Food-Food Antagonistic Interactions

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Abstract:- The Relationship between food and health is complex involving many antagonistic and synergistic interactions either by food combinations or during processing activities and physiological biotransformation post ingestion. Although we have a database of many of the food-food interactions but is limited in this era of food products abundance and food industry revolution. There is a need to develop or use existing analytical methods to measure the food-processing induced chemicals and their concentrations in foods and evaluate the toxicity of the whole range of compounds. In many cases, the presence of these natural compounds or processing-induced chemicals in food cannot be avoided; however, assessment of the risk by chemicals in food, exploring the compatibilities/incompatibilities of food combinations, understanding of the processes and biotransformation by which these compounds are formed can allow us to optimize or adjust food preparation methods, formulae or processes, thereby reducing or eliminating the formation of such chemicals. Additionally, Nutritional sciences should expand knowledge on the evolutionary connection between food and disease by generating the evidence from an epigenetic perspective between food and possible discord with respect to disease risk to recommend nutritional guidelines with greater prominence. Moreover, scientists conduct research to understand the physiological interactions of food components by using emerging technologies such as nanotechnology and biosensors so that the formation of such chemicals can be reduced or, where possible, eliminated or to develop a set of recommendations for avoidance of incompatible food combinations and adoption of safe food processing methods.

Keywords:- *Food Antagonism, Synergy, Food Generated Toxins, Processingmethods, Nanotechnology.Biosensors, Epigenetic Changes, Bioavailabilty*

I. INTRODUCTION

There are no second thoughts that a healthy diet is important to prevent non-communicable diseases and as part of treatment regime in acute disorders. There are billions of dollars are invested in addressing the malnourishment crisis not only in developing countries but also in developed countries in the last few decades. But ironically one of the prominent reasons for malnourishment in today's time is not the undernourishment but the overfeeding since the Industrial Revolution and Globalization have profoundly changed the human ecology and biology because of major transitions in nutritional and dietary practices, epidemiological and demographic scenario. Advances in food technology led to exponential growth food processing industry. It addressed the food availability and food affordability issues by providing the access to less healthful or poor choices of ingredients because food manufacturers objective is to enhance the palatability of foods usually done online in automated assurance studies rather than in quality assurance labs to get rapid and precise measurements so the real time interactions of nutrients during food processing to find out the food synergy or antagonism is a farfetched road. So the potential adverse effects are not traced and even considered by nutrition experts while prescribing diets so it is obvious that experts don't associate the nutritional status of patients with the beneficial effects or adverse consequences of various food combinations. Moreover, the effect of these interactions may be masked by overlapping symptoms of illness of patients.

II. MOREOVER, THESE EFFECTS MAY BE MASKED BY THE OVERLAPPED SYMPTOMS OF DISEASES

Various factors such as interactions due to industrial processing, natural raw materials, and home preparation may change the physico-chemical properties of the meal, and thus influence the bioavailability of a whole range of nutrients and overall quality of food. Until now, out of all these factors, the prime focus was on food processing related interactions but interactions and compatibility of natural food constituents during food preparation, bioavailability and biotransformation in vivo is the area less travelled road. Despite the consumption of healthy food, the bioavailability of nutrients is emerging as a prominent cause of malnourishment. Zinc deficiency due to high dietary fiber consumption is a classical example of malnourishment documented in the rural population of Iran due to poor bioavailability[1]. While most of the dietary recommendations for identified nutrients are based on studies either by using purified test meals or isolated nutrients[2] while interactions of nutrients among themselves during consumption of two or more ingredients or food preparation are not traced beyond some nutrients and food products. Moreover, dietary patterns, habits and food preparation styles, individual genetic makeup vary widely which means they don't necessarily mimic the complex biochemical reactions of real foods with complex compositions and structures among themselves.

Many natural constituents can alter the nutrition status of the population by affecting the process of absorption and tissue specific assimilation of nutrients. As mentioned earlier the leading cause of malnourishment and subsequent morbidity is poor biotransformation or utilization as per the specific need of tissues. The body is endowed with a complex network of enzymes inhabited within all tissues and organs which influence or carry out the various biochemical reactions or catalytic reactions in presence of cofactors (many of them are micronutrients) which contribute to the biotransformation of food in terms of metabolic capacity.

