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Editorial

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Is Garlic a Wonder Plant?

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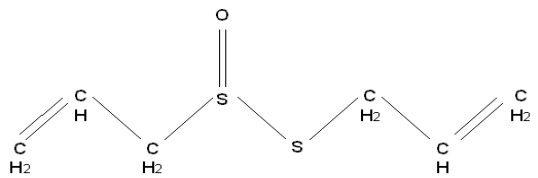
The term wonder drug was coined for aspirin, acetylsalicylic acid, for decades – because of its benefits in alleviating many health problems, conditions and symptoms. Aspirin is easily synthesized and its price is very affordable worldwide. Ancient cultures relied on the use of traditional medicines for alleviating and treatment of many human ailments. Most of these folkloric remedies utilized different types of plants as a whole or some of their parts. With advancements in analytical techniques, many compounds that are of bioactive properties; such as those containing sulfur, flavonoids, and other phenolic compounds, have been discovered in plants. Some of food items of a plant origin contain such compounds, thus became known as functional foods. Functional foods are described as: natural or processed foods that contain known or unknown biologically-active compounds – which, in defined amounts, provide clinically-proven and documented health benefits for the prevention, management, or treatment of chronic diseases. The pharmaceutical industry develops and manufactures drugs on which modern medicine relies for treating different ailments and diseases. The association between sound nutrition and general health has been established long ago; thus, dietary aspects can be viewed as the modifiable factor for healthy human existence. Recent trend indicates that functional foods of health-protective and medicinal value have caught the attention of nutritionists, physicians and many health care professionals. One of the most recognized functional food items is garlic.

Garlic (*Allium sativum*) is a perennial herb that belongs to the Liliaceae family, which shares relationship with onion (*Allium cepa*).[1] The fully-grown garlic plant reaches a height of 50-60 cm and bears underground bulbous root containing about 8-20 segments that are known as cloves, which constitute the edible part. Garlic is abundantly available and is considered to be a common ingredient in the human diet all over the world. It is can be eaten fresh, in salads and in the preparation of meals for its pungency and flavoring value. Garlic has always been mentioned in the literature of all ancient world cultures and kingdoms as having beneficial effects on health and was included in their medicinal remedies. Nowadays, for health-protective effects or for relief of some conditions and symptoms, several preparations of garlic are available in the market for the public, particularly in health food stores.

From a nutritional standpoint, garlic contains some amounts of the 3 energy generating nutrients and significant amounts of others - such as: manganese, calcium, phosphorus, copper, sodium, selenium, the amino acid tryptophan, and vitamins B_1, B_6 and vitamin C. It also possesses a number of compounds that are not classified as nutrients, but known as phytochemicals, for which reported health benefits are also attributed. The main phytochemicals in garlic are alliin, methiin and S-allylcysteine. When garlic is damaged or crushed, different organosulfur compounds result. For example, enzymes in fresh garlic convert alliin into another compound known as allicin, which is potent for a very short time when exposed to air - thus, it will lose its biological effectiveness.



Structure of allicin

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In contrast, the compound known as S-allylcysteine is more stable and can be bioavailable when properly preserved.

Garlic has been studied extensively; thus, the literature on many aspects of its composition, benefits and possible adverse effects is very vast.[2] Experimental studies either used commercially-available preparations or prepared their own for their purpose. In addition to aqueous garlic homogenates and aqueous extracts used in several studies, there are four main known preparations of garlic, with the following brief descriptions:

- Garlic oil: prepared by steam distillation processing, where water-soluble compounds are eliminated – including allicin.
- Garlic oil macerate: are made of encapsulated mixtures of whole cloves that are ground into vegetable oil. This preparation contains allicin and all other constituents of garlic.
- Garlic powder: where garlic cloves are sliced or crushed, dried and then pulverized into powder. The main sulfur compound in this preparation is allicin.
- Aged Garlic Extract (AGE)[3]: where sliced raw garlic is stored in 15-20% ethanol for 20 months. This process reduces the content of allicin, but preserves other effective sulfur-containing compounds.

Because of some discrepancy among research data, mainly attributed to the garlic preparation type used, there is a need to standardize such preparations for better-controlled experiments and clinical trials. While many benefits of garlic have been scientifically confirmed and reported, there is still more research to be carried out. In general, more clinical trials for considerable durations that cover many aspects of health and disease are to be conducted, so that the pool of data can be analyzed for conclusive evidence. Many researchers expressed the urge for clinical trials that involve long-term supplementation with garlic in relation to cancer of the stomach, colon and rectum in particular. In addition, pharmaceutical research can emphasize devising ointments and creams that have garlic as an active ingredient for topical applications in skin diseases, and in others that can be beneficial in different medical conditions and symptoms.

Many studies involving the health effects[4] of garlic involved mainly those that relate to cardiovascular diseases and their risk factors.[5] Garlic has been shown to reduce the following blood parameters: systolic and diastolic blood pressure, low-density lipoprotein (LDL) cholesterol, triglycerides, plasma viscosity, and increase red blood cell velocity of the skin. It is considered as an antiplatelet aggregation agent,[6] thus possesses antithrombotic property. Some studies suggested that garlic can be a substitute antithrombotic agent for people who are allergic to or do not tolerate aspirin. Garlic was shown to reduce blood glucose level, thus can be of significance to diabetic patients. Because of its many micronutrients, garlic is considered as an antioxidant agent that has a cell protective property.[7] Such a property involves protection of neural cells, thus can be of benefit to those who may be susceptible to degenerative neuronal diseases such as: Alzheimer's, Parkinson's and Huntington's. Some studies indicated that garlic has a beneficial effect in the protection against cancer and protects the liver from toxins. Additionally, among many of the reported health benefits of garlic are: being a natural antibiotic agent and a remedy for the treatments of colds, coughs, congestion, ear ache, tooth ache, and skin infections. Historically, it was recorded that garlic was used to overcome ring worms in infected individuals.

