



JANUARY 25, 2018

# PHOSVITIN'S ANTIOXIDANT PROPERTIES

THE AMAZING WAYS THAT PHOSVITIN PROMOTES HEALTH BY  
PREVENTING OXIDATIVE STRESS

ALEX HOLDCROFT, BSC., MM.  
ECOVATEC SOLUTIONS INC.  
31231 Wheel Ave., Abbotsford, B.C., CANADA, V2T6H1

## Executive Summary

**Ecovatec's revolutionary technology has unlocked the amazing potential of Phosvitin.** Ecovatec is the only known commercial producer of phosvitin in the world.

Phosvitin has been characterized by many scientific papers, and the literature consensus is that it has huge potential as a bio-active molecule, which are often used in nutraceutical, pharmaceutical, cosmetic, and food industries. Bioactivity is based on the ability of a compound to be "able to exert a biological effect at a physiological level, and it must be measurable and able to provide health benefits."<sup>1</sup> The research explored in this white paper is **very clear about the strong antioxidant and iron-binding properties of phosvitin and its incredible ability to promote healthy body systems by reducing oxidative stress.** It is also clear that phosvitin peptides could be used in food preparation to increase the quality of products and extend their shelf life.

## Background

Phosvitin is the most highly phosphorylated protein found in nature and is derived from the egg yolks of vertebrates.<sup>2</sup> Proteins are made up of peptides, which are short chains of amino acids linked by peptide bonds. Bioactive peptides have shown the most promising potentials as therapeutic or health promoting agents<sup>2</sup>. Serine is the major amino acid present in phosvitin (50%)<sup>1</sup>, and almost all the serine residues are phosphorylated. This phosphorylation gives phosvitin its strong metal binding and antioxidant ability.<sup>1-5</sup>

*Samaraweera, et al* (2011)<sup>2</sup> and *Ren, et al* (2015)<sup>4</sup> both note that the potential use of phosvitin as a functional ingredient is only hampered by lack of a scalable method of extraction. **Ecovatec Solutions Inc. has eliminated this barrier.**

## Oxidation in the Body

According to *Lobo, et al* (2010)<sup>6</sup>, free radicals such as oxygen and nitrogen are generated by the body in its daily functions and systems. However, when free radicals build up in the body and are out of balance with available "antioxidants", the body undergoes oxidative stress, which is known to be associated with many diseases<sup>5,6,14</sup>. This has led scientists to try to find more dietary, natural antioxidants that will help to regulate this balance. An antioxidant is any molecule stable enough to bind to a free-radical and neutralize it, thereby delaying or inhibiting cellular damage. Antioxidants can act in many ways such as by binding to a free radical or metal ion (calcium, iron, magnesium), inhibiting enzyme activity, or decomposing peroxide molecules.<sup>5,6,9</sup>

### Oxidative Stress Related Disorders in Humans

Some of the oxidative stress related disorders include: **cardiovascular diseases, carcinogenesis, ageing, neurological disorders** (Alzheimer's disease, Parkinson's disease, muscular dystrophy), **inflammatory diseases** (such as arthritis), **diabetes**, and many others.<sup>6,9,14</sup> Oxidative stress can also change the structure of the fats and proteins in the body thereby changing their functions.<sup>6</sup>

## Egg Yolk Phosvitin as an Nutraceutical Antioxidant

The need for natural antioxidants is high, with many scientists looking for better alternatives than the chemically-synthesized ones which have negative side effects<sup>6-14</sup>. *Nimalaratne and Wu* (2015)<sup>7</sup> noted that phosvitin peptides work by scavenging free radicals in the body and by binding metals such as Iron<sup>7</sup>. In their review on the ability of various egg components and their abilities to act as antioxidants, they noted that free iron cannot be excreted by the body and when it builds up, can cause **heart arrhythmia and heart failure**. They also state that phosvitin has been proven to be effective at reducing iron induced oxidative damage through its metal chelating properties and it is effective against UV-induced lipid peroxidation in the presence of excessive iron<sup>7,8</sup>.

*Ishikawa et al* (2004)<sup>8</sup> go into further detail regarding the mechanisms causing phosvitin's iron-binding ability and rank antioxidants on their ability to inhibit iron-catalyzed hydroxyl radical formation, finding that phosvitin and its phosphopeptides **are far more effective than the other antioxidants** tested. They also noted that of phosvitin and its phosphopeptides could be beneficial for preventing iron-mediated oxidative stress related diseases, such as **colorectal cancer**.

*Zambrowicz et al* (2012 and 2015)<sup>9,14</sup> further corroborated the findings of other researchers noting the strong iron chelating and free radical scavenging properties as well as noting the lack of cytotoxic effects (the peptides don't have negative effects on regular human cells). They also saw an inhibition of lipid oxidation and the protection of intestinal cells from oxidative stress. They had previously proven<sup>10</sup> that these peptides acted as an angiotensin I-converting enzyme (ACE) inhibitor, a class of drugs used to treat **high blood pressure**, which could have an

### Technology Solutions for **Healthy Living**

application in drug-development. Lastly, they saw results proving the ability of the peptides to inhibit enzymes ( $\alpha$ -glucosidase and DPP-IV) associated with **type II diabetes**, which could help maintain stable blood sugar and health for individuals with this disease.