Since scientists working in research organizations, universities, and food companies have done basic research which usually carries out on simple model systems while same is difficult to simulate in the lab due to complexity or heterogeneity of real-time metabolic reactions happening inside the human body. It has been observed that during the combination of certain food items or post digestion, certain toxins formed which cause adverse or undesirable effects which are caused by the antagonistic effects of nutrients while combining, processing, or post digestion [3]. Additionally, non-nutrient substances such as drugs, artificial flavors, or natural contaminants can also interfere with nutrient absorption or assimilation[4]. Specifically in conditions such as kidney or liver disorders or in the geriatric population where toxin clearance is impaired amplify the possibility of toxin-nutrient interactions. Thus, these patients are at greater risk of developing adverse reactions to the food generated toxins even at lower concentrations.

So there is a need to explore food incompatibilities as well as synergy in terms of human nutrition physiology, epigenetic influence to optimize the nutrient assimilation to correct the malnourishment if any or to meet the actual nutrient requirements of individuals.

Food-Food Interactions- As it is clear by now that Nutrient interactions may affect the bioavailability of other nutrients antagonistically or synergistically. For instance, vitamin A and Zinc enhance the vision[5]. Conversely, it has been reported that the 1.5 gm of Vitamin C decreases the serum copper concentration thus lowers the ceruloplasmin levels significantly[6].

These interactions can occur at three levels primarily:

- During food preparation:-The mode of food preparation is as important as the dietary composition of ingredients which either is affected by the environment in which food is assembled or cooked(Ph of medium).For example: Since vitamin C get destroyed while cooking in an alkaline medium so can affect the absorption of iron present in the food negatively[7]**.**
- By affecting the nutrient availability in the intestinal lumen: The nutrient interactions happen mostly directly but sometimes indirectly via gut hormones secretion or inhibition.
- By decreasing transport of nutrients across the intestinal wall. This is a crucial factor since the nutrient availability is determined in the lumen due to its translocation through the enterocytes.
- In the post-absorptive phase: Post absorption, the complex interactions are responsible for the utilization of nutrients as per the requirements of the body which can be antagonized by the inhibitory effect of non nutrients or toxins or competitive interactions among nutrients.

Different ways of Nutrition interactions:

- By changing the intestinal pH: Zinc bioavailability increases significantly in the acid-precipitated medium than neutralized concentrates post consumption of soya based food products.[8]
- By increasing nutrient anabolism or catabolism.
- By increasing nutrient losses.

Further, the mode of food interactions is of two types- Unidirectional and bidirectional. Unidirectional interactions are the effect of one nutrient on the utilization of another nutrient which usually is passive while bidirectional interactions affect the absorption or utilization of both involved constituents due to the same physiochemical properties. It also has demonstrated that more than two constituents even affect the metabolic transformations or bioavailability[9]. These interactions are not additive to maintain the homeostasis of the body. For instance, vitamin C and Haem iron both increase the bioavailability of non-haem iron individually but while taken together don't affect its absorption more than each one does alone[10].

FOOD PROCESSING: Biochemical, nutritional, and toxicological changes of foods during food processing are complex phenomena.

Various processing methods may affect certain interactions to different degrees that depend on many factors such as processing methods, conditions, even the characteristics of raw ingredients. Toxins are further categorized not only by structural characteristics but also by biochemical interactions they do or by adopted processing methods. It has been demonstrated through innumerable animal studies that these toxins are mutagenic, carcinogenic ,or neurotoxic but many of the studies yet to be replicated in the human population.

1**.Based on Processing methods**: For instance, thermal processing is an age old process of food treatment having many benefits like food sterilization or enhanced bioavailability but it also has undesirable consequences such as loss of nutrients or allergenicity of foods both negatively or positively as it leads to the formation of many harmful and toxic compounds such as furan, acryl amides, trans fatty acids, mallard reaction products which are a concern from a health risk point of view due to their carcinogenic, genotoxic ,and teratogenic properties[11 12].