While many benefits of garlic are now known, it should be noted that those who are allergic to it and those with low blood pressure must refrain from consuming it. For all others, the question of what is the best way to derive the benefit(s) of garlic is posed? While it is now known that different preparations of garlic, as well as the common uses of it in cooking and preparation of meals, can provide benefits at varying degrees – the best is to consume it fresh. The World Health Organization (WHO-UN) and the European Scientific Cooperation on Phytotherapy recommend crushing and ingesting a fresh garlic clove daily, which contains 3-5 mg of allicin. Meanwhile, the National Cancer Institute (USA) does not recommend such - however, it recognizes that garlic as one of the vegetables that have potential anticancer properties. With such reported health benefits of garlic illustrated here in, is it not worthy of being referred to as: the wonder plant?

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Editorial

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The Basic of Trans-Fatty Acids in Foods: An Update to Prevent Diseases

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Most of naturally occurring Fatty Acids (FAs) in humans are found in *cis* (Z) configuration. The change of *cis*-FAs (e.g. monounsaturated and polyunsaturated FAs) in *trans* (E)-Fas is made by isomerization, which could be geometric and/or positional according to a given carbon chain.[1-3] In the *cis* configuration, the two hydrogen atoms are on the same side of the carbon chain with respect to the double bond, a situation that produces a bend in the FAs, whereas in the *trans* configuration, the two hydrogen atoms are diagonally opposed to each other, straightening the carbon chain.[1,2] (Figure 1).

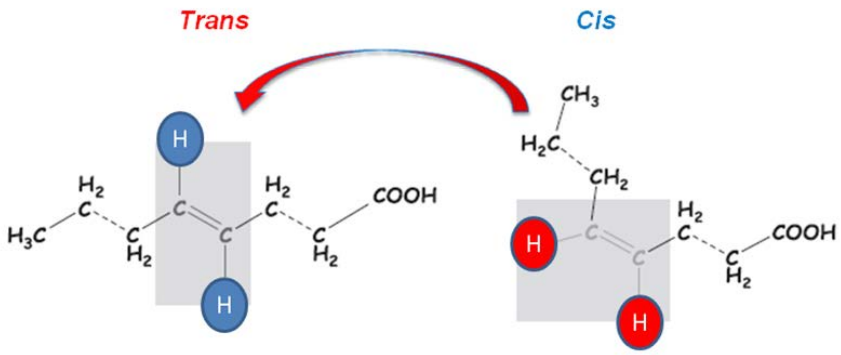

Figure 1: *Cis*- and *trans-configurations* of fatty acids.[1]

TFAs mainly arise from hydrogenation either through: (i) naturally occurring enzymatic process involving desaturases (i.e. enzymatic transformation) in the rumen of animals (e.g., bacterian flora in cows, sheeps, goats) in mammalian breasts;[4,5] (ii) partial (or total) industrial catalysis of vegetables or fish oils requiring hydrogen gas or a metal catalyst (e.g. nickel) to replace saturated FAs, solidify vegetal fat products (e.g. pizzas, cakes, chocolates, shortenings such margarines), decrease their oxidation sensitivity, and enhance their taste;[2,6] or (iii) extreme thermal treatments (e.g., deep-fat frying, barbecue, deodorization during oil refining), although these are considered as a minor source.[1,2]

While too little information is available about the effects of natural TFAs on human health,[1,7,8] most experimental and experimental studies, *albeit* sometimes controversial, report that industrial TFAs are neither essential nor salubrious, and could even predispose to important pathologies, including fetal malformations, Cardiovascular diseases (CVDs), and other inflammatory-state diseases (e.g., cancers, diabetes, metabolic syndrome, obesity), especially when consumed chronically or at high doses.[1,7,9] Interestingly, certain TFA isomers (e.g. Conjugated Linolenic Acids (CLAs), which are polyunsaturated FAs in mixed configuration *cis/trans*) would be beneficial for health,[1,10] and so, should not be banned.

Prevention modalities should be based on finding alternative industrial approaches and preventive actions. Thereby, two relevant industrial approaches can be used to reduce or

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eliminate TFAs in food:[1,2,11,12] (i) food reformulation (e.g. replacement of TFAs with edible base stock FAs, such palm oil, although some of the fat replacers might run the risk of increasing SFA levels); and (ii) modification of FA composition through valuable innovative processes (e.g. chemical or enzymatic fat interesterifications, which usually display interesting physicochemical features that minimize SFA levels). Furthermore, the production of healthier shortenings by these industrial processes, along with reforms for greater transparency in labeling (i.e. specifications of TFA composition and amount on prepackaged foods) and/or active consumer educational campaigns to substantially reduce TFA production and consumption, have been successfully applied in some countries but remain a challenge in many others, despite the growing evidence of their impact on health.[1,2,13-15]

Therefore, it becomes clear that both individual- and policy-level initiatives to decrease TFA consumption should continue, particularly in population subgroups (e.g. young individuals), and recent findings provide further evidence to support the concerted effort to minimize or even ban TFAs in the diet.[16]

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Editorial

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Feed Efficiency: A Key Production Trait and A Global Challenge

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Animal agriculture is facing substantial challenges from a steep projected increase in global demand for high quality animal protein and the need to adapt to higher temperature due to climate change. Indeed, with predictions that the world human population will increase to between 9 and 10 billion, United Nations Food and Agriculture Organization (FAO) estimates that by 2050 there will be increased demand for meat and egg protein by 73% and dairy products by 58% over 2011 levels.[1] Meeting the expected growth in global demand for high quality animal protein will be very strenuous, especially under environmental temperature constraints due to climate change and increased feed cost.

