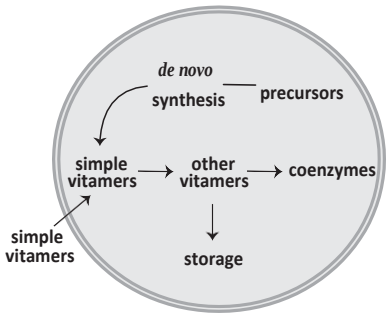
UPDATE

Vitamin-B Complex

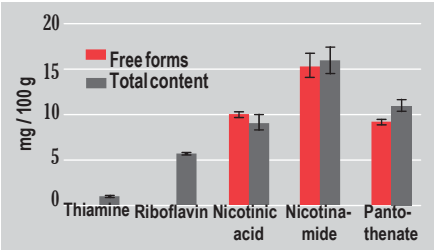
Accumulation of B Vitamins in Yeast

Humans lack the biosynthetic capacity for most vitamins, and so those vitamins must be provided exogenously. Yeast, on the other hand, can *de novo* synthesize and become a source of B vitamins. Like many other microorganisms and plants, yeasts of *Saccharomyces* sp. have the required machinery to synthesize and store several B vitamins. The accumulation of B vitamins in yeast can also result from the uptake of simple vitamers provided in the growth medium (see figure below).



To grow adequately, *S. cerevisiae* benefit from receiving from the growth media's minimal levels of B vitamins, including thiamine, pantothenic acid, pyridoxine, and biotin (Wainwright, 1970). The levels of B vitamins in yeast grown under optimal conditions are shown in the chart below. According to Paalme *et al.* (2014), some of the B vitamins in the yeast are found in free form (thiamine and riboflavin), whereas others are in bound form (both forms of niacin vitamers and pantothenate).

B VITAMIN LEVELS IN YEAST



Health Benefits of Vitamin-B Complex

Several water-soluble vitamins, because of their distribution in natural sources, and related physiological functions, are grouped together under the name *vitamin-B complex*.

The vitamin-B complex is a set of eight enzyme cofactors and their derivatives: thiamine (B1), riboflavin (B2), niacin (B3), pantothenate (B5), pyridoxine (B6), biotin, folate (B9), and cobalamin (B12). These B vitamins all appear to be essential in facilitating the metabolic processes of all forms of animal life. Adequate intake of B vitamins is important to ensure optimum energy production and the building and repair of muscle tissue (ADA, 2006).

The B-complex vitamins have two major functions directly related to exercise. Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, and biotin are involved in energy production during exercise, whereas folate and B12 are required for the production of red blood cells, for protein synthesis, and in tissue repair and maintenance, including of the central nervous system. Of the B vitamins, riboflavin, pyridoxine, folate, and B12 are frequently low in female athletes' diets, especially those who are vegetarian or have disordered eating patterns. These vitamins also contribute to numerous bodily functions, as described in the table below.

VITAMIN B IMPORTANCE TO HEALTH*

CONDITIONS AND VITAMIN B CONTRIBUTIONS		B VITAMINS INVOLVED
Anemia	Normal formation of red blood cells	B6, B12
	Maintenance of normal red blood cells	Riboflavin
	Normal metabolism of iron	Riboflavin
	Reduction of tiredness and fatigue	Niacin, riboflavin, pantothenic acid, folate, B6, B12
Reproduction, growth, and development	Process of cell division	Folate, B12
	Maternal tissue growth during pregnancy	Folate
Health and beauty	Maintenance of normal hair	Biotin
	Maintenance of normal skin	Riboflavin, biotin, niacin
	Protection of cells from oxidative stress	Riboflavin
Heart health	Normal function of the heart	Thiamine
	Normal homocysteine metabolism	Folate, B6, B12
Brain health	Normal function of the nervous system	Thiamine, riboflavin, niacin, biotin, B6, B12
	Normal psychological function	Thiamine, niacin, folate, biotin, B6, B12
	Normal mental performance	Pantothenic acid
Inflammation and immunity	Normal function of the immune system	Folate, B6, B12