2. Based on Biochemical interactions: Lipid oxidation is the second most detrimental process after microbiological spoilage of meat which is due to the formation of highly toxic compounds such as denaturation products of haem, aldehydes, and carbonyl derivatives responsible for chronic inflammation[13]. Oxidation has detrimental effects due to the formation of aldehydes, carbonyl derivatives of proteins, and denaturation products of haem. The most harmful aldehyde formed is 4-hydroxy-2-nonenal (HNE) which modulates gene expression, cell proliferation, differentiation, and apoptosis by acting as the intercellular signal carrier[14]. Endocrine disruptors such as leukotoxin diols also are formed due to HNE[15].Other genotoxic and mutagenic substances formed during lipid oxidation are oxylipins-peroxides, epoxyacids, hydroperxoides, and peroxyacidse and malonic dialdehydes. Fried and processed foods particularly meat products and fast foods contain high amounts of proathrogenic(oxycholestrols,keto ,and epoxycholestrols derivatives[16][17].Compounds formed during lipid oxidation-furans,pyrazines and other secondary amines not only damages liver but also is one of the prominent reason of increased allergic disorders in human population noticed recently.

3. Based on Epigenetic changes:-In response to poor dietary patterns and food generated toxins, epigenetic changes exhibit the antagonistic pleiotrophic effects [18], predispose post transition populations to chronic diseases such as cancer, coronary heart diseases ,and allergic disorders due to mismatch between past genomic profiles and the current food environment. Also, there are a significant number of atopic allergies cases have been reported in the last decade. However, there is not enough evidence that the processing of food responsible for epigenetic changes.

4. Toxin Products based on structural characteristics.

Advanced Glycation Products: It is well established that the end products of glycation reactions are linked to the pathophysiology of diabetes, its complications (diabetic nephropathy) ,and progressive inflammatory disorders. These uremic toxins accumulated particularly pentosidine or CML in tissues and blood and contribute to oxidation and inflammation leads to many noncommunicable disorders[19].However, Glycation products (AGE) production is a slow process but is accelerated in presence of favorable conditions such as the presence of mallard reaction products.

Furan:-This strong mutagenic compound is generated in a variety of carbohydrate and amino acid combinations, certain amino acids combinations (e.g., casein, alanine, and cysteine), and vitamins (Vitamin C, dehydroascorbic acid, Vitamin B1)[20].

Acrolein: Processing of lipid-rich foods such as pork, beef at high temperature as well as cooking oils are responsible for the generation of acrolein[21].This minuscule compound than sustain in the air responsible for indoor as well as outdoor air pollution so people who are having healthy eating habits even are prone to inhalation of these compounds and their hazardous effects.

Nitrates, Nitrites, and Nitrosamines:-These compounds are primarily used as food preservatives in meats to prevent the growth of toxin producing microorganisms such as botulism. However, these compounds specifically nitrites react with secondary amines to produce a whole range of nitrosamines-a potent carcinogenic(DNA damaging effect) and tetrogenic class of compounds in meat and meat products when subjected to processing techniques such as salting, curing ,or smoking[22]. The intake of cured meat products is way beyond the recommended intake which is approximately 0.2–0.3 μ g/person, respectively 3.3–5 ng/kg body weight[23].

Trans Fatty acids: Another class of athrogenic compounds is Trans fatty acids which are formed by the deterioration of unsaturated fatty acids. There is enough data correlating the Trans fatty acids to cardiovascular disease, diabetes mellitus, and sudden stroke due to its hazardous effects on plasma lipoproteins that alter the desirable LDL/HDL ratio by decreasing high-density lipoprotein (HDL) levels and increasing low-density lipoprotein (LDL) levels which is a strong biomarker of the risk of development of cardiovascular diseases[24]. Moreover, a higher intake of TFA is responsible for hampering the intrauterine growth of baby[25]. As per some studies, there is a link between the rise of allergic diseases and consumption of TFA more than recommended intakes. The association between TFAs in adipose tissue and the incidence of cancers of the breast, prostate, and colon is still equivocal.