Large, abrupt, and widespread extreme heat waves have occurred repeatedly in the past[2] and resulted in estimated total annual economic loss to the US livestock production industry of $1.69 to 2.36 billion.[3] More intense and frequent heat waves are predicted to increase for the next century.[4] Thus, there is a critical need for extensive applied and basic research efforts to improve animal adaptability and tolerance to high ambient temperature and to maximize their productivity. Our research is devoted, using top-down/bottom-up approaches and multidisciplinary area ranging from integrative physiology and genetics to molecular and cellular biology, to understanding the molecular mechanisms that regulate energy homeostasis and feed efficiency in avian species as well as the basis of their response to environmental stress.

Although it is moderately heritable, Feed Efficiency (FE) that defines the animal's ability to convert feed into body weight, is a trait of vital importance for maintaining sustainable agriculture. Two parameters are widely used to assess FE in chickens and in livestock: 1) Feed Conversion Ratio (FCR) that is defined as the amount of feed consumed per unit of weight gain[5] and 2) Residual feed consumption or intake (RFC or RFI) which is the variation between animal's actual and expected feed intake based on the estimated requirement for maintenance and growth/production.[6] Genetic selection based on these parameters has made spectacular progress in meat production traits. For instance, as seen in Figure 1, under optimal husbandry conditions, body weight and breast yield have dramatically increased however FCR decreased. The selection methods however have been applied without knowledge of the fundamental molecular mechanism changes that might be induced by the selection. Associated with these successes (increased muscle yield and high growth rate) there have been a number of undesirable changes in modern chickens such as muscle disorders (muscle myopathy, white striping), heart failure syndrome, ascites, lameness and fat deposition. Thus, a deep molecular and mechanistic understanding of traits of breeding interest may help to avoid the above mentioned unfavourable consequences.

Our group has developed several avian (chicken and quail) genetic populations designed to attack specific (patho) physiological and environmental challenges facing the modern poultry industry. As the regulation of energy homeostasis (energy intake and expenditure) and the stress response are coupled physiological processes,[8] we have unique experimental models including quails that were divergently selected for high or low feed efficiency and for sensitivity or resistance to stress.[9] As the hypothalamus, which contains the satiety and hunger centers, plays a crucial role in the regulation of body energy balance,[10] we determined the feeding-

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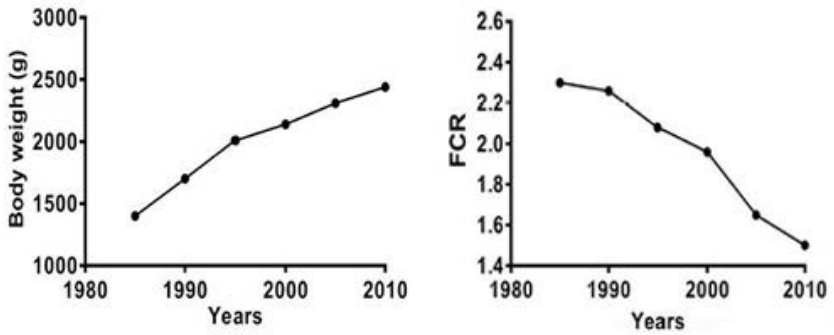

Figure 1: Time trends increase of economically important broiler traits (body weight, FCR, and breast yield). The graph is presented based on the data published by Siegel PB.[7]

related hypothalamic neuropeptide profile in two chicken lines divergently selected for low (R^-) or high residual feed consumption (R^+). For the same body weight and egg production, the R^+ chickens consume 40% more feed than their counterparts R^- lines.[11] We identified several feeding-related hypothalamic key genes that are differentially expressed between the two lines that might explain the difference in feed intake.[12] We also identified avian mitochondrial uncoupling protein and found that it was highly expressed in the muscle of R^+ compared to R^- chicken suggesting that the R^+ chickens dissipate energy as heat and they are thereby inefficient.[13] Our previous studies have also revealed a link between mitochondrial bioenergetics and dynamics and FE in broiler chickens. Low FE birds exhibited lower mitochondrial electron transport chain coupling and higher hydrogen peroxide compared to high FE counterparts.[14] Interestingly, we recently found that the orexigenic peptide, orexin, was highly expressed in chicken muscle and orexin treatment altered mitochondrial biogenesis, bioenergetics and dynamics (fission and fusion) in avian muscle cells,[15] however the role of orexin in high and low feed efficiency warrants further studies.

With the new cutting edge techniques involving genomics, proteomics, transcriptomics, mobilomics, microbiomics and metabolomics we will have the potential to identify molecular signatures for feed efficiency and to solve the intervening puzzle between nutrients, genes, environment and performances. A personalized nutrition approach based on identification, selection and optimization of nutrients fine-tuned with animal genetic profiles and animal's capability to withstand environmental stress will improve performances, health and wellness.

CONFLICTS OF INTEREST

The authors have declared that no conflicts of interest exist.

