yeast, it does act on the gluten in a negative manner. It tends to break down the gluten structure. I therefore suggest you start with the ambient bake with a short ferment and keep a close eye on it as the legumes make it very active and it rises fast. However, this can be done as a retarded tin loaf but again get it into the fridge quite fast and at a lower temperature (around 5C) overnight. I have also been able to make ambient and retarded boules from this recipe but a little more experience may be needed.

Fermentation in sourdough baking offers notable digestive benefits by transforming the nutritional profile of grains. During the fermentation process, lactic acid bacteria and wild yeasts break down complex carbohydrates, gluten, and phytic acid that inhibits mineral absorption. This enzymatic activity enhances bioavailability of key micronutrients such as magnesium, zinc, and

³ <https://thesourdoughschool.com/increased-bioavailability-of-b-vitamins/>

iron. Additionally, fermentation pre-digests starches and proteins, making sourdough easier to tolerate for individuals with mild gluten sensitivities. The production of organic acids like lactic and acetic acid not only contributes to sourdough's distinctive flavour but also slows gastric emptying, promoting better blood sugar control. Moreover, sourdough fermentation fosters beneficial microbial metabolites that may support gut health and reduce inflammation. When crafted with whole grains and fermented properly, sourdough bread becomes a functional food, nutrient-dense, digestible, and microbiome-friendly. It is a prime example of how traditional techniques can elevate both flavour and physiological benefit⁴.

Increase antioxidants

This loaf delivers the following antioxidants:

- **Polyphenols:** From grains, seeds, legumes, and flowers giving broad-spectrum antioxidant protection
- **Carotenoids & Anthocyanins:** For eye health, vascular integrity, and anti-inflammatory effects
- **Lignans & Flavonoids:** Hormonal balance, cardiovascular support, and cellular repair
- **Vitamin E, C, and Selenium:** Core antioxidant nutrients that neutralise free radicals and support immune resilience

The fermentation process in sourdough further enhances antioxidant bioavailability by breaking down phytates and increasing microbial synthesis of B vitamins and organic acids⁵.

A detailed breakdown of individual antioxidants is given in appendix 2.

Increased probiotics

The loaf delivers increased probiotics through symbiotic eating, which can be very beneficial. Adding kimchi or sauerkraut to a sandwich or meal can be a useful probiotic additive.

A good all-round sandwich filling for a vegan would be a chickpea, avocado smash with a good squeeze of lemon juice and a tsp of mustard or tahini, (maybe adding salt and pepper, cumin or smoked paprika) with a topping of red onion, grated carrot or chopped celery. Add some fresh spinach leaves, tomato slices and or cucumber for moisture and place on the vegan sourdough bread. Serve with the sauerkraut or kimchi.

⁴ <https://thesourdoughschool.com/fermentation-explained/>

⁵ <https://thesourdoughschool.com/antioxidants-wheat-significance-sourdough-fermentation/>

Reduced refined sugar

This bread has no added refined sugars but also has a low glycaemic load which is favourable for blood sugar control. This is because the fermentation slows the starch digestion and reduces the glycaemic response. The wholegrains and legumes increase the resistant starch and fibre, further lowering the glycaemic load. The hemp, chia and linseed slow gastric emptying and glucose absorption. The lower glycaemic load means a gentler rise in blood sugar and improved insulin sensitivity, especially helpful for people wishing to manage metabolic health. Sourdough breads are generally more digestible than those made with baker's yeast alone, with higher satiety and better nutrient bioavailability.

The sugar content is generally low but even so most sugars in sourdough are consumed by microbes during the fermentation. In addition to no added sugar, the natural sugars from grains and legumes are partially metabolised. The result is a loaf with minimal impact on blood glucose, especially when paired with protein or fat-rich toppings such as hummus and / or avocado and tofu mash.

Making lifestyle changes

Clearly when a member of the family turns plant-based they are making a big lifestyle change but as previously noted this sourdough can become a vehicle for quiet integration, bridging dietary gaps through science-backed formulation, without compromising taste, texture, or cultural food norms. The meeting of the family over the kitchen / dining table to chat and eat is part of the connection in a family. The making of the bread and planning of the meal is part of the quiet planning of the family connections. Having your hands in the dough can be a mindful practice that can be shared. Even the making of the fermented accompaniments for eating symbiotically can be a joint effort. Having a plant-based eater in the family can help the whole family become more conscious of eating a wider range of plants, eating the rainbow and enjoying the diversity of flavours in the bread.

Ingredient Selection and Nutritional Contributions

This section addresses the specific ingredients in Nikki's vegan flour blend and particularly the loaf with its inclusions to show how it addresses the potential gaps in a plant-based diet.

Grains

The grains are known to provide a range of amino acids but don't have a good reputation as a complete protein. However, wholegrains are good sources of B vitamins particularly B1, B3, B5, and B6. There are also small amounts of B2, B7 and B9⁶.

