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ORGANIC FARMING BY VERMICULTURE: PRODUCING CHEMICAL-FREE, NUTRITIVE AND HEALTH PROTECTIVE FOOD FOR THE SOCIETY

Vermicompost produced from 'organic wastes' are scientifically proving to be an 'extraordinary powerful growth promoters and protectors' for crops (5–7 times over other bulky organic fertilizers and 20–40% higher over chemical fertilizers). They are rich in NKP, micronutrients, beneficial soil microbes like 'nitrogen-fixing' and 'phosphate solubilizing' bacteria, 'mycorrhizal fungi', humus and growth hormones – auxins, gibberellins and cytokinins. It has very high 'porosity', 'aeration', 'drainage' and 'water holding capacity' and makes the soil soft & fertile. More significantly it also protect plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants to fight them or by killing them by their beneficial microbes (chitin and cellulose degraders). 'Vermiwash' (liquid filtered from worm's body) and the 'vermicompost tea' (fermented solution in water) also works as 'powerful bio-pesticides' eliminating the use of toxic chemical pesticides. Organically grown fruits & vegetables especially on 'earthworms & vermicompost' have been found to be highly nutritious, rich in 'proteins, minerals & vitamins' and 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health They have elevated antioxidants levels in about 85% of the cases studied. They have been found to be protective against several forms of 'cancers' and against 'cardiovascular diseases'.

Key words: *vermicompost; earthworms; biofungicides; the nutritional value of food; "organic food"; crop yields; antioxidants.*

Introduction

Agrochemicals which ushered the 'green revolution' in the 1950-60's came as a 'mixed blessing' for mankind. It boosted food productivity, but at the cost of environment and society. It dramatically increased the 'quantity' of the food produced but decreased its 'nutritional quality' and also destroyed physical, chemical and the biological properties' of soil over the years of use. It killed beneficial soil organisms which help in renewing natural fertility. It also impaired the power of 'biological resistance' in crops making them more susceptible to pests and diseases. Over the years it has worked like a 'slow poison' for the farm soil and the society. The excessive use of 'nitrogenous fertilizer' (urea) has also led to increase in the level of 'inorganic nitrogen' content in groundwater (through leaching effects) and in the human food

with grave consequences for the human health. Chemically grown foods have adversely affected human health all over the world. According to UNEP and WHO some 25 million farmers and agricultural workers are poisoned by pesticides every year and nearly 3 million people suffer from 'acute pesticide poisoning' and some 10 to 20 thousand people die every year from it in both developed and developing countries [1].

Also, there has been a serious decline in the 'nutritional values' of food produced by agrochemicals in the wake of 'green revolution'. More concerning is that there is a significant increase in some undesirable constituents like 'nitrates' and 'free amino acids' in chemically grown crops. Nitrates can potentially endanger health. Davis et al. [2] compared the nutritive contents of 43 garden crops between 1950 (beginning of chemical farming) and 1999 and found that there was a reliable decline in 6 nutrients viz. proteins, calcium, potassium, iron, riboflavin and vitamin C ranging from 6% in proteins to 38% in riboflavin. Significantly lower 'carotene' was found in all vegetable crops produced by chemical fertilizers as compared to organically grown crops [3].

To resolve various problems related to 'human food safety, nutritional quality and environmental security' a global movement is going on to scientifically revive traditional 'Organic Farming' systems [4]. Scientifically produced 'organic fertilizers' with recent knowledge in biotechnologies are much more nutritive and productive than those produced traditionally by farmers in earlier days. Organic foods are significantly rich in 'antioxidants', 'proteins', 'vitamins' and essential 'minerals'. They have also been found to be 'protective' to human health even against 'colon cancer' and 'breast cancer' [5].