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Research

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Berry-Vegetable Nectar May Help to Diminish Hospital Visits and Service Reliefs in Conscripts during the High Risk Period of Upper Respiratory Tract Infections

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ABSTRACT

Phytophenols can counteract Upper Respiratory Tract Infections (URTI) by effecting on the microbes or by promoting immunity. At population level URTI has high economic significance. The aim of the study was to clarify if hospital visits or hospitalization or service reliefs from military service in conscripts could be diminished by phytophenol rich berry-vegetable nectar supplementation during high URTI-risk period. The 6.5 week intervention was carried out during highest URTI-risk at winter. The intervention subjects were predominantly healthy male conscripts (n=188) in a four military companies. Controls were either from same four companies (n=359) or from eleven other companies (n=1597). All conscripts lived in a same garrison within similar environment and had similar exercise program and had similar diet *ad libitum*. Intervention subjects received three portions of berry-vegetable nectar in a day. Weekly visits at the hospital, service reliefs and days in the hospital per company were recorded. Effect by intervention was analyzed between intervention and control companies by repeated measures analysis of variance. Intervention effect by berry-vegetable nectar was seen as a lower amount of visits at the hospital clinic (P=0.002), and as a lower amount of reliefs from outdoor service (P=0.049), while significant effect on hospitalization or on releases from indoor and outdoor reliefs was not observed. We conclude that nutritional supplementation by-phytophenol rich berry-vegetable nectar may diminish hospital visits and reliefs from outdoor service in conscripts during high URTI-risk period.

KEYWORDS: Anti-infective; Berries; Nutritional; Phytophenols; URTI.

INTRODUCTION

Berries are rich in antioxidants such as vitamin C and phytophenols.[1] Experiments have shown that phytophenols may possess antioxidant, anti-allergic, anti-inflammatory,[2,3] anti-bacterial and antiviral activities.[4] Phytophenols can counteract upper respiratory tract infections (URTI) by the destruction of microbes, and preventing their adhesion to mucous membranes.[5] Furthermore, phytophenols may be beneficial for health by promoting the innate immunity.[6] Moreover, vegetarians have lowered incidence of inflammatory processes.[7]

URTI-risk is highest during cold seasons[8] and especially during winter months. The URTI-risk also increases when peoples are gathering or interact with each other.[9] This occurs when new conscripts start their military service. Moreover, exhaustive exercise may increase the URTI-risk, and during open window phase of weaker resistance, viruses and bacteria may be more infective, thus increasing infection risk.[10] Thus, the physical demands of the military service may increase URTI-risk. Among Finnish conscripts URTI is most important reason for service reliefs and hospital visits during military service.[11]

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Our earlier infection frequency crossover study among small group of young cross-country skiers showed that phytophenol rich berry-vegetable nectar had a health promoting potential: total URTI-days diminished during intervention as compared to control period.[12] Previously we have also observed that quercetin content of samples correlated strongly with the inhibition of the bacterial cultures while using agar diffusion assay.[12]

We hypothesized that phytophenols may help to decrease morbidity and/or alleviate the symptoms in a large number of peoples during URTI epidemics. There are no corresponding studies where the uniform age group of participants in partly isolated society with similar physical training and with the similar menu *ad libitum* would be supplemented by berry-vegetable nectar to detect effects on need of health services during high URTI-risk period. Thus, we aim to clarify if the consequences of epidemical URTI-morbidity could be affected by supplementing the nutrition of conscripts by phytophenol rich berry-vegetable nectar.

METHODS

Subjects and controls were conscripts who started their military service at the beginning of January two weeks before intervention started. Garrison of Vekaranjärvi (Tuohikotti, Finland) includes 15 separate companies, in which conscripts do their military service. Companies are military groups and each company has their own military task such as "*tank defense*" or "*military engineering*". Voluntary conscripts, who did their military service in a four of these 15 companies, represented intervention subjects (n=188) and conscripts who were not voluntary for berry-vegetable nectar supplementation in these same four companies served as company controls (n=359). Conscripts from other 11 military companies were called as other controls (n=1597). All conscripts were predominantly healthy men and approximately 18 to 21 years of old reflecting Finnish male population. In Finland, military service is mandatory for all predominantly healthy men and military service may be avoided only due to poor health or by performing alternative public service. Total drop-out during the intervention was 28% and at the end of the intervention number of intervention participants was 135. All of the intervention participants and controls lived in the similar military conditions within same garrison and had the similar menu *ad libitum*. The study plan was accepted by the Ethical Committee of the Kuopio University Hospital.

The intervention of 6.5 weeks was carried out during highest URTI-risk after conscripts start their military service in the beginning of January, 2001. The start time of intervention varied between companies less than one week, and the first week was running-in period. The intervention period was followed by post-intervention period of 2.5 weeks. Intervention subjects received three portions (100 ml) of berry-vegetable nectar (Lieksan Laatuherkut OY, Lieksa, Finland) (Table 1) per day: one at the breakfast, one at the lunch and one before going to sleep. Berry-vegetable nectar was manufactured without heating to preserve nutritional content, and berry-vegetable nectar was preserved within refrigerator temperatures (35.6 to 42.8 degrees of Fahrenheit) before eating. Participants got their berry-vegetable nectars by military personnel daily or required amount when subjects had camps or weekend frees.

A)	Blackcurrant	27%
	Strawberry	20%
	Carrot	10%
	Tomato	6%
	Vegetable oil	-
	Water	-
	Sugar	-
	Preservative E202	-
B)	Energy	71.4 kcal
	Protein	1 g
	Carbohydrates	17 g
	Fat	1 g
	Vitamin C	30 mg
	Vitamin E	3 mg
C)	Total flavonoids	60 mg
	Quercetin	1.4 mg
	Myricetin	1.3 mg
	Kaempferol	0.7 mg
	Delphinidin	38.6 mg
	Cyanin	14.7 mg
	Pelargonidin	3.3 mg

Table 1: Ingredients (A) of the berry-vegetable nectar and its contents of the energy, main vitamins (B) and flavonoids (C) (per 100 gram).

