

## REVIEW PAPER

**‘Foodoceuticals’- Ensuring Improved Well Being Beyond basic Nutrition**

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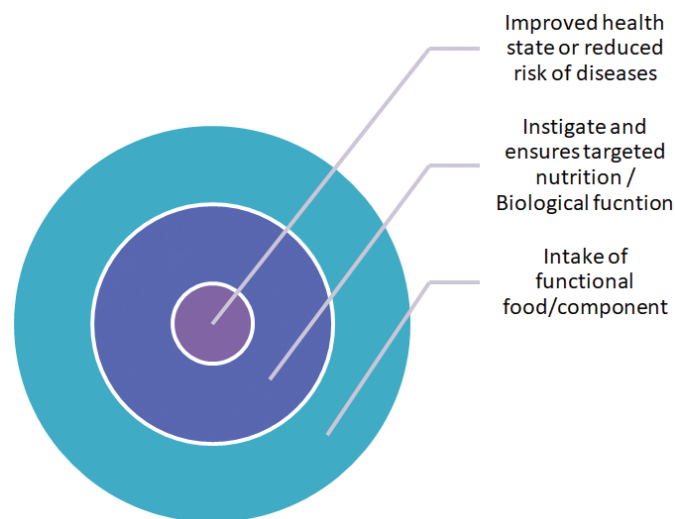
Adequate nutrition is very essential for Armed Forces in terms of maintaining the nutritional status. In the present review it was compiled about dietary habit and required diet for Service personnel to become fit and control the life style disease such as diabetes, obesity, cancer, hypertension and cardiovascular disease etc. It also focuses on functional foods rather than normal diet which are recommended as ration pack for armed forces. Functional foods enrich and improve the quality of dietary intake. It also represents promising avenues of nutritional in recent days of global dietetics. Functional ingredients such as essential fatty acids, antioxidants, dietary fibre, isoflavones,  $\beta$ -carotene etc are included in ration pack. It also provide large varieties of functional foods are made available to the consumers with the intension to provide dietary management of life style diseases while enhancing our overall well being conversely. It must be understood that these foods and ingredients are not instant medicine or ultimate remedies for imbalance dietary habits as proper diet management. It also provides comprehensive approach for good physical and mental health.

**Keywords:** Functional food; Health benefit; Dietary management; Nutrition; Obesity

**1. INTRODUCTION**

The food and its components which provide health benefits beyond basic nutrition and foster an additional function of providing essential nutrients are termed as ‘Functional Food’. Commercially these are also categorised under ‘Health and wellness products’. According to the American Dietetic Association (ADA) functional food is ‘any potential health food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains<sup>1</sup>. The term functional food was first put forwarded in Japan during 1980s. Japanese composed the term ‘FOSHU’ which stands for Foods for Specified Health Use, to which a functional ingredient is being added for benefiting health. Japanese ministry of health and welfare has approved ‘FOSHU’. India has recently passed the Food Safety and Standard Act (FSSA) 2006, a modern integrated food law to serve as a single reference point in relation to regulation of food products including nutraceutical, dietary supplements and functional food and as per FSSAI the functional food are described as “Foods which provides benefits beyond basic nutrition and may play a role in reducing or minimising the risk of certain diseases and other health conditions (Fig. 1).” Nutritionally adequate ration packs had become the integral part of Armed Forces diet management system to maintain passable nutritional and physiological health. This also ensures balanced energy and specific nutrient level required for their operation specific tasks. For satisfactory nutrient deliverance functional foods must be integrated with normal ration packs

which often are deficient in such functional entities. Functional foods help in maintaining sound health with proper growth of a consumer. These fractions take care about various life style diseases including obesity, diabetes, cancer, cardiovascular malfunctions along with digestive system. It is now being recommended by various experts of this domain to include certain functional elements in the diet rather only focusing on basic nutrition *viz.* protein, fat, carbohydrate, vitamins and minerals. Similar to functional foods the term ‘Nutraceutical’ is an amalgamation of two techno-scientific terms ‘Nutrition’



**Figure 1. Diagrammatic representation of mechanism of functional foods.**

and ‘Pharmaceutical’ which refers to foods that provides both medical and health benefits and helps in prevention and treatment of diseases<sup>2</sup>.