Organic farming systems with the aid of 'Vermiculture Biotechnology' promoted by earthworms which was visioned by Sir Charles Darwin centuries ago calling them as 'friends of farmers' can resolve diverse problems related to safety, security and productivity of food, protection of farmlands and farmers in most economical way. Earthworms have protected the 'earth' for over 600 million years and have fed people since mankind arrived on earth. Earthworms secrete 'humus' in soil which is essential for plant growth. Earthworms vermicompost give a very 'high food productivity' comparable to or even better than chemical fertilizers with significantly 'higher nutritional quality' while also improving the physical, chemical and biological properties of soil. Vermicompost is a highly nutritive and powerful 'plant growth promoter and protector' and has scientifically proven to be a 'miracle plant growth promoter'. It is rich in NKP, micronutrients, beneficial soil microbes and also contains plant growth hormones and enzymes secreted by earthworms. Vermicompost retains nutrients for long time and also 'protects crops from pests and diseases'. It has a high 'moisture holding capacity' and hence also reduces the use of water for farm irrigation by 40–50%. The 'vermiwash' (liquid produced during vermicomposting) and 'vermicompost tea' (solution of vermicompost produced in water) are highly effective 'bio-pesticides' with 100% control of crop pests and diseases.

Chemically Produced Foods: Slow Poison for Mankind

Adverse effects of agro-chemicals on the health of farmers using them and the society consuming chemically grown food have now started to become more evident all over the world. Fruit and vegetables are foods that receive the highest doses of pesticides. Millions of people suffer from ‘acute pesticide poisoning’ and thousands die every year from it in developing countries. The US have some 600 pesticides in use today [6]. The US scientists predict that up to 20,000 Americans may die of cancer, each year because of low levels of ‘residual pesticides’ in chemically grown food [7].

A report by the Pesticide Action Network of North America and Commonwealth tells that the Americans can experience up to 70 daily exposures to residues of POPs (Persistent Organic Pollutants) including DDT and Dioxins through their foods. Two most pervasive POPs found in food are ‘dieldrin’ and DDE (breakdown product of DDT). The US Agriculture Department showed that 73% of the food grown conventionally by agrochemicals had residues from at least ‘one pesticide’ and were 6 times as likely as ‘organically grown foods’ to contain multiple pesticide residues. Jones [6] reported 35% of the food purchased in the US has detectable pesticides levels, 1–3% above the legal tolerance levels. Heaton [8] reported 48% of the fruit and vegetables in the UK have detectable pesticides residues. Many of these chemical residues remain on produce after washing and some are taken up by the entire plant and contaminate the entire flesh. Some 53 fruits and vegetables have been identified which have the most and least ‘pesticides residues after ‘washing and peeling’ as pesticides can even penetrate the skin. Apples top the list with 92% containing two or more pesticides as more pesticides are used after the harvest for longer shelf life to fruit. Apples have been found to contain 13 times the average residue levels and carrots can have 29 times the average [8]. This is followed by Celery, Strawberries, Peaches, Spinach, Grapes, Potatoes and Lettuce. Exposure to these chemicals is linked with serious diseases and developmental disorders like ‘Nervous System Disorders’, ‘Immune System Suppression’, Breast and Other Cancers’ ‘Reproductive Damages’, ‘Impairment of Brain Development in Children’ and ‘Disruption of Hormonal Systems’ [9].

Studies indicate that there is a significant amount of ‘residual pesticides’ contaminating our food stuff long after they are taken away from farms for human consumption. American studies found detectable levels of DDT in 17% of carrots tested 20 years after this pesticide was banned in US [8]. In an Indian study vegetable samples were contaminated 100% with HCH and 50% with DDT. Bhatnager and Sharma [10] reported pesticide residues in wheat flour samples. Contamination with HCH was 70%, Heptachlor 2 was 45%, Aldrin 45% and DDT 91%. 60% of water samples were found to be contaminated with Aldrin and 50% with DDT. They were all higher than permissible limits of WHO. A study made by the Society for Research and Initiative for Sustainable Technologies and Institutions (SRISTI), Ahmedabad, India, to analyse the residual pesticide in soils

of croplands of Gujarat found that 41 out of 70 samples contained insecticidal residues of Phosphamidon, DDVP, Methyl parathion, Malathion, Chlorpyrifos and three different pyrethroids [11]. Rao [12] also reported residues of pesticides in meat, fish, eggs, butter, milk including mother's milk and human fat in India. The contamination was 100% with HCH, 69% with DDT and 43% with aldrin. In human fat DDT residue ranged from 1.8 ppm in Lucknow to 22.4 ppm in Ahmedabad; HCH ranged from 1.6 ppm in Bombay to 7 ppm in Bangalore.