When conscripts had health problems, they had opportunity to visit in the hospital clinic of the garrison. Depending on the severity of health problem, conscripts may be released from both indoor and outdoor military service or released only from in outdoor military service. Moreover, if health was poor enough, conscripts were hospitalized. Decisions of releases and hospitalizations were done by doctors, who were not aware of the study groups.

Afterwards, we got the number of company specific visits in hospital clinic and number of service relieves. In Finnish military forces URTI is most important reason for hospital visits and service reliefs during service.[11] Moreover, highest URTI-risk was during study period.[8] Unfortunately, detailed or individual diagnoses of the patients were not available, and hence we were unable to distinguish URTI from other causes. Moreover, the analyzed number of bed days in the hospital was defined by daily roll call data. Unfortunately, the data of roll

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calls in one of the intervention company was unavailable.

Statistical analyzes were done by comparing companies. Eleven of companies included other controls and four of companies included company controls and intervention subjects. The number of endpoint incidences such as the hospital visits, service relieves and bed days in the hospital in companies were scaled by the amount of conscripts. The number of endpoint incidences were calculated and reported week by week. The effect of intervention as compared with controls was explored by repeated measures analysis of variance. Moreover, differences between control and subjects were also detected by T-test. Correlations between endpoint incidences were computed by Pearson's coefficients of correlation. Statistical analyses were performed by the SPSS software, version 19.0 (IBM Corp., Armonk, NY, USA) and significance was defined as P<0.05.

RESULTS

Characteristics

The total number of the hospital visits during study period has been presented in Figure 1. Moreover, table 2 presents the characteristics of endpoint incidences in control and intervention subject companies. The number of hospital visits week by week was associated with service reliefs from outdoor service (r 0.84; P<0.001) and with reliefs from all service (r 0.71; P<0.001). Furthermore, reliefs from outdoor service correlated with reliefs from all service (r 0.63; P<0.001).

The Number of Visits at the Hospital

The intervention subjects visited less at the hospital

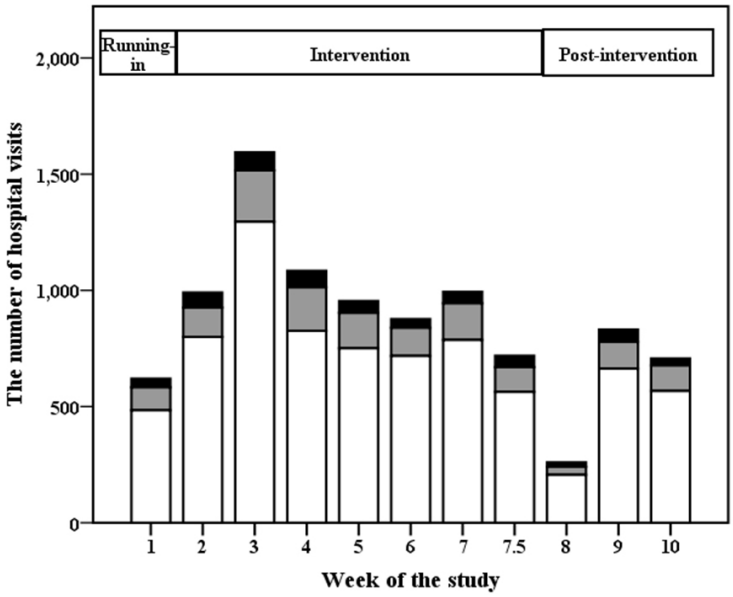

Figure 1: The total number of visits at the hospital during running-in, intervention and post-intervention periods represented week by week. Black color represents intervention subjects (n=188), and gray color refers company controls (n=359), and white color refers other controls (n=1597). Intervention ended between seventh and eight week and week number 7.5 refers three intervention days and week number 8 includes four post-intervention days.

		Intervention				Post-intervention			
			Releases from outdoor service	Releases from all service	Days in the hospital	Visits in hospital	Releases from outdoor service	Releases from all service	Days in the hospital
Intervention subjects	Mean	1.08	1.67	0.43	0.46	0.81	0.56	0.22	0.65
	SD	0.45	0.71	0.30	0.40	0.32	0.30	0.09	0.61
Company controls	Mean	1.55	2.07	0.54	1.08	0.81	0.52	0.16	0.43
	SD	0.43	0.29	0.07	0.16	0.30	0.15	0.06	0.24
Other controls	Mean	1.83	2.48	0.53		1.10	0.52	0.20	
	SD	0.33	0.60	0.12		0.36	0.18	0.11	

Abbreviations: SD = Standard Deviation.
The number of companies: intervention companies (n=4, except for days in the hospital where n=3), company controls (n=4 except for days in the hospital where n=3), and other control companies (n=11).

Table 2: Weekly average and standard deviation values for the endpoint incidences during intervention and post-intervention. These values has been calculated between specific companies and scaled by number of conscripts.

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clinic as compared to all controls during intervention according to repeated measures analysis of variance (P=0.002) (Figure 2). However, the difference in the total amount of visits during intervention as compared with company controls was not significant. During post-intervention period there were any differences between intervention subjects and control groups.

The Number of Reliefs from Outdoor Service

The intervention explained differences in the reliefs from outdoor service (P=0.049) (Figure 3) i.e. intervention subjects had the minor amount of releases from outdoor service as compared to all controls. The difference between the intervention subjects and company controls was not significant. Moreover, there were no differences during post-intervention period.