## 2. FUNCTIONAL FOODS FOR DIABETIC POPULATIONS

Type 2 diabetes (T2D), formerly known as adult-onset diabetes, is characterised by high sugar levels in blood (fasting blood sugar > 7 mmol/L & after meal >8.5mmol/L), insulin resistance, and relative lesser secretion of insulin. Increased thirst, frequent urination, and unexplained weight loss are among most common symptoms. Type II diabetes is closely associated with obesity and improper dietary habits. Isoflavones found in soybean has structural and functional similarity with human estrogen when consumed at the level of 20–100 mg/day helps in the reduction of glucose level<sup>3</sup>. Dietary fibers from psyllium, lipoic acid (spinach, broccoli, tomatoes, peas, and Brussels sprouts) and omega fatty acids (fishes, almonds, flax seeds, cinnamon) also control glucose and insulin levels in the blood. Studies have shown that increasing consumption of dietary fibre and simultaneously not changing energy intake from carbohydrates, fats and protein enhances glycemic control and reduces need for insulin in persons with diabetes<sup>4</sup>. Bitter gourd can be used for treating type II diabetes<sup>5</sup>. Bitter gourd contains active chemical principles (charantin, vicine and polypeptide-p) which are thought to be main hypoglycemic components<sup>6,7</sup>. A previous study exhibited that blood sugar level – dependent cataract formation decreases by bitter gourd fruit extract consumption<sup>8,9</sup>. 4- hydroxyisoleucine (amino acid) in fenugreek seed increases glucose induced insulin in human beings and is found helpful in reducing post-prandial hyperglycemia<sup>10,11</sup>. Drumstick plant (*Moringaolifera*) extract was found to decrease blood glucose concentration<sup>12</sup>.

## 3. FUNCTIONAL FOODS FOR WEIGHT CONTROL

Obesity is a global health problem. It is an unwanted fat deposition over various parts of the body leading to various diseases such as angina pectoris, respiratory disorders, renal problems, reduced potency, cardiovascular problems, and hypertension. The basic cause of this is sedentary life style, genetic build up and excessive, regular consumption of fat and carbohydrate rich foods. Functional foods needed to overcome obesity are low glycemic index foods having high amount of complex carbohydrates; insulin and oligofructose, non-digestible fermentable fructans, fructo-oligosaccharides (soybean, oatmeal, brown rice), fibre rich foods (psyllium husk, green pods of various beans, whole grains; buckwheat, maize, whole-grain sorghum, bulgur, millets, barley). Glycemic index of various starchy foods has been studied and compared, which gives an idea of what type of food should be included in the diet<sup>12</sup>. Green tea and coffee contains catechin and caffeine, respectively which were proven to be effective in weight loss by enhancing calories expenditure of the body and reducing appetite. According to a study, high intake of caffeine was found associated with weight loss through thermogenesis and fat oxidation<sup>13</sup>. Conjugated linoleic acid (whey and animal protein), capsaicin (chilies) possess anti-obese properties<sup>14,15</sup>.

Brown adipose tissue plays a significant role in regulation or maintenance of energy expenditure and body fatness. It can be activated by many food ingredients like catechins in green tea and capsaicin in chili pepper, and prevent obesity<sup>16</sup>.

## 4. FUNCTIONAL FOODS FOR THE PREVENTION OF CANCER

Similar to developed nations, cancer is a major public health problem emerging in developing countries as well due to stressed lifestyle, addiction for narcotics items and indecorous life style. Various polyphenols present in vegetarian sources are promising functional components to reduce the risk of cancer. Antho-cyanidine present in colorful fruits (berries and blue grapes), catechins and proanthocyanidine present in tea, babul pods, mustard, rapeseed, cocoa and chocolate, flavonone of citrus fruit, isoflavones and isoflavonoids of soybean, saponins of soy and chick pea have a potential benefit of scavenging free radicals from the body hence reduce the risk of cancer. People who consume large amount of beta-caroteine (carrots, lucerne, pumpkin), lutein (chicken eggs, spinach, and leafy), limonoids (oranges and other citrus fruits), lignans (flax, rye) and lycopene (tomatoes) rich foods greens experienced the lowest incidence of colon, breast, uterine, and prostate cancer. Tocotrienols and tocopherols present in cereal grains, insoluble fiber of wheat bran<sup>17,18</sup>, conjugated linoleic acid present in milk and meat products, indoles and glucosinolates of cruciferous vegetables<sup>19,20</sup>, anthocyanidins of colourful fruits and flowers also has cancer preventive effect<sup>21</sup>.