** Recognized health relationships based on EFSA authorized Article 13.1 health claims for these vitamins.*

B Vitamins from Foods

OVERWEIgHT and obesity rates continue to soar due to excessive food intake, but many people still do not get enough of essential micronutrients. B-vitamin intake in particular is under close scrutiny, as deficiencies are becoming more frequent in industrialized countries. In Europe, for example, the prevalence of inadequacy for folate is above 20 percent in adults and the elderly, and adolescents have inadequate intakes of vitamin B6 and folate (Diethelm *et al.,* 2014). Moreover, achieving adequate vitamin B6 and folate intakes from diets is problematic in the US (Morris *et al.,* 2008).

Yeast *(Saccharomyces cerevisiae)* is known to be a natural and rich source of B-complex vitamins. For centuries people have been consuming inactive yeast on a daily basis—one tablespoon mixed with salads, soups, pasta, or juice or as a supplement. Because of its naturally rich B-vitamin content, notably riboflavin, folate, and niacin vitamers, yeast is often recommended to stimulate appetite and milk production during lactation. It is also used by athletes and the elderly who need to supplement their nutrient intake to maintain a good energy level, as well as by vegetarians who want to prevent B12 deficiency. Foods naturally containing significant amounts of B-complex vitamins are listed above.

DIETARY SOURCES OF B VITAMINS

Thiamine (B1)	Whole grains, nuts, dried legumes
Riboflavin (B2)	Dairy products, eggs, meats, yeast, green leafy vegetables
Niacin (B3)	Milk, eggs, meats, fish, yeast, whole grains
Pantothenic acid (B5)	Chicken liver, fish, avocado, sunflower seeds, corn, broccoli, mushrooms, cauliflower, yogurt
Pyridoxine (B6)	Cabbage, bananas, fish, milk, brewer's yeast, soybeans, eggs, bran
Folate (B9)	Green vegetables, liver, eggs, yeast, fruits such as oranges and cantaloupes, fortified breads and cereals*
Cobalamin (B12)	Meat, milk, egg, fish, shellfish

** In 1998, folic acid fortification of all enriched cereal grain product flour was implemented in Canada and the US.*

Bioavailability of B Vitamins in Fortified Yeast

YEAST HAS THE capability to accumulate within its cells B vitamins in excess of what is required for its normal growth. According to Paalme *et al.* (2014), yeast has great uptake capacity for thiamine, niacin, and pantothenic acid.

There is also scientific evidence that yeast fortified with B vitamins can be a bioavailable source of these vitamins. The bioavailability of the B vitamins in fortified yeast was first investigated by Dr. Vinson (1989) using rats as a model in supplementation studies. Vitamin levels in the liver and in the blood of this animal were monitored from the moment they followed a vitamin-deficient diet until they completed supplementation treatments with either purified forms of B vitamins or yeast B vitamins. The yeast B vitamins were shown to be more slowly absorbed and more bioavailable in rats compared to the purified forms of the B vitamins.

The company conducted a study in 2012 with Metabrain Research to determine the bioavailability of the thiamine and riboflavin found in Lalmin® B-complex vitamins. growing Wistar rats were fed a B-vitamin-deficient diet before initiating an acute oral administration of either yeast fortified with B vitamins or a blend containing the purified forms of the same B vitamins. The thiamine from the yeast was found to be more slowly absorbed and four times more bioavailable than the purified form of thiamine (see chart below). The bioavailability of yeast pyridoxine and of the purified form of that vitamin were shown to be equivalent.

The company continuously innovates by optimizing yeast production to create products that can be used as dietary supplements. The products offered contain varying levels of B-complex vitamins:

- *Lalmin® Complex-B yeast* is ideal for supplements and protein bars. It contains elevated levels of thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, biotin, and cobalamin.
- *Engevita® premium nutritional yeast* is naturally rich in B-complex and D vitamins, protein, β-glucans, and glutathione and is ideal for direct consumption and protein bars.
- *Yesto-Seal® brewers yeast* for direct tableting is naturally rich in B-complex vitamins, protein, and β-glucans.

BIOAVAILABILITY OF THIAMINE IN WISTAR RATS