The Number of Reliefs from Outdoor and Indoor Service

The number of service reliefs from both in- and outdoor services was similar in intervention subjects to company controls, to other controls and to all controls during intervention and post-intervention.

The Number of Bed Days in the Hospital

Intervention did not effect on the amount of the bed days in the hospital during intervention (P≥0.067) when comparing intervention subjects and controls. Correspondingly, there were no significant differences during post-intervention period between intervention and control companies.

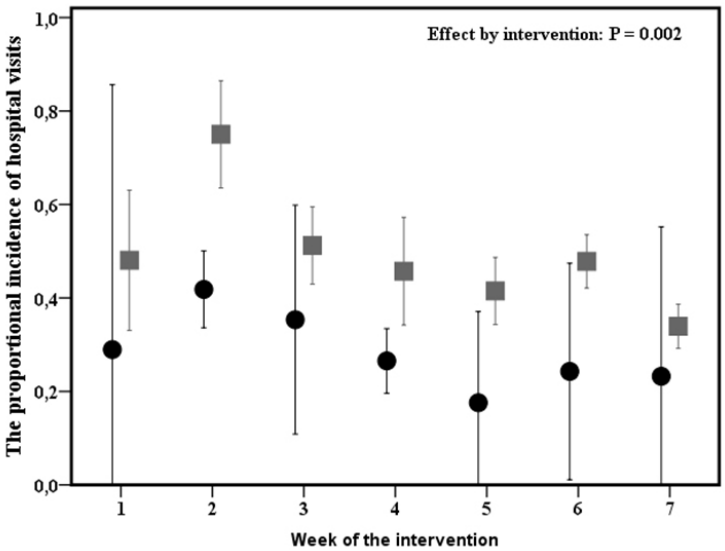

Figure 2: The average amount and 95% confidence interval of the visits at the hospital clinic in intervention (n=4, black circles) and in control (n=15, gray squares) companies week by week during the intervention. Effect by intervention has been analyzed by repeated measures analysis of variance. Seventh week includes only three days.

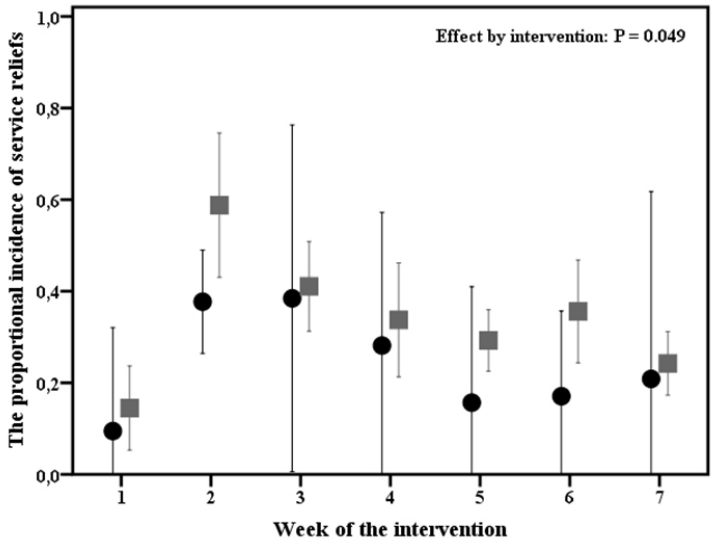

Figure 3: The average amount and 95% confidence interval of the reliefs from the outdoor service in intervention (n=4) and in control (n=11) companies week by week during the intervention. Group effect has been analyzed by repeated measures analysis of variance. Seventh week includes only three days.

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DISCUSSION

Results suggest that conscripts who were eating berry-vegetable nectar visited less at the hospital clinic and had minor amount of outdoor service reliefs during intervention. These differences were seen while comparing intervention subjects and all controls, but not between intervention subjects and company controls who were living in same barracks.

The results were similar as compared to the earlier study among young skiers, where number of the overall URTI-days and bed days decreased.[12] However, there are certain differences between participants in these two studies: while young top level athletes tend to observe their health in detail, current conscripts were sample of Finnish male population. Moreover, in the current study the decisions of service relieves and the hospitalization were done by physician instead of subjective diary as in the case of young skiers. Unfortunately, we did not have specific individual diagnoses and thus we must suppose that an observed alternation in the hospital visits (Figure 1) and in the other endpoint incidences reflects URTI epidemics. In general, epidemic diseases may increase the number of hospital visits. Furthermore, most of hospital visits and missed service days among Finnish conscripts are due to URTI.[11] Moreover, time of the study i.e. cold seasons is typical for URTI-epidemics.[8]

Population immunity[13] may potentially explain why significant differences were not observed between intervention subjects and company controls. On other hand, while analyzes were done by company by company, comparison with company controls were done within four companies, and low number of companies potentially limits statistical power.