## 5. FUNCTIONAL FOODS FOR HEART DISEASES AND ARTHROSCLEROSIS

Poly-unsaturated fatty acids e.g.omega fatty acids-docosahexaenoic acid (DHA) and eicosapentaenoic acid(EPA) present in fish oils, flax seeds, mustard, linseed, rapeseed, almonds and olives helps to prevent various heart diseases. Phytochemicals such as flavonoid (flavonols, and proanthocyanidins) occur naturally in onions, tomatoes, berries, apples, and cabbage also have potential to protect human health against cardiovascular diseases (CVD)<sup>22</sup>. Anthocyanins, present in blueberries, cranberries, raspberries, cherries, eggplant, and purple cabbage do have controlling potential for various heart diseases<sup>22,23</sup>. In cardiovascular diseases soluble fibre play a pivotal role as it binds with cholesterol and fresh legumes and ash guard are among rich sources of soluble fibres. They aid in reducing blood levels of atherosclerotic low density lipoprotein (LDL) cholesterol. Soluble fibres such as  $\beta$ -glucan present in oats can be potentially helpful in significantly reducing the LDL cholesterol levels intern ensures enhanced cardiovascular benefits<sup>24</sup>.

## 6. PROBIOTICS AND PREBIOTICS AS FUNCTIONAL FOODS

Ageing is associated with changes to the intestinal microflora including a reduction in bifidobacteria and an increase in harmful bacteria (*Clostridium difficile*). The decline of bifidobacteria is associated with reduction in adhesion to intestinal mucosa<sup>25</sup>. Such changes can lead to gastrointestinal discomfort and has a negative impact on the digestive health

of an individual particularly geriatric population. Use of antibiotics and drugs are common cause of hyposalivation resulted into poor mucosal health and antimicrobial defence action of oral cavity. These disturbances in gut microbiota due to consumption of broad-spectrum antibiotics may lead to increase in population of pathogenic bacteria such as *Clostridium difficile*<sup>26</sup>. Elderly people do suffer from loss of immunity, higher risk of heart diseases and diabetes. Hence, probiotic foods such as curd, yoghurt, having live or culturable population of lactobacilli, bifidobacteria may provide immunoprophylactic effects to overcome acute diarrheal infections: Crohn's disease, and ulcerative colitis (i.e inflammatory bowel disease)<sup>27,28</sup>. These probiotic foods also supports gut mediated and nonspecific immunity against cold, flu and lactose intolerance, decrease risk of colon cancer, improve absorption of nutrients and gain of appetite<sup>29</sup>. The food fibres that cannot be digested by human digestive enzymes are termed as prebiotic supplements. These fibre fractions are being used by gut microflora i.e. probiotics including bacteria and yeast for proper growth. Both prebiotics and probiotics play a synergistic role in supporting helpful bacteria and other organisms in the GI track. Some of the common prebiotic food supplements include chicory roots, dandelion greens, garlic, onion, asparagus, bananas, barley, oats, flax seeds etc. The emerging concept in the field of pre and probiotic nutrition is 'synbiotics' meaning a mixture of food containing both intestinal bacteria and indigestible dietary fibres. Therefore the elderly population must adopt the principle of 'synbiotics' in their diet plan as one of the functional food measures<sup>30</sup>. Age related reduction in calcium absorption efficiency<sup>29</sup> can be a partial cause of deficiency of calcium among elder people. Therefore, foods rich in calcium (curd, dried fish, drumstick leaves etc) and vitamin D are required for geriatric people. Incorporation of cholesterol lowering functional food active fractions such as sterol/ stanols (2g approximately) in the daily diets of both men and women aged 55-64 as a part of healthy lifestyle would benefit by reducing the risk of developing cardiovascular diseases (CVD)<sup>31</sup>. Daidzein, genistein present in soybean, flax seeds, lentil, maize, lucerne reduce menopause symptoms in elderly female group<sup>32</sup>.