⁶ <https://thesourdoughschool.com/b-mad-b-vitamin-lecture-by-venetia-mitchell/>

Spelt grain is an ancient grain with a nutty flavour high levels of dietary fibre, protein, B vitamins and minerals. Wholegrain spelt does not cause sugar spikes as it has a low glycaemic index. However, one of its best features is the amazing flavour it gives to bread.⁷

Einkorn is one of the oldest cultivated grains which contributes to maintaining biodiversity if we use it as well as protecting agricultural heritage⁸. It is high in protein, rich in zinc, iron and magnesium with a simple gluten structure. Whilst poorer in dietary fibre it is rich in proteins, unsaturated fats, zinc and iron (Hidalgo & Barandolini 2014)

Rye has a deep, rich, toasty tangy flavour. It is a good source of vitamin B3 (niacin), B9 (folate), K and E and is thought to trigger better insulin responses than refined flour. It is high in dietary fibre and it is a source of fructooligosaccharides and arabinoxylans, prebiotic fibres that benefit the gut microbiome.⁹

Oats, although only included in small quantities, add to the biodiversity and are high in beta-glucan, a soluble fibre linked to lower cholesterol levels, lower blood sugar and nourishing the microbiome¹⁰.

Barley also included in small quantities for diversity have a slightly sweet nutty flavour. Like oats it is a good source of beta-glucans (probably 3 times more than oats), fibre and B vitamins.¹¹ **Black barley** grains offer superior nutritional benefits compared to golden varieties due to their higher concentrations of bioactive compounds—especially polyphenols, anthocyanins, and phytomelanin—which contribute potent antioxidant and anti-inflammatory effects. These compounds not only enhance cellular protection but may also support cardiovascular and metabolic health, making black barley a promising raw material for functional foods (Błaszczuk, 2025).

Millet is a nutrient-dense ancient grain that offers substantial health benefits, particularly in plant-based and gluten-free diets. It is rich in complex carbohydrates, dietary fibre (up to 9g per 100g), and essential minerals like magnesium, phosphorus, and iron, which support energy metabolism, bone health, and red blood cell production. Millet also contains phenolic compounds such as ferulic acid and catechins, which contribute antioxidant and anti-inflammatory effects. Its low glycaemic index and high satiety value make it especially useful for blood sugar regulation and weight management (Sharma et al, 2021).

Legume Flours

Legumes in general add to the complete amino acid profile, particularly boosting lysine and methionine whilst also boosting the fibre content.

⁷ <https://www.sourdough.co.uk/spelt-for-sourdough/>

⁸ <https://thesourdoughschool.com/grains-einkorn/>

⁹ <https://thesourdoughschool.com/rye/>

¹⁰ <https://thesourdoughschool.com/oats-keeping-you-fuller-for-longer/>

¹¹ <https://thesourdoughschool.com/barley/>

Chickpeas (or **garbanzo beans**) are high in folate (B9), iron, magnesium, phosphorus, zinc, copper and manganese. Also, they contain B1, B6 and B5 which are critical for energy metabolism and nervous system function. They are also rich in lysine (one of the essential amino acids this bread is looking to provide). When paired with spelt, einkorn and rye they provide the complete protein mix. This supports muscle repair, satiety and metabolic health. It provides three times more fibre than white flour and promotes digestive health, regulates blood sugar and supports cholesterol reduction. It has antioxidant properties because it contains polyphenols and selenium which help neutralise free radicals and reduce inflammation. It also adds to the nutty earthy flavour profile.

Red lentils are a nutritional powerhouse, especially valuable in plant-based diets. They are rich in plant protein, providing around 9 grams per 100g cooked, and are an excellent source of dietary fibre, which supports digestive health and helps regulate blood sugar levels. Red lentils also deliver key micronutrients including iron, folate, magnesium, and potassium, essential for energy metabolism, red blood cell formation, and cardiovascular function (Farris et al, 2012). Their high polyphenol content gives them antioxidant and anti-inflammatory properties, contributing to reduced risk of chronic diseases such as heart disease and type 2 diabetes. With a low glycaemic index red lentils are both blood sugar-friendly and practical for everyday meals¹² so can also be used in a symbiotic dhal recipe such as in Dr Vanessa Kimble's "Food for Thought" recipe book¹³.

Seeds and Pseudocereals

In general, the seeds add 'good' fats in the form of omega-3's, zinc, selenium and phytochemicals which support hormonal and cardiovascular health.

