Organic selenium – understanding the differences

The uptake and utilisation of selenium depends greatly on the form in which the element is presented and plays a critical role in its bioavailability and efficacy.

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Selenium supplements are available in two forms, inorganic mineral salts, such as sodium selenite or selenate, and organic forms, such as selenium enriched yeast.

Selenised yeast, in which selenium is assimilated during a controlled fermentation process, is the most bioavailable organic selenium source. Even though numerous other products are labelled as organic, a consideration of the production methods and basic chemistry behind these claims indicates otherwise.

Selenium absorption occurs within the small intestine and, while selenoamino acids are absorbed using amino acid and peptide transport mechanisms, the absorption of inorganic selenium, such as selenite, is less efficient and occurs mainly by passive diffusion.

Following absorption, selenium-containing amino acids such as selenomethionine (SeMet) can be incorporated non-specifically into general body proteins in place of methionine and can act as a biological pool for selenium, which can be utilised during periods of suboptimal selenium intake.

While selenomethionine is the predominant selenium species in selenised yeast, recent research has indicated the presence of more than 60 selenium-containing species, including 20 plus previously unreported metabolites.

There is evidence that all of these diverse selenium-containing amino intermediaries are recognised as selenium species and utilised intracellularly in the synthesis of selenoproteins.

In contrast, inorganic sources that are taken up through the small intestine are either utilised or methylated and subsequently excreted.

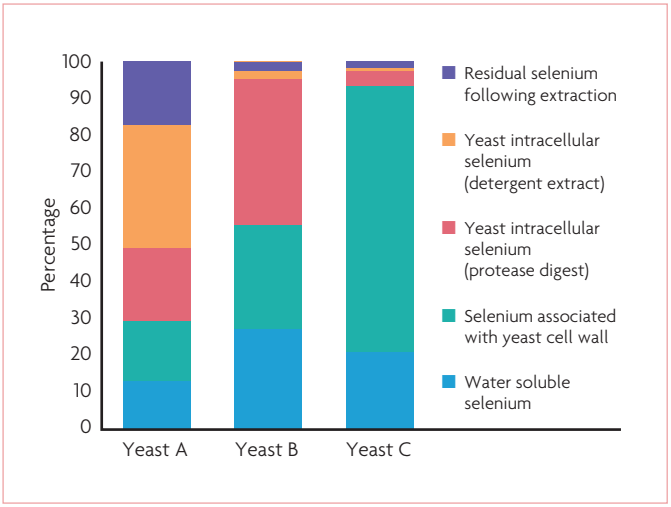
The tissue specific distribution of selenoamino acids can give some indication as to the function that the accumulated selenium is involved in and also to the metabolic fate of the selenium source.

Selenocysteine content within tissues is typically associated with selenoenzyme activity, as SeCys forms the functional core of all selenoenzymes.

The accumulation of SeMet within tissues is an indicator of not only enhanced Se uptake and retention but also of an endogenous Se pool that can be utilised during periods of sub-optimal Se intake or during periods of oxidative challenge.

As an added benefit, SeMet incorporated into the tissues of meat-producing animals not only increases the selenium content of the tissue but will also be more available to the consumer of such animal products.

Fig. 1. Selenium associated yeast fractions (adapted from Encinar, 2003).



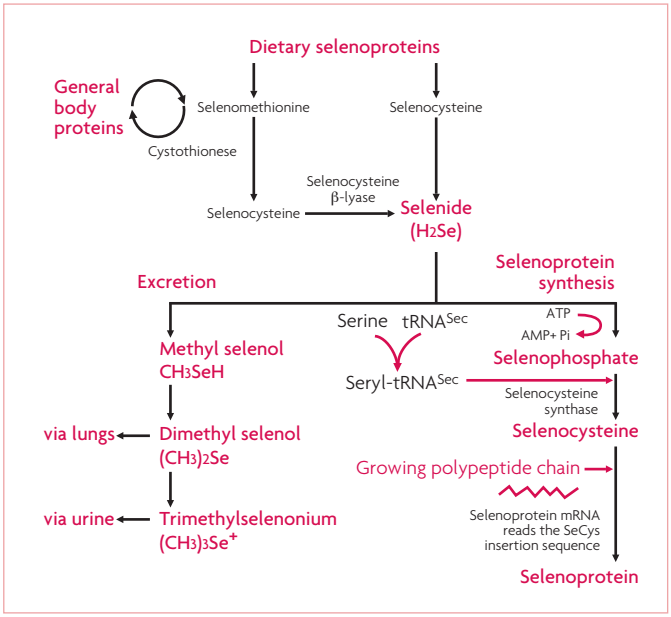


Fig. 2. Selenium metabolic pathways.