Organic Farming by Vermiculture: Producing Chemical-free, Nutritive and Health Protective Food for the Society

Organically grown fruit and vegetables especially on 'vermicompost' have been found to be highly nutritious, richer in 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health [13]. Organic foods have elevated antioxidants levels in about 85% of the cases studied with average levels being 30% higher compared to chemically grown foods [14–16]. Smith [17] reported high mineral contents in organic foods. Antioxidant vitamins in vegetables are some of nutrients besides vitamins, minerals, flavonoids and phytochemicals, which contribute greatly to human health protection. Studies indicate that organic foods are high in 'organic acids' and 'poly-phenolic compounds' many of which have potential health benefits like antioxidants [18]. A Japanese study indicated that organic vegetables had 30% to 10 times higher levels of 'flavonoids' as compared to chemically grown counterparts and with very high 'anti-mutagenic activity'. This is of great significance in preventing some deadly diseases leading to tremendous health benefits [19]. The greatest anti-mutagenic activity was found in organic spinach.

Leclerc et al. [20] found that carrot and celeriac roots grown organically were richer in 'ascorbic acids' and ' β -carotene' contents. Organic potatoes also had significantly high 'ascorbic acids' than those produced chemically. Significantly higher vitamin C was reported in organically grown spinach, tomato, turnip, apple, cabbage, carrots, beetroots, celery, lentil, lettuce, pepper, potato and pears [3]. In a ten-year comparative study Mitchell [21] reported levels of flavonoids 'quercetin' and 'kaempferol' in organic tomatoes (115.5 and 63.3 mg per gram of dry matter) were 79 and 97% higher than those in chemically grown tomatoes (64.6 and 32.06 mg per gram of dry matter) respectively. The levels of flavonoids increased over time in samples of tomatoes treated organically. Ismail et al. [22] analyzed β -carotene, vitamin C and riboflavin contents and found that swamp cabbage grown organically was richer in β -carotene, vitamin C and riboflavin contents among the entire samples studied. Worthington [23] reviewed 41 organic crops and found 27% more vitamin C, 21.1% more iron (Fe), 29.3% more magnesium (Mg), and 13.6% more phosphorus (P) in them as compared to chemically grown crops. There was an increase in iron (Fe), calcium (Ca), magnesium (Mg), phosphorus (P) content in organically grown spinach, tomato, turnip, apple, cab-

bage, carrots, beetroots, celery, lentil, lettuce, pepper, potato and pears. In addition, organic products had 15.1% less nitrates than their chemical counterparts. Heaton [8] found 14 studies showing average 50% lower nitrates in organically grown crops. Shankar and Sumathi [3] reported significantly higher 'nitrates' in chemically grown tomatoes. Nitrates in food is linked with 'gastric cancer' (as it can be transformed into nitrosamines in the stomach) and 'infantile methaemoglobinemia (blue baby syndrome) and may affect DNA alkylation and transcription, teratogenesis [24].

Schuphan [25] reported the results of 12 years of experiment on vegetables grown organically on compared with NPK. The dry matter increased by 23%, relative protein by 18%, ascorbic acids (vitamin C) by 28%, total sugars by 19%. Among the minerals potassium (K) increased by 18%, calcium (Ca) by 10%, phosphorus (P) by 13% and iron (Fe) by 77% (in spinach). The undesired constituents in organic crops diminished – nitrates by 93% (in spinach), free amino acids by 42 % and sodium (Na) by 12%. He also studied an increase in proteins by 4–6% in spinach, 33–40% in savoy, 15–24% in lettuce, 24–37% in celeriac, 21–25% in carrots and slightly in potatoes. The reduction in 'free amino acids' by organic fertilizers is beneficial for crops. Aphids feeding on plants use this as a source of protein.

Organic fertilizers unequivocally increase one of the most important essential amino acids 'methionine' which plays a key role in the biological value of proteins. Plant breeders are keen to increase these amino acids genetically. A serious negative impact of use of chemical fertilizers is the increase in 'water contents' of plant tissues. In other terms, a 'decrease in dry matter'. On the contrary, all organic fertilizers significantly increase the 'dry matter' contents in plants even up to 96%.