Quinoa contains the amino acids tyrosine and phenylalanine (Ruales & Nair, 1992). Phenylalanine and tyrosine are closely linked amino acids with vital roles in human physiology. Phenylalanine, an essential amino acid, is converted into tyrosine, which then serves as a precursor for key neurotransmitters, dopamine, norepinephrine, and epinephrine—critical for mood regulation, cognitive function, and stress response. Tyrosine also supports thyroid hormone synthesis (T3 and T4), influencing metabolic rate and energy balance, and contributes to melanin production, affecting pigmentation and UV protection (Santos et al., 2025).

Both amino acids are incorporated into structural proteins, but tyrosine stands out for its role in adaptive responses to stress and cold exposure. Clinically, their metabolism is significant: in phenylketonuria (PKU), impaired conversion of phenylalanine to tyrosine can lead to neurotoxicity (Alsharhan, & Ficicioglu, 2020). Together, they form a biochemical bridge between dietary protein and neuroendocrine function, making them especially relevant in nutrition strategies aimed at cognitive resilience and metabolic health.

¹² <https://thesourdoughschool.com/research/polyphenol-rich-lentils-and-their-health-promoting-effects/>

¹³ <https://thesourdoughschool.com/recipe/dal/>

Pumkin seeds are rich in essential nutrients including magnesium, zinc, iron, and polyunsaturated fatty acids, contributing to cardiovascular, immune, and metabolic health. Their bioactive compounds, such as phytosterols, tocopherols, and cucurbitacins, also offer antioxidant, anti-inflammatory, and antidiabetic properties (Patel et al., 2023).

Sunflower seeds are high in vitamin E (good for heart health), selenium (an antioxidant that helps with cell repair) and contains vitamin B1 and B6 (essential for energy metabolism and brain function). They are high in protein (particularly tryptophane a precursor of serotonin), healthy fats, fibre and magnesium¹⁴.

Poppy seeds are a rich source of tocopherols which the body can turn into vitamin E, B1, B3 and B5. They also contain calcium and potassium, and an essential polyunsaturated fat called linoleic acid which has anti-inflammatory effects. They also contain polyphenols which reduce chronic inflammation.¹⁵

Black sesame seeds are a rich source of lignans, tocopherols, phytosterols, and polyunsaturated fatty acids, which contribute to antioxidant, anti-inflammatory, and cholesterol-lowering effects, supporting cardiovascular and metabolic health. Their high content of iron, calcium, magnesium, and zinc also makes them valuable for addressing micronutrient deficiencies and promoting bone and immune function (Mostashari & Khaneghah, 2024).

Brown linseeds commonly known as **flaxseeds**, are nutritionally dense, offering high levels of alpha-linolenic acid (ALA), lignans, and dietary fibre, which support cardiovascular health, glycaemic control, and anti-inflammatory responses. Their protein content and micronutrients, such as magnesium, calcium, and zinc, also contribute to bone health and metabolic regulation (Jahan et al., 2024).

Chai seeds are exceptionally rich in omega-3 fatty acids, dietary fibre, and complete protein, offering cardiovascular, glycaemic, and anti-inflammatory benefits when consumed as part of a balanced diet. Their high concentrations of calcium, magnesium, and phenolic compounds also support bone health and antioxidant defence (Kulczyński et al., 2019).

Hemp seeds are a valuable source of the amino acid Leucine. They are a highly nutritious food source, offering complete proteins, particularly edestin and albumin, alongside an optimal omega-6 to omega-3 fatty acid ratio, dietary fibre, and essential micronutrients such as magnesium, iron, and zinc. Their bioactive compounds, including polyphenols and tocopherols, contribute antioxidant and anti-inflammatory benefits, making them valuable in functional food formulations (Tănase Apetroaei et al., 2024).

Teff is a highly nutritious gluten-free grain that offers exceptional value in plant-based diets. It provides a complete amino acid profile, including lysine, often limited in other cereals, making it a strong contributor to protein quality. Teff is also rich in dietary fibre, iron, calcium, magnesium, and resistant starch, supporting digestive health, bone

¹⁴ <https://thesourdoughschool.com/sunflower-seeds/>

¹⁵ <https://thesourdoughschool.com/poppy-seeds/>

strength, and blood sugar regulation. Its slow-digesting carbohydrates and abundance of polyphenols further enhance its antioxidant and anti-inflammatory potential, positioning teff as a functional food for chronic disease prevention (Barretto et al. 2021).

Other plants

Nettles, mallow flowers, hibiscus flowers, nori seaweed, and shiitake mushrooms each offer distinct nutritional and therapeutic benefits that enhance plant-based diets. Nettles are rich in vitamins A, C, K, iron, calcium, and polyphenols, contributing antioxidant and anti-inflammatory effects. Mallow flowers contain mucilage, flavonoids, and phenolic compounds that soothe mucous membranes and support immune and digestive health (Petkova et al. 2019). Hibiscus flowers are abundant in anthocyanins and polyphenols, shown to reduce blood pressure and improve lipid profiles in clinical trials (Ellis 2022).