In the current study, the action mechanisms of the berry-vegetable nectar remains speculative. It has been concluded that vitamin C supplementation may not decrease URTI morbidity,[14] but phytophenols may promote health and diminish URTI.[4,5,15-19] There are, however, other potential explanations such as supplementation by energy ingredients due to nectar,[12] and among young skiers high URTI morbidity was partly explained by great gap between high training load and low nutritional energy intake. Moreover, the post-exhaustion related open window of immunity may be modulated by phytophenols, while phytophenols like tannins decrease the oxidative damage including lipid peroxidation,[20,21] which might diminish post-exhaustive exercise related low immunity phase.[22] However, once ingested, phytophenols may be subjected to extensive metabolization, which may effect on phytophenols affects.[23] Correspondingly, our earlier study indicated that rather quercetin than the vitamin C content correlated with their antibacterial activity *in vitro*.[12] However, while eating phytophenol containing foods as berries, conditions in the mouth and in the upper respiratory tract may become less favourable for pathogenic microbes,[4,24] and the prevention of microbial adhesion is one possible mechanism to explain antimicrobial effects by phytophenols.[16,17]

Staying healthy and being capable to exercise have importance during military service. On other hand, the effects of URTI on public health may have high relevance. Military environment may work as a potential melting pot for URTI-microbes when conscripts gather to do their military service. Correspondingly, while these conscripts return among civilians using public transport, more viral version of URTI may be passed back to infect civilians. Total economic effects of URTI are significant due to lost in school and workdays and medical costs.[25]

The current study has strengths such as an objective and the blinded recording of health incidences. Moreover, military system offers some unique advantages for a science, such as high number of participants who are living in similar environment, who do similar exercise, and who had similar diet *ad libitum*. This kind of circumstances may be difficult to organize elsewhere. On other hand, because of military systems and habits, we did not got the more specific data of individual health such as URTI-related diagnoses. Therefore, we were forced to perform analyses between companies, which diminished statistical power and refers that our results are rather suggestive.

Our results suggest that the nutritional supplementation by berry-vegetable nectar may possess health promoting potential; subjects with berry-vegetable nectar supplementation had lower number of visits at hospital clinic and the minor amount of releases from military outdoor service during URTI epidemics as compared to controls. However, additional studies with more specific data are needed to confirm the results.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest. The study was performed in accordance with the ethical standards of the Declaration of Helsinki and the authors declare that these experiments comply with current Finnish laws. The study protocol was approved by the Research Ethics Committee of the Hospital District of Northern Savo. All subjects gave informed written consent. These results have not been published elsewhere.

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ADVANCES IN FOOD TECHNOLOGY AND NUTRITIONAL SCIENCES

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Review

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Reaching out to Farmers with High Zinc Wheat Varieties through Public-Private Partnerships – An Experience from Eastern-Gangetic Plains of India

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ABSTRACT

The main objective of the HarvestPlus led wheat biofortification breeding program at the International Maize and Wheat Improvement Center (CIMMYT) and its national program partners in South Asia is to develop and disseminate competitive wheat varieties with high grain zinc (Zn) and other essential agronomic features. The emphasis of this program is to introduce novel sources of genetic diversity from wild species and landraces, into the adapted wheat background. This variation is being exploited through limited backcross approach with shuttle breeding at two contrasting locations in Mexico, which resulted in widely adapted, durable rust and foliar disease resistant, high Zn wheat varieties. The new wheat varieties developed by CIMMYT in HarvestPlus project are 20-40% superior in grain Zn concentration and are agronomically at par or superior to the popular wheat cultivars of South Asia. The biofortification breeding program of CIMMYT utilizes new wheat varieties from the core-breeding program as background parents that are higher yielding, resistant to rusts, heat tolerant, water-use efficient and 5-10% higher yielding than main varieties grown at present. The biofortified high Zn wheat varieties with 20 to 40% (8-12 mg/kg) Zn superiority and grain yield potential at par or superior to the popular wheat varieties are being adopted by small-holder farmers in South Asia. Through Public-private partnerships (PPP) more than 50,000 farmers and 250,000 household members expected to benefit from the Zn-biofortified wheat varieties in South Asia by the 2015-2016 wheat seasons.

KEYWORDS: Biofortification; High zinc wheat; Public-private partnership; Dissemination.

ABBREVIATIONS: CIMMYT: International Maize and Wheat Improvement Center; WHO: World Health Organization; PPP: Public-private partnerships; RDA: Recommended Daily Allowance; BHU: Banaras Hindu University; NEPZ: North Eastern Plain Zone; PVS: Participatory Variety Selection; CGIAR: Consultative Group on International Agricultural Research.

INTRODUCTION

About 2 billion people around the world suffer from micronutrient deficiency, according to the World Health Organization.[1] Also known as "hidden hunger," micronutrient

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deficiency occurs when people eat food that does not provide enough vitamins and minerals. People living in South Asia and Sub-Saharan Africa are hardest hit by hidden hunger, which is characterized by iron-deficiency anemia, vitamin A and zinc deficiency.[1] Zinc is important for cellular growth, cellular differentiation and metabolism. Zinc deficiency limits childhood growth and decreases resistance to infections. Supplements may help to improve linear growth of children under 5 years of age. Zinc deficiency affects about one-third of the global population. Severe zinc deficiency can result in short stature of preschool children and approximately 165 million children under five years of age are stunted, with the vast majority living in Africa and Asia resulting in the hypogonadism, impaired immune function, skin disorders, cognitive dysfunction, and anorexia. Wheat (*Triticum aestivum L.*) is a major staple crop, providing 20% of dietary energy and protein consumption worldwide.[2] It is an important source of mineral micronutrients such as zinc (Zn) and iron (Fe) to the resource poor consumers.[3] The breeding targets for high Zn wheat was derived based on the bioavailability of Zn enriched wheat, daily per capita intake of wheat, type of food preparation, and estimated average requirements or Recommended Daily Allowance (RDA). The preliminary breeding target for Pakistan and Northern India is to increase Zn levels by 12 mg/kg, above the baseline levels of 25 mg/kg, which is the mean of popular varieties currently grown in the region.[4]

Large variability for these micronutrients has been found in landraces and wild relatives of common wheat.[3] A targeted breeding program was initiated at the International Maize and Wheat Improvement Center (CIMMYT) in 2006-2007 to develop wheat germplasm with 8-12 mg kg^{-1} increased grain Zn concentration over the popular varieties grown in the target regions along with profitable yields, and farmer preferred agronomic and end-use quality attributes.[5,6] The main feature of this program is the introduction of novel genetic diversity from wild species and landraces into the adapted wheat backgrounds. The objective of the research reported in this paper is to update the varietal adoption status of high Zn wheat varieties in the target environments of Eastern Gangetic Plains of India as a case study example.