Organic Foods Reduces the Risk of Some Cancers

More significantly, *in vitro* studies indicate that organic foods can reduce the risks of 'cancer' in humans. The 'anti-mutagenic' properties of organic foods carry great significance in this respect [19, 26]. A wide range of studies show that antioxidant plant phenolic compounds are 'anti-proliferative' and can prevent or slow tumour progression. Flavonoids can interfere with several steps in the development of cancers. They can protect DNA from oxidative damage that leads to abnormal cell proliferation. They can inhibit 'cancer promoters' and activate 'carcinogen-detoxification system' [27, 28]. Recent research has confirmed a specific mechanism leading to the anti-cancer activities of the flavonoids 'resveratrol'. It starves cancer cells by inhibiting the actions of a key protein that helps feed cancer cells [15].

The studies of flavonoids extracted from 'cranberries' have revealed significant impacts on a number of human cancer cell lines. It is suggested that flavonoids extracts from 'cranberries' might someday find application as a novel 'anti-cancer'

drug [26]. Extracts from organic strawberries showed higher 'anti-proliferative' activity against 'colon cancer' and 'breast cancer' cells than did the extracts from conventional strawberries [5]. A European study found that the carrot antioxidant 'falconin' satisfied six criteria suggested for food intake of antioxidants to reduce the risk of cancers [15]. The tomato is one of the most 'protective food' due to excellent source of balanced mixture of minerals and antioxidants, including vitamin C, total carotene and lycopene. Lycopene has been found to have preventive effects on 'prostate cancer' in human beings. Lumpkin [29] reported significantly a higher lycopene in tomatoes grown organically. A potent antioxidant in canola oil has recently been discovered which has 'anti-mutagenic', 'anti-proliferative' and 'anti-bacterial impacts' [30].

Protection from Cardiovascular Diseases by Organic Foods Rich in Antioxidants

A number of studies have suggested that antioxidant vitamins, especially 'vitamin E' and 'beta-carotene' (precursor of vitamin A) may prevent the initiation and progression of cardiovascular diseases. A Japanese study indicated significant protection from coronary heart diseases in women to the relatively high dietary intake of 'quercetin' and 'isoflavones'. The organic foods contain significantly high amounts of both these antioxidant vitamins and flavonoids. Possible importance of 'lycopene' (found in significantly high amounts in organic tomatoes) has also been suggested for protection from cardiovascular diseases [15].

Impact of Earthworms and Vermicompost on Nutritional Values of Food Produced

Studies made at CSIRO (Council of Scientific & Industrial Research Organization), Australia, found that the presence of earthworms (*Aporrectodea trapezoids*) in soil lifted protein value of the grain of wheat crops (*Triticum aestivum*) by 12% [31]. Shankar and Sumathi [3] studied tomatoes grown on vermicompost and reported that they had significantly higher total antioxidants, total carotene, iron (Fe), zinc (Zn), crude fibre and lycopene content (which protect from 'prostrate cancers') than other organically grown tomatoes. Also tomatoes, spinach and amaranthus grown on vermicompost had a significantly higher vitamin C. Vermicompost applied tomatoes also registered significantly higher 'shelf-life' when stored at room temperature.

Earthworms and Vermicompost: Posed to Bring Revolution in Organic Farming

Vermicompost is a nutritive 'organic fertilizer' rich in NKP (nitrogen 2–3%, potassium 1.85–2.25% and phosphorus 1.55–2.25%), micronutrients, beneficial

soil microbes like 'nitrogen-fixing bacteria' and 'mycorrhizal fungi' and are scientifically proved as 'miracle growth promoters and protectors' with significantly higher agronomic impacts (5–7 times) over the conventional composts discussed above. Kale and Bano [32] reports as high as 7.37% nitrogen (N) and 19.58% phosphorus as P_2O_5 in worms vermicast. Exchangeable potassium (K) was over 95% higher in vermicompost. There is also a good amount of calcium (Ca), magnesium (Mg), zinc (Zn) and manganese (Mn). Additionally, vermicompost contains enzymes like amylase, lipase, cellulase and chitinase, which continue to break down organic matter in the soil (to release the nutrients and make them available to the plant roots) even after they have been excreted. Annual application of adequate amount of vermicompost also leads to a significant increase in soil enzyme activities such as 'urease', 'phosphomonoesterase', 'phosphodiesterase' and 'arylsulphatase' and the soil has a significantly more electrical conductivity (EC) and near neutral pH [33].