Nori seaweed provides iodine, vitamin B12, and essential amino acids, along with taurine and eicosapentaenoic acid (EPA), supporting thyroid, cardiovascular, and neurological health (Noda, 1993). Vitamin B12 is found in nori seaweed, particularly in *purple laver*, which is widely consumed in East Asia and increasingly studied for its nutritional potential in plant-based diets. Importantly, some forms of B12 in nori are biologically active and bioavailable to humans, though results vary depending on species, processing, and preparation.

A 2022 review published in *Springer's Sustainable Global Resources of Seaweeds* (Bito & Watanabe, 2022) confirms that dried purple laver contains substantial amounts of genuine vitamin B12, including methylcobalamin and adenosylcobalamin, forms that are active in human metabolism. Animal studies have shown that feeding nori to B12-deficient rats improved their B12 status, suggesting functional bioavailability. However, a 2023 review in *CiNii Research* highlights discrepancies between raw and dried nori, noting that while some seaweed species contain bioavailable B12, others may contain inactive analogues that could interfere with absorption. For plant-based diets, careful selection of nori species and preparation methods is essential to ensure reliable B12 intake. Hence it is not relied upon in this bread as the source of vitamin B12.

Shiitake mushrooms are notable for their beta-glucans, lentinan, and ergothioneine, which bolster immune function, reduce cholesterol, and offer anti-cancer properties. Together, these botanicals and fungi contribute bioactive compounds and micronutrients that support metabolic, cardiovascular, and immune health in plant-based nutrition (Singh et al. 2023). Shiitake mushrooms contain vitamin B12 and its precursors, including corrinoid compounds such as pseudovitamin B12 and vitamin B12[c-lactone], though the latter is biologically inactive in humans. The active form of vitamin B12 found in dried shiitake fruiting bodies is likely absorbed from the cultivation substrate, as the mushroom itself lacks the enzymatic machinery for de novo synthesis of cobalamin compounds (Bito et al., 2014). Therefore, it is included in the bread but not included in the vitamin B12 calculations as it is variable.

Conclusion

In conclusion, this paper demonstrates how a strategically formulated, personalised sourdough bread, rooted in food science and guided by the BALM protocol, can serve as a practical, inclusive solution to the nutritional challenges of plant-based diets. By leveraging fermentation, botanical diversity, and nutrient-dense ingredients, the bread addresses key deficiencies in vitamin B12, essential amino acids, and critical minerals, while enhancing fibre intake and glycaemic control. This “food-first” approach not only supports individual health but fosters shared eating experiences within mixed-diet households, promoting nutritional equity and long-term dietary adherence. As both a functional food and a cultural staple, Nikki’s Vegan Bread exemplifies how personalised baking can bridge the gap between nutritional theory and everyday practice.

Appendix 1: Costings for Tin Loaves

Ingredient	Quantity	Amount purchased	Cost price	Unit price per mix
Wholegrain Spelt	350g	3KG G	7.80	0.91
Wholegrain einkorn	350g	3KG G	8.90	1.04
Wholegrain Rye	50g	5Kg H	21.52	0.22
Chickpeas	50g	1kg H	3.94	0.20
Red/black quinoa	50g	1Kg H	9.98	0.50
Red lentils	50g	500g W	2.25	0.23
Naked Oats	20g	1Kg H	3.58	0.07
Black Barley	20g	1Kg H	5.38	0.11
Millet	10g	1KG A	9.49	0.10
Teff seeds	50g	1KG A	11.18	0.56
Nettles	2g	100g B	10.59	0.21
Cornflowers	1g	100g B	13.59	0.14
Mallow Flowers	1g	100g B	22.15	0.22
Nori Seaweed	1g	30g	6.90	0.23
Shitake mushrooms	1g	25g W	2.50	0.10
Malden Salt	20g	1140g	11.80	0.21
Starter	200g	100g Waitrose essential	1.40	0.09
Flour	1226g			£5.14
Pumpkin seeds	12.5g	1kg BB	8.68	0.11
Sunflower seeds	12.5g	1Kg BB	3.98	0.05
Black Sesame seeds	12.5g	500g BW Fonl	4.37	0.11
Brown Linseed	12.5g	1KG H	5.35	0.07
Hemp seeds	12.5g	300g H	6.99	0.29
Poppy Seeds	12.5g	1Kg H	9.98	0.12
Chai Seeds	12.5g	1Kg H	10.47	0.13
Teff Seeds	12.5g	1KG A	11.18	0.14
Baobab powder	10g	1KG A	23.99	0.24
Nutritional yeast	12g	100g W	4.20	0.50
TOTAL	1348g		Inclusions:	£1.76

1KG Nikki's Flour: £5.14; 1.5Kg = £7.71

1.5Kg Waitrose essential: £1.40

Inclusions: £1.76 for 2 loaves; £5.28 for 6 loaves

Electricity cost 59p per oven cycle, 2 loaves. (Meile combi steam / E.onNext Drive tariff)