## 7. FUNCTIONAL FOODS FOR GROWING CHILDREN

Growing kids have different needs for nutrients. For their proper mental and physical development omega fatty acids eicosapentaenoic acid and docosahexaenoic acid (EPA and DHA) present in cod liver oil (fish), nuts (almond, walnut, and pistachio), flax, mustard, olive, rapeseeds, and linseeds must be the integral part of diet<sup>33,34</sup>. It is recommended by food and drug administration (FDA) that uses of omega-3 fatty acid supplements is safe and recommended that the daily intake of both eicosapentaenoic acid and docosahexanoic acid from supplements shall not go beyond 2g/day<sup>35</sup>. Daidzein, genistein of soy promotes bone health<sup>36</sup>,

lutein / helenien present in carrots, sweet potatoes, mangoes, squash, corn, tomatoes and dark green leafy vegetables such as amaranthus, fenugreek and kale, and zeoxanthine present in lettuce, broccoli, corn, green peas, egg yolks, brussel sprouts, cabbage, green beans, kale, collard greens, kiwi, spinach supports improved vision of children. Protein and mineral rich foods such as egg, soy, meat, milk, whole legumes and cereals are essential diet components for growing children<sup>37</sup>.

Classification of potential functional foods among various food groups:

- Colourful Seasonal Fruits and Vegetables: Avocado, Berries (raspberries, gooseberries, cran berries, strawberries), Grapes, Tomato, Papaya, Melons, Carrot, Beetroot, Chilli, Citrus fruits (vitamin C, anthocyanins, carotenoids).
- Green and Leafy Vegetables: Capsicum, Spinach, Fenugreek, Amaranthus (chlorophyll, leutin, zeaxanthin), Moringa leaves (essential amino acids).
- Cereals and grains: Oat, barley, Buck wheat ( $\beta$ -glucan and arabinoxylan, oligosaccharides; galacto and fructooligosaccharides and resistant starch, soluble and insoluble dietary fibres).
- Legumes and Beans: Soybean and its products (biologically valuable protein, Isoflavons, and omega fatty acids).
- Probiotic Dairy Supplements: Curd, Yoghurt, Miso soup, sauerkraut, Kombucha tea, Kefir, tempeh, fermented pickles (health promoting live bacteria), Colostrum, Butter milk, Whey (Conjugated Linoleic Acid).
- Prebiotic Functional Foods: Asparagus, bananas, onions, garlic, cabbage, beans, lentils, chickpeas fructooligosaccharide (FOS), insulin, isomalto-oligosaccharides (IMO), polydextrose, lactulose, and resistant starches.

**Table 1. Recommended dietary requirement for functional nutrients and their Rich Sources**

Functional ingredients	Daily intake for health benefits	Rich sources
Vitamin C (Antioxidant) <sup>23</sup>	40 mg/day	Amla 600, Guava 212, Kiwi fruit 90, Litchi 70, Papaya 62 (mg/100g)
Dietary fibre <sup>4</sup>	25-35 g/day	Navy beans 19, Dry peas 16, Lentil 15, kidney bean 12, barley 11 (g/100g)
$\omega$ -3 Fatty Acids <sup>35</sup>	1.0-1.6 g/day	Flax seeds 22.8, Walnut 9.1, Fish 0.4-1.2, Soybean 1.4, Wheat germ 0.72 (g/100g)
$\omega$ -6 Fatty Acids <sup>35</sup>	5.0-6.4 g/day	
Lutein	3-6 mg/day	Spinach 12.2, Parsley 5.56, Lettuce 2.31, Egg 1.1, Cabbage (mg/100g)
Lycopene <sup>57</sup>	6-12 mg/day	Tomato 1.5-6.5, Water Melon 2.5-5.5, Papaya 2.3-3.6 (mg/100g)
$\beta$ -Carotene	800-1000 $\mu$ g/day	Sweet potato 9444, Kale 9226, Carrot 8285, Squash 4570 ( $\mu$ g/100g)
Isoflavones <sup>3</sup>	20-100 mg/day	Soybeans 120-220, Tofu 22.70, Peas 2.42, pigeon peas 0.56 (mg/day)
As per ICMR Dietary Guidelines approximately 400g/day of colorful seasonal fruits are required to provide antioxidants helpful in protecting against certain chronic disorders		

Note: Values shown for the nutrients are mean of the range available in the scientific literatures.