## Egg Yolk Phosvitin as an Food Ingredient Antioxidant

Researchers are also looking at the use of biopeptides to **extend the life of food products**.<sup>11-14</sup> Lipid oxidation is a significant problem for the food industry<sup>11-14</sup>. In an experiment performed by *Jung et al* (2013), it was discovered that when added to meat products processed through high hydrostatic pressure, phosvitin was able to reduce the lipid and protein oxidation caused by the processing method. This indicates that phosvitin can also be added to food products as an antioxidant to maintain their high quality and attractiveness to appeal to customers.<sup>11</sup>

*Duan et al* (2016) found that phosvitin's antioxidant properties could be applied to food emulsions and suggest further research on the types of ingredient interactions that work with phosvitin-based emulsifiers where oxidative stability is important.<sup>12</sup> These findings are corroborated by *Xu et al* (2007) who performed an enzyme digest of phosvitin into its phosphopeptides and articulated the same antioxidant and iron-binding effects. They also noted that the peptides increased iron absorption in the intestines while preventing oxidative stress<sup>13</sup>.

## Practical Applications

The two main practical applications of this research are 1) phosvitin and its phosphopeptides can be used as a nutraceutical supplement to be ingested on its own for its antioxidant and blood-sugar maintaining properties or with iron to increase iron absorption and potentially prevent anemia<sup>7-10,14</sup>; and 2) it can be used in the preparation of food products to extend their shelf life and maintain their high quality by preventing lipid and protein oxidation<sup>11-13</sup>.

## Sources

<sup>1</sup>Mudiyanselage and Himali. "Production and Characterization of Phosphopeptides from Egg Yolk Phosvitin." *Graduate Thesis and Dissertations*. 2012. Paper 12451.

<sup>2</sup>Samaraweera, H., et al. "Egg Yolk Phosvitin and Functional Phosphopeptides-Review." *Journal of Food Science*, vol. 76, no. 7, Jan. 2011, doi:10.1111/j.1750-3841.2011.02291.x.

<sup>3</sup>Samaraweera, H., et al. "Characterisation of phosvitin phosphopeptides using MALDI-TOF mass spectrometry." *Food Chemistry*, vol. 165, 2014, pp. 98–103., doi:10.1016/j.foodchem.2014.05.098.

<sup>4</sup>Ren, J., et al. "Preparation and characterization of phosphopeptides from egg yolk phosvitin." *Journal of Functional Foods*, vol. 18, 2015, pp. 190–197., doi:10.1016/j.jff.2015.07.007.

<sup>5</sup>Jung, S., et al. "The functional property of egg yolk phosvitin as a melanogenesis inhibitor." *Food Chemistry*, vol. 135, no. 3, 2012, pp. 993–998., doi:10.1016/j.foodchem.2012.05.113.

<sup>6</sup>Lobo, V, et al. "Free radicals, antioxidants and functional foods: Impact on human health." *Pharmacognosy Reviews*, vol. 4, no. 8, 2010, p. 118., doi:10.4103/0973-7847.70902.

<sup>7</sup>Nimalaratne, C., and Wu, J., "Hen Egg as an Antioxidant Food Commodity: A Review." *Nutrients*, vol. 7, no. 10, 2015, pp. 8274–8293., doi:10.3390/nu7105394.

<sup>8</sup>Ishikawa, S., et al. "Egg Yolk Phosvitin Inhibits Hydroxyl Radical Formation from the Fenton Reaction." *Bioscience, Biotechnology, and Biochemistry*, vol. 68, no. 6, 2004, pp. 1324–1331., doi:10.1271/bbb.68.1324.

<sup>9</sup>Zambrowicz, A., et al. "Antioxidant and antidiabetic activities of peptides isolated from a hydrolysate of an egg-Yolk protein by-Product prepared with a proteinase from Asian pumpkin (*Cucurbita ficifolia*)." *RSC Advances*, vol. 5, no. 14, 2015, pp. 10460–10467., doi:10.1039/c4ra12943a.

<sup>10</sup>Eckert, E., et al. "Egg-Yolk protein by-Product as a source of ACE-Inhibitory peptides obtained with using unconventional proteinase from Asian pumpkin (*Cucurbita ficifolia*)." *Journal of Proteomics*, vol. 110, 2014, pp. 107–116., doi:10.1016/j.jprot.2014.08.003.

<sup>11</sup>Jung, S., et al. "Effect of phosvitin on lipid and protein oxidation in ground beef treated with high hydrostatic pressure." *Meat Science*, vol. 95, no. 1, 2013, pp. 8–13., doi:10.1016/j.meatsci.2013.04.005.

<sup>12</sup>Duan, X., et al. "Physicochemical properties and antioxidant potential of phosvitin–resveratrol complexes in emulsion system." *Food Chemistry*, vol. 206, 2016, pp. 102–109., doi:10.1016/j.foodchem.2016.03.055.

<sup>13</sup>Xu, X., et al. "Antioxidant activity of tryptic digests of hen egg yolk phosvitin." *Journal of the Science of Food and Agriculture*, vol. 87, no. 14, 2007, pp. 2604–2608., doi:10.1002/jsfa.3015.

<sup>14</sup>Zambrowicz, A., et al. "Antioxidant and antimicrobial activity of lecithin free egg yolk protein preparation hydrolysates obtained with digestive enzymes." *Functional Foods in Health and Disease*, vol 2, no. 12, 2012, pp. 487-500.