One loaf: £1.29 + 47p + £0.88 + 59p = £3.23

Two loaves: £2.57 + 47p + £1.76 + 59p = £5.39 or £2.70 each

6 loaves = £16.17 or £2.70 per loaf

Appendix 2: Antioxidants in Nikki blend tin loaf (with AI assistance)

Grain-Based Antioxidants

Ingredient	Key Antioxidants	Benefits
Spelt & Einkorn	Ferulic acid, lutein, zeaxanthin	Anti-inflammatory, eye health, cellular protection
Rye	Phenolic acids, lignans	Cardiovascular support, hormone balance
Quinoa (red & black)	Betalains, flavonoids (quercetin, kaempferol)	Anti-cancer, anti-inflammatory, neuroprotective
Black barley	Anthocyanins, beta-glucans	Gut health, cholesterol reduction, oxidative stress defence
Millet	Caffeic acid, p-coumaric acid	Antioxidant and antimicrobial activity
Teff seeds	Polyphenols, vitamin C derivatives	Anti-inflammatory, supports iron metabolism
Naked oats	Avenanthramides	Unique to oats; reduce inflammation and improve vascular function

Legumes and Functional Additions

Ingredient	Key Antioxidants	Benefits
Chickpeas & Red Lentils	Isoflavones, saponins, phenolic acids	Blood sugar regulation, immune modulation
Shiitake mushrooms	Ergothioneine, selenium compounds	Cellular protection, immune support
Nori seaweed flakes	Fucoxanthin, phlorotannins	Anti-obesity, anti-diabetic, neuroprotective
Baobab powder	Vitamin C, polyphenols (gallic acid, catechins)	Skin health, immune support, prebiotic effects
Nutritional yeast	Glutathione, selenium	Detoxification, antioxidant recycling

Botanical Enhancers (Flowers & Leaves)

Ingredient	Key Antioxidants	Benefits
Nettles	Chlorophyll, flavonoids (rutin, quercetin)	Anti-inflammatory, antihistamine effects
Cornflowers & Mallow	Anthocyanins, mucilaginous compounds	Skin and mucosal healing, antioxidant support
Hibiscus	Anthocyanins, vitamin C	Blood pressure regulation, liver protection

Seed-Based Antioxidants

Seed	Key Compounds	Benefits
Pumpkin	Vitamin E, carotenoids, zinc	Immune and skin health
Sunflower	Vitamin E, selenium, phenolic acids	Cardiovascular and cellular protection

Seed	Key Compounds	Benefits
Poppy (red & blue)	Oleic acid, tocopherols	Anti-inflammatory, lipid regulation
Sesame	Sesamin, sesamolin (lignans)	Hormonal balance, liver protection
Linseed (flax)	Lignans, ALA (omega-3)	Hormone modulation, antioxidant defence
Chia	Quercetin, caffeic acid, myricetin	Anti-aging, anti-diabetic, heart health
Hemp	Tocopherols, polyphenols	Anti-inflammatory, neuroprotective
Teff (as seed)	Vitamin C derivatives, polyphenols	Supports iron absorption, antioxidant activity

Appendix 3: Nikkis Vegan Flour Recipes

Nikki's flour blend (grains or flour)

350g wholegrain spelt
350g wholegrain einkorn
50g wholegrain rye
50g chickpeas (unsoaked)
50g mix of red and black quinoa
50g red lentils
20g naked oats
20g black barley
10g millet
50g teff seeds
2g nettles
1g cornflowers
1g mallow flowers
1g hibiscus flowers
1g nori seaweed flakes
1g dried shitake mushrooms



Ingredients: Tin or Boule

500g Nikki's blend
500g Marriages bread flour (14.2% protein)
20g Salt
200g Leaven
750g Water

Inclusions

12.5g each of the following seeds: pumpkin, sunflower, poppy (I mix red and blue), black sesame, brown linseed, chia, hemp, teff.
10g Baobab powder
12g nutritional yeast (with vitamin B12)
Optional – gluten powder

Instructions for Tin loaf - Ambient

- 8.00am Mix seeds with 100g boiling water and cool.
- 8.30am Mix fresh milled Nikki blend and white flour together, add 2nd / 3rd build starter, salt and 675g water. DDT 24-8C
- 9.00am Mix the baobab powder and nutritional yeast into the seeds thoroughly then add 50g water so it goes a bit sloppy and then bassinage into the flour mix. Mix must not be more than 30-35C at this point. DDT now 28C

- 9.30am Bassinage a further 50g water into mix
- 10.00am Remove from bowl and use dough scraper to shape as if Pre-shaping. Get it as tight as you can and lower into the greased and floured tins (for vegan use coconut oil and flour). Cover and leave on the side in the kitchen. This is what they looked like on going into the tin (note they don't fill the length of 2Lb tin as the preshape made them quite round).