- Animal Products: Fishes (chitosan, and poly unsaturated fatty acids,  $\omega$ -3,  $\omega$ -6 and  $\omega$ -9).
- Nuts and Oil Seeds: Melon seeds, Pumpkin seeds, Almonds, Walnuts, Dates, Olive, Flax, Linseeds, rape seeds, Mustard (sources of vitamin E-a natural antioxidant and poly unsaturated fatty acids).
- Spices: Turmeric, Ginger, Garlic, Clove, Cinnamon, Bay Leaves, peppers, Fennel, Azowine seeds, Fenugreek seeds (rich sources of polyphenolic compounds).

### 7.1 Specifications, RDA, and other Regulatory Issues

The food product with beneficial effects is a trendy concept in current industry which results in consumers' acceptance for foods that bestow something more than traditional value. Whereas in case of product development there are primary

hurdles for new functional ingredients, which manifest for safety and efficacy. Any individual ingredient to be used as functional component in any food formulation must either receive premarket approval from Food and Drug Administration (FDA) or should fall under the category of generally regarded as safe (GRAS) status. The GRAS status is granted to the ingredients based on the previous authenticated records of safe use which are well established by scientific procedures<sup>60</sup>. Recommended dietary requirements (Table 1), principal active components (Table 2) and DFRL's contribution for operational pack ration (Table 3) in tabulated form provides ready insight to the reader.

### 7.2 Future Perspective of Functional Foods

It is rational to mention, that not only healthcare costs can be reduced by adopting significant amount of the functional

**Table 2. Functional foods, their principal active components, and respective health promoting effects**

Sources	Active chemical	Health promoting effect
Aloe Vera Garlic	Glycoproteins and lignin Allicin, di (2- propyl) disulfide <sup>39</sup>	Antiulcer, wound healing and anthelmint <sup>38</sup> Cholesterol lowering, respiratory infections, arteriosclerosis, chemoprevention, cancer and diabetes, reduction of glycemia, lipidemia, cholesterolemia in diabetics
Ginger Onion	Gingerol, paradols, shagaols 2- propenyl propyl disulfide <sup>39</sup>	Indigestion, motion sickness <sup>39</sup> , nausea, antioxidant, cholesterol control Direct or indirect stimulation of insulin secretion by pancreas, insulin-sparing action.
Red pepper	Capsaicin	Anti-arthritic, antioxidant action, stimulation of GI Defense and absorption, stimulation of salivary <sup>40</sup> , intestinal, hepatic and pancreatic secretions <sup>41</sup> , and rubefacient
Turmeric	Curcumin	Antimicrobial <sup>42</sup> , antiseptic, reducing inflammation <sup>43</sup> , indigestion, antioxidant and liver related problems, and choleric properties
Fennel	flavonoids (anetholerutin, quercitin) and glycosides	Stomach bloating <sup>44</sup> , stimulant, antioxidant, digestive spasms, catarrh and aphrodisiac
Ginkgo Flaxseed	flavonoids and terpenoids source of omega-3- essential fatty acids	Revitalizes age-related memory loss <sup>45</sup> Constipation, irritable bowel syndrome <sup>47</sup> , cholesterol control <sup>46</sup> , chemoprevention and anti-arthritic
Moringa	Functional proteins, Cellulose, hemicellulose and lignin	Antimicrobial, antiviral, hepatoprotective, anticancerous <sup>48</sup> , antiseptic and in treating rheumatism, skin diseases, asthma and venomous bites
Amla	Ascorbic acid, Polyphenols and tannic compounds	Stress reliever, diuretic, supports liver function <sup>49</sup> , anti-ageing <sup>50</sup> , and anti-diabetes.
Fenugreek	Galactomannan (soluble fibre) <sup>51</sup>	Gastritis, excess cholesterol, diabetes and skin inflammation <sup>52</sup> , antifungal, anticarcinogenic
Coloured Berries and Grapes	Resveratrol & Proanthocyanins, tannins, phenolics, flavonoids, flavonol glycoside. Vitamin- C, $\alpha$ - tocopherol	Urinary tract infections, anti-inflammatory, antioxidant and reduce skin and breast cancer <sup>53</sup>
Marigold, Spinach, Rosemary, and Kale	Zeaxanthin, rutin, lutein, chlorophyll.	Eye health and age-related macular degeneration(AMD) <sup>54</sup>
Rye, Soybean and Broccoli	Lutein, flavones and iso- flavones.	Provides promoting phytoestrogens having high antioxidant properties <sup>55</sup>
Chocolate (Cocoa)	Lignan, polyphenols	Reduces blood pressure and secretes a neurotransmitter (serotonin) which acts as an antidepressant, anti-inflammatory, cardioprotective <sup>56</sup> .
Papaya	Papain, carotene	Antioxidant activity <sup>57,58</sup>
Cinnamon	Cinnamaldehyde, cinnamic acid, cinnamate, dietary fiber	Antioxidant, anti-inflammatory, antidiabetic, anticancer effects, antimicrobial <sup>59</sup> .