There have been several reports that worms worked waste and their excretory products (vermicast) can induce excellent plant growth. It has been found to influence all yield parameters such as-improved seed germination, enhanced rate of seedling growth, flowering and fruiting of major crops like wheat, paddy, corn, sugarcane, tomato, potato, brinjal, okra, spinach, grape and strawberry as well as of flowering plants like petunias, marigolds, sunflowers, chrysanthemums and poinsettias.

The application of vermicompost significantly reduces the demand for irrigation by nearly 30–40%. Most remarkable observation had less incidence of pests and disease attacks in vermicompost applied crops. There has been considerable evidence in recent years regarding the ability of vermicompost to protect plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants to fight them or by killing them through pesticidal action [34]. According to the estimate of an American researcher, 1000000 (one million) earthworms in a garden plot provide the same benefit as three gardeners working 8 hours in shifts all year round, and moreover having 10 tons of manure applied in the plot [35].

Studies on High Growth Impacts of Vermicompost on Crops over Chemical Fertilizers

There have been several reports that earthworms and its vermicompost can induce excellent plant growth and enhance crop production. Edwards and Burrows [36] found that vermicompost consistently improved seed germination, enhanced seedling growth and development, and increased plant productivity. Application of vermicompost in potted and field crops displayed excellent growth performances in terms of height of plants, colour and texture of leaves, appearance of fruiting structures etc. as compared to chemical fertilizers and the marketed conventional composts certified by Compost Australia. There was also less incidences of pest

and disease attack & reduced demand of water for irrigation. Our studies have also confirmed that [11, 37, 38, 40, 13, 41, 42, 43].

– **Wheat Crops (*Triticum aestivum*)**

Baker and Amato [31] found that earthworms (*Aporrectodea trapezoids*) increased growth of wheat crops by 39% and grain yield by 35%. It also resisted crop diseases as compared to the control. Palaniswamy [44] also reported that earthworms and its vermicast improve the growth and yield of wheat by more than 40%.

– **Rice Crops (*Oryza sativa*)**

Kale and Bano [32] studied the grain yield of rice crops on vermicompost and chemical fertilizers and found that rice crops receiving vermicompost (10,000 kg / ha) were statistically at par with those receiving chemicals (200 kg / ha). Guerrero [45] also reported that yield of grain in rice crops was 40 % higher with vermicompost.

– **Corn Crops (*Zea mays*)**

Guerrero [45] reported 14% increase in ear yield of corn crops applied with vermicompost (5 ton / ha) as compared to inorganic fertilizers applied at normal recommended dose.

– **Grapes (*Vitis vinifera*)**

Buckerfield and Webster [46] found that vermicompost boosted grape yield by two-fold as compared to chemical fertilizers. Treated vines with vermicompost produced 23% more grapes due to 18% increase in bunch numbers. Still more significant was that ‘single application’ of vermicompost had positive effects on yields of grapes for long 5 years.

– **Strawberries: (*Fragaria ananasa*)**

Arancon et al. [47] studied the agronomic impacts of vermicompost and inorganic (chemical) fertilizers on strawberries. Significantly the ‘yield’ of marketable strawberries and the ‘weight’ of the ‘largest fruit’ was 35 % greater on plants grown on vermicompost as compared to inorganic fertilizers in 220 days after transplanting.

– **Cherries:**

Webster [48] studied the agronomic impact of vermicompost on cherries and found that it increased yield of ‘cherries’ for three years after ‘single application’. At the first harvest, trees with vermicompost yielded an additional \$ 63.92 and \$ 70.42 per tree respectively. After three harvests profits per tree were \$ 110.73 and \$ 142.21 respectively.

Important Feedbacks from Farmers in India & Australia Using Vermicompost
Some of the important observations of farmers using vermicompost were:

Reduced use of ‘water for irrigation’ as application of vermicompost over successive years improved the ‘moisture holding capacity’ of the soil.

Flower blooms were more colourful and bigger in size.