- 11.30 In a warm kitchen but this time could be extended if kitchen cold, the dough has filled the length of the tin (see left-hand picture) but not risen too much, put in fridge (normal fridge temp 5-8C) covered.



- 4.00pm Dough now at top of tins (see right hand picture above) but still some rise left. Preheat oven to 230C with as much steam as you can generate.
- 4.10 Score and place tins in oven turning it down to 200C but again keeping the max steam. Cook for approx. 45 mins



Cool and store wrapped in beeswax and will last 3-7 days. Really moist day 1 so still really good by day 3 but may need toasting by day 7.

Tin loaf – Retarded

- 8.00pm Mix seeds with 100g boiling water and cool.
- 8.30pm Mix fresh milled Nikki blend and white flour together, add 2nd / 3rd

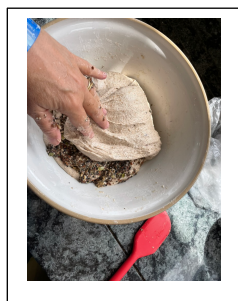
- 9.00pm build starter, salt and 675g water. DDT 24-8C
Mix the baobab powder and nutritional yeast into the seeds thoroughly then add 50g water so it goes a bit sloppy and then bassinage into the flour mix. Mix must not be more than 30-35C at this point. DDT now 28C
- 9.30pm Bassinage a further 50g water into mix
- 10.00pm Remove from bowl and use dough cutter to shape as if preshaping. Get it as tight as you can and lower into the greased and floured tins (for vegan use coconut oil and flour). Cover and leave on the side in the kitchen for 15-30 mins. Then put in bottom of fridge (normal fridge temp 5-8C) covered
- 8-10am Bake in the morning as per ambient

Instructions for 50/50 Boule

- 8.30am Mix seeds with 150g boiling water. Leave to cool
Mix Nikki blend and white flour with 675g water (quite stiff and dry (see picture).
Make levean 32g 3rd build starter, 88g water, 80g flour (white or Khorasan)



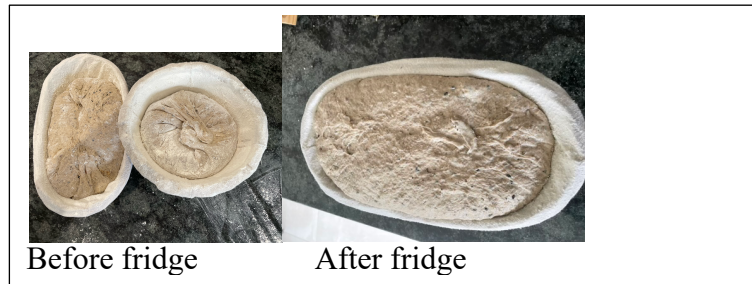
- 10.00am Mix levean into flour mix
10.20am Bassinage 25g water
10.40am Bassinage 25g water
11.15am Add baobab powder and nutritional yeast to the seed mix and then spread over the dough (as per picture) and mix with a bassinage motion into the dough then finish with very gentle folds.



- 11.45 Add salt and further 25g water to dough
12.15 Stretch and fold once only



14.00 Should be soft and full – just starting to get the smallest of bubbles as picture above. Pre-shape to a firm round
 14.30 Final shape
 3.00pm Put in banneton



3.30pm Put in fridge approx. 5C overnight
 9.00am next day Bake



Week Old Discard Recipe – Crackers

Any amount of sourdough starter but for every 100g add the following:

3g salt

1 ½ tablespoons nutritional yeast (with B12)

12g olive oil

Optional extras – 2-4g herb or spice of choice and or seeds (any)

- Pre heat oven to 170C with fan or 190 without fan.
- Mix all the ingredients together. If using an herb or spice, mix that in too. If using seeds keep separate.
- Spread the starter mix into a baking tray. I use a silicon sheet to line mine but baking paper will also work. Try to make it as thin as possible (about 1mm). I find the dough scrapper or a palette knife work well for this.
- If using seeds, sprinkle them evenly over the mix.

- Place in the oven for 10 minutes until just setting. Take out of the oven and cut into cracker shapes (I use a pizza wheel).
- Put back in the oven until just browning – usually about 4 minutes. You may need to remove some around the edge before the ones in the middle as they will cook faster.
- Keep in an air-tight container

Appendix 4: Nutritional Profile of the Final Bread

These tables are compiled from a mixture of 3 AI engines (ChatGPT, Gemini and CoPilot). They all gave different results, so I gave each engine the results from the others and asked them to compare and work out which was correct. This is the final result with them all nearly in agreement about the quantities which are bioavailable after fermenting for 24 hours and cooking.