Acrylamide: There is new compound suspected to be harmful is acrylamide however, the concerns raised are not yet established although some in-vitro and in-vivo studies have demonstrated the induction of gene mutations by acrylamide in animal studies and also in cell culture studies[26]. In food containing high concentrations of the amino acid asparagines and reducing sugars, mallard reaction between carbonyl and amines form a pleasant flavor compound named acrylamide. It has been observed in one trial that workers exposed to high acrylamide doses have reported neurological issues while another study conducted on rats fed 5-10 mg acrylamide/kg body weight per day have shown the association between acrylamide and low fertility rate[27].

Heterocyclic amines: The toxic group of heterocyclic amines- carbolines, imidazoquinoxalines, and imidazopyridines are formed from the grilling of fish, meat, or other foods on direct intense flame-a very harmful carcinogenic[28].

III. CONCLUSION

In practice, there is incoherence/gap between basic research and food product development researches. Basic researchers provide the information about the food composition and sometimes the food interactions in vitro or animal studies while food product developers conduct low cost analytical techniques to ascertain the role each ingredient plays in determining the food properties specifically palatability or enhancement of texture or flavor or improvement in shelf life with the broad calculation of nutrient composition and to determine how the above-mentioned properties of foods are optimized by various processing conditions. For the influence of food combination and processing on nutrient bioavailability or detection of harmful toxins, various approaches such as biochemical, immunochemical, and clinical techniques in an integrated way should be considered along with the food product development process or existing food products consumed popularly. To understand the mechanism of various chemical reactions and epigenetic changes and the factors impacting chemical reaction rates enabling careful selection of ingredients and methods to formulate the food

ISSN No: 2456-2156

products and process designs with the required safety with desired quality.

Very little is known about the long term consequences of complex food interactions in vivo so involvement of interdisciplinary expertise like food chemistry, toxicology, nutrition, epidemiology, agronomy, analytical chemistry, food technology is required to understand the effect of these interactions among food constituents and food generated toxins at the population level. Hence, it is need of the hour to design and conduct a strong systematic interdisciplinary research project to shed further light on these complex food compatibility issues.

As it is evident that food synergy and antagonism research is a burgeoning field, despite disagreements regarding the mathematical definitions of synergy, additivity, and antagonism and issues with translatability between in vitro and in vivo systems, it is increasingly important to pinpoint and understand the potentially inhibitory and antagonistic impacts of food products on the activity of chemotherapeutics. High throughput screening (HTS) is a relatively low-cost and expeditious technique used frequently to reveal synergistic/antagonistic food interactions. However, HTS should be utilized more commonly to study antagonism between natural products and chemotherapeutics and bolster nutrient–nutrient interaction research. Advances in deep learning models that take into account processed food products as well as conventional foods will be essential for continued progress in this field. The identification of natural products that antagonize chemotherapeutics and the elucidation of their mechanisms of action have the potential to improve the safety and efficacy of food products. Improvements in this field can also help fuel better recommendations for the timing and use of natural & processed food products and prevent potentially dangerous interactions.

To protect the consumers from food borne diseases or to detect hazardous toxins or materials whether it is because of food processing or wrong combinations, rapid and sensitive detection systems need to be developed and adopted. Due to technological advancements in nanotechnology in the last decade, there is a surge in the development of biosensors which not only enhance assay sensitivity and reduce assay time but also are portable for point of care (POC) testing. There is a whole range of biosensors are developed-optical, electrochemical piezoelectric (mass-sensitive), thermal, sensors which are adopted by scientists in developed countries according to their biorecognition elements such as DNA sensors, enzyme based sensors, microbial and immunosensors for fast and precise results[29] but still is farfetched among developing countries. In near future, it is anticipated that many more developments and researches will be done globally in food nanotechnology to fill the knowledge gaps from the food industry and public safety standpoints to support the policy development and food products regulations for the safety and health of consumers and the environment.

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