SCALING UP DEPLOYMENT OF ZN ENRICHED WHEAT

To assure nutritional and food security, it is paramount that suitable biofortified wheat varieties identified for specific growing conditions that are released and seed disseminated for their widespread adoption. Competitive high Zn wheat varieties were distributed to national program partners in South Asia to reach resource poor small-holder farmers. Superior agronomic traits are inherent in these biofortified wheat varieties along with enhanced nutritional value. Adoption of these new varieties together with improved agronomy is expected to scale up significantly with the public-private partnerships (PPP). A public-private partnership (PPP) is a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, skills and assets of each sector (public and private) are shared in delivering seeds of biofortified wheat to farmers.

In 2012, HarvestPlus program of the Consultative Group on International Agricultural Research (CGIAR) devised a strategy in alliance with Banaras Hindu University (BHU) and CIMMYT to reach thousands of wheat farmers with high zinc wheat in North Eastern Plain Zone (NEPZ) of India. We along with HarvestPlus identified Eastern Uttar Pradesh (UP) of NEPZ as a proof-of-concept strategy to test and promote high Zn wheat varieties. The productivity of wheat in farmers' field in this region is comparatively low when compared to other parts of the country due to unavailability of new improved wheat varieties and low mechanization, for example. Hence, this region was chosen to replace existing disease susceptible varieties with zinc-fortified, disease resistant wheat varieties by creating awareness about nutritional and agronomic benefits of high Zn wheat varieties. After two years of multi-location testing led by BHU researchers at the university's research stations and on-farm testing in neighboring villages of 3 districts, several leads were identified, which combined 8-14 ppm Zn advantage, competitive yielding ability and tolerance to water-stress and heat. In 2012, these biofortified wheat varieties were demonstrated to farmers through Participatory Variety Selection (PVS) approach in 18 villages falling under the districts of Mirzapur, Chandouli and Varanasi. There was a great interest among farmer's community to adopt high Zn wheat varieties by seeing their agronomic potential and its nutritional benefit. To expedite the variety release process and a fast-track commercialization, six best leads were identified for pre-release seed multiplication, of which T.SPELTA PI348449//2*PBW343*2/KUKUNA (BHU-3) and CROC_1/AE.SQUARROSA (210)//INQALAB 91*2/KUKUNA/3/PBW343*2/KUKUNA(BHU-6) were the 'best bets' with high Zn and competitive agronomic benefits.[7] In India, wheat can be grown only in winter season, but to expedite seed availability to meet the seed demand the crop delivery team of HarvestPlus undertook off-season seed multiplication in the Himalayan Mountains. As soon as seeds were multiplied, during 2013 season about 1000 mini-kit seed bags were distributed to progressive farmers in Eastern UP. Simultaneously, rest of the seed was used for main season multiplication led by HarvestPlus. To meet the seed demand, the 'Sai Seeds' company owned by a progressive farmer in that region came on board to multiply and commercialize high Zn wheat varieties as truthfully labelled seed. In 2014, more than 10,000 farmers adopted high Zn wheat through formal and informal seed systems. The Sai Seeds, in conjunction with BHU scientists, conducted several field days by inviting men and women farmers to demonstrate the agronomic and nutritional superiority.

The public-private partnership (PPP) is gaining momentum in seed sector in India. The Nirmal seeds of India joined hands with HarvestPlus for fast-track commercialization of two of the lead varieties Abhay (ZincShakthi) and Akshai (BHU3)

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by rigorous multi-location testing of more than 250 diverse sites and full-fledged seed production of these varieties to commercialize during 2015-2016 crop season. Astha Beej based in Uttarakhand also marketed 4 tons of 'ZincShakthi' seeds (produced and provided by HarvestPlus) in 2014 as "Chitra" and also multiplied its seeds in over 100 acres for marketing in 2015. In addition seed multiplication of BHU6 was undertaken by HarvestPlus in 170 acres to ensure that through the PPP more than 50,000 wheat farmers will benefit from the zinc-biofortified wheat varieties in India during 2015-2016 crop cycle.

As a follow-up action of the outreach activity, regular field visits were ensured by BHU, CIMMYT and HarvestPlus scientists to oversee seed multiplication programs in Mirzapur district of UP. The feedback from the progressive farmers in the region, was very encouraging. They were happy with the performance of 'Zinc Shakthi' variety for its good performance under fully irrigated and limited irrigated conditions. For instance, this variety had about 5-10% yield advantage under limited irrigated conditions over the currently grown local varieties with 40% Zn increment (Figures 1 and 2). All the farmers expressed their satisfaction about the performance of 'ZincShakthi' and other leads which are in seed chain. Most of the farmers ensured that they will use part of the harvested seed for their use and will also distribute to neighboring farmers. Some of the farmers also expressed their satisfaction about its grain size, cooking quality, grain color and overall appearance.

Figure 1: Biohappiness: a happy farmer grows ZincShakti wheat on his farm, Uttar Pradesh, India.

Figure 2: Women farmers involved in seed production and dissemination of high Zn varieties, along with BHU and CIMMYT researchers.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONSENT

We have obtained written permission from the farmers in the image.

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