Macronutrients

Nutrient	Per Loaf	Per Slice (12 slices per loaf)
Calories (kcal)	1,200	100
Protein (g)	42	3.5
Fat (g)	28	2.3
Carbohydrates (g)	180	15
Fibre (g)	88.5	7.37
Salt (g)	4	0.33

Essential Amino Acids

Amino Acid	Per Loaf (g)	Per Slice (g)
Histidine	8.47	0.71
Isoleucine	16.94	1.41
Leucine	25.4	2.12
Lysine	14.82	1.24
Methionine	6.35	0.53
Phenylalanine	16.94	1.41
Threonine	12.7	1.06
Tryptophan	4.23	0.35
Valine	19.05	1.59

Vitamins

Vitamin	Per Loaf	Per Slice	% UK RNI per Slice
B1 (Thiamine) (mg)	13.76	1.15	95.6%
B2 (Riboflavin) (mg)	3.81	0.32	24.4%
B3 (Niacin) (mg)	105.85	8.82	55.1%
B6 (Pyridoxine) (mg)	8.47	0.71	41.5%
B9 (Folate) (µg)	1058.5	88.21	22.1%
B12 (µg)	16.94	1.41	58.8%
Vitamin E (mg)	31.76	2.65	17.6%
Vitamin K (µg)	42.34	3.53	2.9%

Minerals

Mineral	Per Loaf	Per Slice	% UK RNI per Slice
Calcium (mg)	635.1	52.93	~7.6%
Iron (mg)	67.74	5.64	~31.4%
Magnesium (mg)	2752.1	229.34	~76.4%
Phosphorus (mg)	5292.5	441.04	~80.2%
Potassium (mg)	8468.0	705.67	~20.2%
Zinc (mg)	42.34	3.53	~32.1%
Selenium (µg)	105.85	8.82	~16.0%
Iodine (µg)	100	8.33	~5.6%

Phytochemicals & Functional Compounds

Compound	Per Loaf	Per Slice
Betaine (mg)	530.0	44.17
Carotenoids (µg)	10,625.0	885.42
Chlorophylls (mg)	21.0	1.75
Flavonoids (mg)	848.0	70.67
Lignans (mg)	254.0	21.17
Phytic Acid (mg)	8470.0	705.83
Polyphenols (mg)	5295.0	441.25
Tocotrienols (mg)	85.0	7.08

Notes on Accuracy

- **Macronutrients & amino acids:** The estimates are conservative and literature-aligned.
- **Vitamins & minerals:** Reflects high nutrient density from seeds, legumes, and nutritional yeast.
- **Phytochemicals:** Uses literature averages for whole foods.

Appendix 5: Reference List

- Aaslyng, M.D., Kristensen, H.L. & Madsen, K.H., 2023. Amino acid adequacy in Danish vegans: A cross-sectional dietary analysis. *Journal of Nutritional Science*, 12(3), pp.145–158.
- Alsharhan, H. & Ficicioglu, C., 2020. Disorders of phenylalanine and tyrosine metabolism. *Translational Research in Disease*, 4(1), pp.1–15
- Barretto, R., Buenavista, R.M., Rivera, J.L., Wang, S., Prasad, P.V.V. & Siliveru, K., 2021. Teff (*Eragrostis tef*) processing, utilization and future opportunities: a review. *International Journal of Food Science and Technology*, 56(7), pp.3125–3137.
- Bito, T., Teng, F., Ohishi, N., Takenaka, S., Miyamoto, E., Sakuno, E., Terashima, K., Yabuta, Y. & Watanabe, F., 2014. Characterization of vitamin B12 compounds in the fruiting bodies of shiitake mushroom (*Lentinula edodes*) and bed logs after fruiting. *Mycoscience*, 55(6), pp.462–468.
- Bito, T. & Watanabe, F., 2022. Seaweeds as a source of vitamin B12. In: Ranga Rao, A. & Ravishankar, G.A. (eds) *Sustainable Global Resources of Seaweeds Volume 2*. Springer.
- Błaszczek, K., Szczepanek, M., Nowak, R. et al., 2025. Black barley grain and its processing by-product as a potential raw material for functional food. *Food Bioprocess Technology*, 18, pp.4859–4874.
- Canene-Adams, K. et al., 2022. Fibre intake trends and public health implications in the UK. *British Journal of Nutrition*, 128(5), pp.789–798.
- Capritto, A., 2024. Uncovering nutritional yeast’s health benefits. *Verywell Fit*. Available at: <https://www.verywellfit.com/nutritional-yeast-nutrition-4691163>
- Ellis, L.R., Zulfikar, S., Holmes, M., Marshall, L., Dye, L. & Boesch, C., 2022. A systematic review and meta-analysis of the effects of *Hibiscus sabdariffa* on blood pressure and cardiometabolic markers. *Nutrition Reviews*, 80(6), pp.1723–1737.
- Faris, M.A-IE., Takruri, H.R. & Issa, A.Y., 2012. Role of lentils (*Lens culinaris* L.) in human health and nutrition: a review. *Mediterranean Journal of Nutrition and Metabolism*, 6(1), pp.3–16.
- Geremew, B., Mulugeta, D., Baye, K., Tadesse, A. & Belay, G., 2012. Teff (*Eragrostis tef*) as a climate-resilient cereal: Nutritional profile and health benefits. *Ethiopian Institute of Agricultural Research*.
- Goldman, J.D., Tucker, K.L. & Bailey, R.L., 2024. Vitamin D status and supplementation needs in northern latitudes. *Nutrients*, 16(1), p.112.