Selenium yeast efficacy

It is a well accepted fact that even closely related yeast strains have their own unique biochemical and genetic characteristics and numerous peer-reviewed research papers have been published on this topic.

One such study examined three commercial preparations of selenium enriched yeast and assessed the composition of each product in terms of selenium deposition within individual yeast fraction. Each product was initially extracted with water and subsequently followed by a variety of enzymatic digestions designed to liberate selenocompounds associated with various polysaccharide and protein portions.

These selenocompounds were subsequently separated and speciated by SEC-ICP MS and the recoveries in the various fractions from each yeast product compared to each other (Fig. 1).

The results depicted in Fig. 1 monitor the fractionation of the selenocompounds in yeast by using different extraction techniques and illustrate the large variation that exists in the composition of selenium yeast products.

Although there is a very common perception that all selenium yeast preparations are exactly the same, this is not the case.

It is clear that the deposition of selenium within yeast is totally different between products. Just as there are differences among yeast strains at a genetic level, so too there appear to be fundamental differences in the way yeasts distribute selenium within the cell.

It is reasonable to expect, therefore, that these preparations will also differ in parameters such as shelf life, bioavailability and, indeed,

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toxicology. Rather than viewing these products in exactly the same light, it is clear that they must be seen as distinct selenium preparations.

Metabolism of selenium

Regardless of source, selenium requires a metabolic transformation to selenide prior to its assimilation into SeCys and subsequent incorporation into selenoproteins. No such intermediate step is necessary for the incorporation of SeMet into general proteins.

Consequently, the biological actions of Se depend not only on the amount but also on the form of the selenium source.

In the case of organic selenium products such as selenised yeast, biological efficacy is more dependent on the accessibility of selenium containing proteins and peptides present in the preparations. Fig. 2 outlines the main metabolic pathways for selenium.

It is important to make the distinction between total SeMet and free SeMet, as only the free form of this selenoamino acid is available for non-specific incorporation into proteins. Unless SeMet is liberated as a free amino acid, then regardless of the total selenium and/or total SeMet content, the selenium source must be metabolised to selenide prior to its assimilation into the general selenium pool.

Within the feed industry there is a misconception regarding the total SeMet content of selenium enriched yeast with the belief that 'more is better.'

Such arguments have no scientific basis and indeed no evidence to indicate the availability of the selenium containing proteins and peptides within individual products. This misconception is based on the belief that SeMet is the 'active' component in selenium yeast.

While the level of SeMet may vary between products, it is also to be anticipated that the accessibility, digestibility and thus the amount of free SeMet that is liberated will also differ (Fig. 3).