**Table 3. Various functional foods developed at DFRL, Mysore for operational pack ration of Army**

Fermented food products (As Probiotic supplement with antioxidant and phenolic compounds)							
Product	Antioxidant strength (AOA) (per cent)			Total phenols (mg per cent)		Shelf life (months)	
Ash gourd Beverage	7.30			26.6		6	
Cucumber Beverage	2.10			-		6	
Cucumber Mint Beverage	13.06			-		6	
Bitter Gourd Beverage	68.00			3.3		2	
Dietary fibre and omega fatty acid rich products							
Product	TDF (per cent)	SL (Months)		Product	TDF (per cent)	*% $\omega$ -fatty acids	SL (Months)
Millet Dhokla mix	15.90	6	7	Flax Spice Powder (pulav)	61.70	19.0	6
Cookies (Ash gourd fiber)	7.87	8	8	Flax Spice Powder (bisibelbhath)	48.3	23.90	6
Bisibele Bhath (Ash gourd fiber)	22.10	6	9	Flax Spice Powder (Rasam)	50.0	20.70	6
Cookies (Ash gourd fiber)	7.87	8	10	Flax Spice Powder (bisibelbhath)	48.3	23.90	6
Bisibele Bhath (Ash gourd fiber)	22.10	6	11	Flax Spice Powder (Rasam)	50.0	20.70	6
Cookies (Ash gourd fiber)	7.87	8	12	Flax Spice Powder (bisibelbhath)	48.3	23.90	6
Carotenoids rich foods				Appetizers (to overcome high altitude sickness and appetite loss)			
Product (Atta)	Carotenoids ( $\mu\text{g/g}$ )	SL		Munches	AOA	Drinks and soups	AOA
Methi	110.8	6	1	Flax Munch		Ginger drink	0.30
Palak	80.5	6	2	Cinnamon Munch	10.10	Karpuravali Drink	12.50
Amaranthus	48.3	6	3	Pepper Ginger Munch	85.40	Karpuravali soup Mix	7.07
Coriander	98.3	6	4	Karpuravali Munch	85.00		
Mint	31.4	6	5	RTS Ajowan Drink	10.10		

TDF; Total dietary fibre, SL; Shelf Life- in months, \*-Total fat basis. AOA-Anti Oxidant activity

foods in the diet but overall quality of life can also be improved. Nutri-genomics is an emerging area which study about interaction between diet and development of diseases based on an individual's genetic profile. After the scientific breakthrough of knowing full human genome sequence it is possible to customise an individual specific adequate diet in terms of genetic silhouette. Nutri-genomics will have strong impact on functional food industry which may focus on the development of food formulations for preventing specific life style diseases.

## 7. CONCLUSIONS

As mentioned earlier, almost all food products possess certain extent of specific health promoting functionality. However, it is obvious that there is a minimum threshold intake of every such specific component having potential health benefits and it must be backed by sufficiently strong scientific evidences. Consumers must realise that functional foods are

not a "magic bullet" or a panacea for poor health and dietary habits and there are no good and bad "foods" only good and bad dietary patterns. To conclude, it is mandatory to mention that diet is only one aspect of a comprehensive lifestyle approach to good health, which should include regular exercise, avoidance to addiction with narcotic items, stress management, maintenance of proper body weight, and other positive health practices. Only when all of these issues are addressed properly then only functional foods can be a part of an effective strategy to maximize health and reduce the risk ailment to common man in general and Armed Forces in specific.

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