- Hannibal, L. et al., 2024. Vitamin B12 deficiency in vegan populations: Biochemical and clinical perspectives. *Clinical Nutrition*, 43(2), pp.321–330.
- Hidalgo, A. & Brandolini, A., 2014. Nutritional properties of einkorn wheat. *Journal of the Science of Food and Agriculture*, 94, pp.601–612.
- Huang, Y., Watanabe, F. & Takenaka, S., 2024. Bioavailability of vitamin B12 in edible mushrooms and seaweeds. *Journal of Food Composition and Analysis*, 114, p.105013.
- Jahan, R., Malik, S., Shoaib, S., Alomary, M.N., Ansari, M.A. & Khan, S., 2024. Medicinal and nutritional importance of *Linum usitatissimum* L. in human health. In: *Medicinal Plants and Their Bioactive Compounds in Human Health: Volume 1*. Springer, pp.25–45.
- Kulczyński, B., Kobus-Cisowska, J., Taczanowski, M., Kmiecik, D. & Gramza-Michałowska, A., 2019. The chemical composition and nutritional value of chia seeds—current state of knowledge. *Nutrients*, 11(6), p.1242.
- Mostashari, P. & Khaneghah, A.M., 2024. Sesame seeds: A nutrient-rich superfood. *Foods*, 13(8), p.1153.
- Neufingerl, N. & Eilander, A., 2022. Nutrient intake and status in vegan diets: A systematic review. *European Journal of Clinical Nutrition*, 76(4), pp.567–579.
- Noda, H., 1993. Health benefits and nutritional properties of nori. *Journal of Applied Phycology*, 5, pp.255–258.
- Patel, K., Soni, A. & Tripathi, R., 2023. Pumpkin seed: Nutritional composition, health benefits. *International Journal of Home Science*, 9(3), pp.93–98.
- Petkova, N., Popova, A. & Alexieva, I., 2019. Antioxidant properties and some phytochemical components of the edible medicinal *Malva sylvestris* L. *Journal of Medicinal Plant Studies*, 7(1), pp.96–99.
- Ruales, J. & Nair, B.M., 1992. Nutritional quality of the protein in quinoa (*Chenopodium quinoa* Willd) seeds. *Plant Foods for Human Nutrition*, 42(1), pp.1–11.
- Santos, M.O., Pereira, R.G. & Fernandes, C.R., 2025. Nutritional and amino acid composition of quinoa varieties: A bioscientific approach. *International Journal of Bioscience and Biochemistry*, 7(2), pp.112–118.
- School of Health Sciences Dept, 2023. Bioavailability of seaweeds as a source of cobalamin (vitamin B12)? Discrepant effects of raw and dried nori. *Bulletin of School of Health Sciences Sapporo Medical University*, 3, pp.11–17.
- Sharma, R., Sharma, S., Dar, B.N. & Singh, B., 2021. Millets as potential nutri-cereals: A review of nutrient composition, phytochemical profile and techno-functionality. *International Journal of Food Science and Technology*, 56(8), pp.3703–3718.

Singh, G., Verma, P.K., Rahmani, U. & Nandi, A., 2023. Shiitake mushrooms: A medicinal mushroom for human health. *International Journal of Plant Pathology*, [online] Available at: ResearchGate [Accessed 23 Aug. 2025]

Spector, T., 2018. *The Diet Myth: The Real Science Behind What We Eat*. London: Weidenfeld & Nicolson.

Storz, M.A., Ronco, A.L. & Müller, A., 2024. Vitamin B12 supplementation in plant-based diets: A public health necessity. *Public Health Nutrition*, 27(1), pp.45–52.

Tănase Apetroaei, V., Pricop, E.M., Istrati, D.I. & Vizireanu, C., 2024. Hemp seeds (*Cannabis sativa* L.) as a valuable source of natural ingredients for functional foods—A review. *Molecules*, 29(9), p.2097.

Watanabe, F., 2007. Vitamin B12 sources and bioavailability in vegetarian diets. *International Journal for Vitamin and Nutrition Research*, 77(5), pp.311–315.