Farmers' opinion on the use of vermicompost on various crops

Crops	Doses of vermicompost applied	Growth impact	Crops	Doses of vermicompost applied	Growth impact
Cereals	2 tons / acre		Ornamentals	4 tons / acre	
Oats		very good	Roses		excellent
Rice		Excellent	–		excellent
Maize		very good	Marigold		excellent
Oil Seeds	3–5 tons / acre		Fruits	2–3 kg / plant	
Sun Flower		very good	Grapes		excellent
Ground Nut		very good	Banana		excellent
Soybean		very good	Water-melon		excellent
Mustard		very good	Custard apple		excellent
Vegetables	4–6 tons / acre		Pomegranate		excellent
Cabbage		excellent	Mango		very good
Potato		excellent	Other Crops	3–5 tons / acre	
Tomato		excellent	Sugarcane		excellent
Carrot		excellent	Cotton		very good
Pumpkin		excellent	Tea		good
Cucumber		very good	Coffee		very good

Conclusions and Remarks

This is a revolutionary century for world agriculture and ‘Sustainable Agriculture’ is the key word. It has to be ‘economically sustainable’ (at low-cost with high productivity); environmentally sustainable (without any adverse effects on soil, air, water and biodiversity and with potential to mitigate global warming); and ‘socially sustainable (nutritive and protective foods for the society to promote human health and without any adverse effects). Organic farming by vermiculture promises to fulfil all the above conditions. A quiet 2nd ‘Non-Chemical Ever Green Revolution’ is now taking place in world in various names like ‘The Ecological Agriculture’, ‘Organic Agriculture’ etc. Today over 60000 farmers in Bangladesh and 20000 in India are practising organic farming with the help of earthworms and its vermicompost [49].

Earthworms are justifying the beliefs of a great visionary scientists Sir Charles Darwin who called them as *‘friends of farmers and unheralded soldiers of mankind working day and night under the soil’*. They are also justifying the beliefs of a great Russian Scientist Sir Anatoly Igonin who said *‘Nobody and nothing can be compared with earthworms and their positive influence on the whole living Nature. They create soil and improve soil’s fertility and provide critical biosphere’s functions: disinfecting, neutralizing, protective and productive’*.

Earthworms vermicompost can truly be a ‘sustainable alternative’ to the agrochemicals which are proving destructive all on counts – socially (as slow

poison for the society), economically (increasing cost of food production due to high cost of chemical fertilizers), agronomically (degrading soil properties and its natural fertility and increasing susceptibility in crops to pest and diseases) and environmentally (soil and water pollution & greater emissions of greenhouse gases from the production and use of agrochemicals).

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ОРГАНИЧЕСКОЕ ЗЕМЛЕДЕЛИЕ НА ОСНОВЕ ВЕРМИКУЛЬТИВИРОВАНИЯ: ПРОИЗВОДСТВО ЭКОЛОГИЧЕСКИ БЕЗОПАСНОЙ И ПОЛЕЗНОЙ ДЛЯ ЗДОРОВЬЯ ПИЩЕВОЙ ПРОДУКЦИИ

Вермикомпост, получаемый из разнообразных органических отходов, является мощным стимулятором роста и средством защиты растений (в 5–7 раз превышая по своим свойствам органические удобрения и на 20–40% – химические). Вермикомпост содержит большое количество микроэлементов, полезных для почвенных бактерий, например азотфиксирующих или фосфатрастворяющих бактерий, а также микоризных грибов. В нем много гумусовых веществ и регуляторов роста – ауксинов, гиббереллинов и цитокининов. Вермикомпост хорошо структурирован и отличается высокой водоудерживающей способностью, тем самым улучшая аэрацию почвы и делая ее мягкой и плодородной. Вермикомпост защищает растения от различных болезней и вредителей, подавляя их жизнедеятельность, стимулирует устойчивость самих растений. Пищеварительные ферменты червей и так называемый вермикомпостный чай (ферментированная водная вытяжка из вермикомпоста) также могут использоваться как очень эффективный биопестицид, что позволяет избежать использования токсичных химических пестицидов. Отмечено, что фрукты и овощи, выращенные на вермикомпосте, обладают высокими питательными свойствами, богаты белком, минеральными элементами и витаминами. В 85% изученных случаев под воздействием вермикомпоста было отмечено повышение содержания антиоксидантов в плодах, оказывающих благотворное воздействие на здоровье человека и препятствующих развитию сердечно-сосудистых и онкологических заболеваний.

Ключевые слова: вермикомпост; дождевые черви; биофунгициды; питательная ценность пищевых продуктов; «органическая пища»; урожайность сельскохозяйственных культур; антиоксиданты.

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