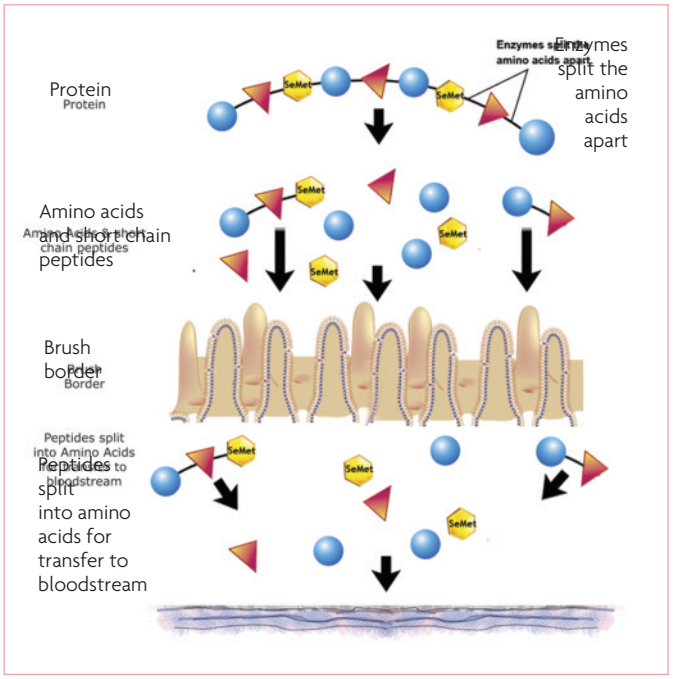

Fig. 3. Digestion of selenium containing proteins releases free SeMet.

Peer-reviewed research has addressed this issue by assessing the digestibility of selenium-containing protein and peptides in selenium enriched yeast using two-dimensional chromatography and mass spectrometry following in-vitro gastrointestinal digestion.

Surprisingly, the authors' findings indicated that while approximately 90% of the total Se was extracted after gastrointestinal digestion, only 34% was quantified in the form of free SeMet amino acid. The rest of the selenium was present in the form of low, medium and high molecular weight Se-species, which could be detected and further characterised by using two-dimensional chromatography.

Interestingly, most of Se-species were in the form of selenium-peptides unspecifically produced by the simulated digestion.

In essence, while the efficiency of gastrointestinal digestion to break down seleno-peptides and proteins found in selenium yeast may be high, its efficiency to convert them into free SeMet is much lower.

It is important, therefore, that consideration be made to the availability of the more than 60 additional seleno-amino acids in selenised yeast. These too are subject to the same digestive processes that influence the bioavailability of the main selenium species.

While it is difficult to make direct comparisons between selenium yeast products on the basis of their bioavailabilities as a selenium source, we can compare published tissue retention data and use this as an indication of the bioavailability of the individual products.

As part of the EU product registration process, each selenium yeast manufacturer is required to submit dossiers detailing the efficacy, safety and toxicity of their products. The European Food Safety Authority (EFSA) then assesses the efficacy and the safety of the products for all species, as well as the safety for the user, consumer and the environment. A summary of the tissue retention data published in the official EFSA opinion on each of the selenium enriched yeast products authorised for use in the EU can be found in Table 1.

While the datasets are not directly comparable in terms of the trials used for the different products, this data does, however, clearly demonstrate that each of the individual products enhances the selenium content and retention in both a tissue and a product specific fashion. In essence, all the available data confirms that selenised yeast products are distinct from each other.

This distinctness is due to the differential deposition of selenium into the numerous peptides and proteins present within individual yeast fractions and indicates that retention and thus bioavailability of selenium from each of these products are different.

Conclusions

When comparing selenium yeast products, consideration needs to be given to the strain specific manner in which selenium is deposited into individual protein and peptide-containing fractions.

These differences are ultimately responsible for the ease with which digestion liberates selenoamino acids and the variation that exists in the bioavailabilities of individual products. Increasing the SeMet content does not necessarily increase the relative bioavailability of the selenium source.

Ultimately, not all selenium yeasts are created equal in terms of the availability of selenium containing proteins and peptides. ■

References are available from the author on request

Table 1. Selenium tissue retention data. Selenium supplementation rates applied during the trials are indicated in parentheses.

Species	Tissue	Se content (ppm)		
		Product 1	Product 2	Product 3
Poultry (broiler)	Muscle	0.34 (0.3)	0.3 (0.27)	0.278 (0.25)
Poultry (broiler)	Liver	0.69 (0.3)	0.63 (0.27)	nd
Poultry (layer)	Egg	0.74 (0.6)	0.33 (0.49)	0.25 (0.3)
Pig	Liver	0.54 (0.3)	0.48 (0.31)	0.68 (0.3)
Piglet	Blood	nd	0.185 (0.31)	0.16 (0.3)
Bovine	Milk	0.031 (0.21-0.27)	0.02 (0.5)	0.04 (0.3)
Bovine	Blood	0.167 (0.24-0.31)	0.12 (0.3)	0.167 (0.3)