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Utilizing Chickpea Isolates as a Fortificant to Develop Protein-Dense Yogurt: A Review

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ABSTRACT

Pulses and dairy products are recognized for their nutritional and functional benefits and are consumed in various forms. Yogurt is considered a source of good quality protein with anti-carcinogenic, hypocholesterolemic properties, and palliating effects on lactose intolerance. Similarly, chickpea is known for its high protein content, low glycemic index, and hypoglycaemic effects. These food ingredients cater to numerous advantages for human health and can address public health issues related to malnutrition or other nutritional deficiencies. With this background, the manuscript explores the possibility of employing chickpea isolates to fortify yogurt to improvise protein content along with sensory and physicochemical properties. So far, the literature has shown that protein extracts, when added to yogurt, result in gaining protein content and overall product quality. The yogurt market is growing, and consumers from different countries have expressed their willingness to purchase fortified yogurts to achieve optimum health. Therefore, developing a new combination of yogurt and chickpea isolates can provide a therapeutic alternative to enhance the nutritional status of the vulnerable population, *viz*. children, pregnant, lactating mothers, elderly, sportsperson, etc., when a judicious food intake is a must.

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Introduction

India has been the leading producer of chickpeas for many decades. Chickpea covers a global acreage with 14.84 million hectares (Mha) area, 15.08 metric tons (Mt) of production, and 1.01 ton/hectare (t/ha) of productivity in the world whereas India has the highest production area for chickpea (10.94 Mha) with a quantity of 11.08 Mt and average productivity of 1.11 t/ha [1]. Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, and Andhra Pradesh are the major states growing pulses in India. These six states contribute around 80% of total pulse production and area. Rajasthan is the highest producer of chickpea in India, followed by Maharashtra, Madhya Pradesh, Uttar Pradesh, and Karnataka. Madhya Pradesh ranks 1st with highest acreage of 3.43 MHa followed by Rajasthan, Maharastra, Karnataka and Uttar Pradesh. The highest production of 4.61 MT was produced by Madhya Pradesh followed by Rajasthan, Maharashtra and Uttar Pradesh. The highest yield of 1344 Kg / Ha was produced by Madhya Pradesh followed by Gujarat (1324), Uttar Pradesh (1272) and Rajasthan (1103) [2].

Kabuli and Desi are the two types of chickpea. Desi chickpea grains are dark, small, and have crinkled surfaces. These are grown majorly in semi-arid land. Unlike Desi, the Kabuli variety has a lighter color shade, thin covering, larger size, and is cultivated in balmy weather. Cultivated regions and climate conditions impact the appearance and chemical composition of chickpeas. Desi and Kabuli varieties predominantly differ in protein, carbohydrate, fiber, and polyphenols. The energy content of the *Kabuli* variety is 365 kcal / 100g, slightly higher than the *Desi* variety grains, which contain 327 kcal /100g [3]. Chickpea is rich in carbohydrates, protein, and micronutrients, constituting about 80% of the seed [4-6]. The high fiber content in the grain rates it as a product with a relatively lower digestibility [7,8]. Misra *et al*. [9] reported that crude protein range from 18.56 to 28.75. However, the crude protein content of chickpea ranges from 12.4 to 31.5%, and fat content is about 6% [10]. Moreover, it also contains vital minerals like calcium and iron. The bioavailability of the latter nutrient is reportedly good [11].

Yogurt is obtained by inoculating fresh milk with bacterial starter cultures that convert lactose into lactic acid. Dairy products are a rich source of protein and essential vitamins and minerals. Hence, consuming dairy items can help ensure the intake of several essential nutrients, including vitamins and minerals, needed for bone functions and growth in childhood [12]. Like milk, people consider yogurt a nutritionally beneficial option as it is an excellent source of good quality protein, calcium, potassium, and B vitamins. A study by Wang *et al*. [13] reported that yogurt was associated with higher intakes of potassium, vitamin B2 and B12, calcium, magnesium, and zinc and resulted in lower levels of circulating triglycerides, glucose, lower systolic blood pressure, and insulin resistance. However, dairy products are deficient in some nutrients such as iron, vitamin C, carotenes, and dietary fibers [14].

Functional and Therapeutic Properties of Chickpea and Yogurt

Reportedly, chickpea is associated with some physiological benefits for humans and possesses nutritional and functional properties [15]. The property of being an inexpensive source of protein, carbohydrates, vitamins, and minerals along with bioactive compounds such as phytates, phenolic compounds, oligosaccharides, etc., makes it capable of gaining consumers' acceptance as a functional food [16-18]. The high content of complex carbohydrates caters to the quality of the low glycemic index. Therefore, it may lower the CVD risk [19]. Research has shown that the resistant starch and amylose content of chickpea lowers glucose's bioavailability, resulting in a steady release of glucose into the bloodstream. It is a notable aspect in reducing the incidences and severity of type 2 diabetes mellitus [20-22]. Consuming chickpea as dal had a beneficial hypoglycaemic effect compared with wheat and rice [23]. Chickpea consumption (200g/d) results in butyrate production by the intestinal microbiome, a short-chain fatty acid, which reportedly restrained cell proliferation and induced apoptosis. This theory corroborates that its consumption is associated with a relatively lower risk of colorectal cancer [24-26]. In a study, chickpea decreased fat accumulation in the obese population. This helps improve fat metabolism, which corrects obesity-related disorders [27]. Researchers have proved the laxation property of chickpea. Its consumption provides ease of defecation and a softer stool consistency [16]. According to the principles of Ayurveda, chickpea preparations are beneficial in treating various ailments such as throat problems, bronchitis, skin diseases, blood disorders, and liver or gall bladder-related problems [28].

As per the Functional Food Center, functional foods can be defined as "*natural or processed foods that contain known or unknown biologically active compounds which in defined, effective, and non-toxic amounts, provide a clinically proven and documented health benefit utilizing specific biomarkers for the prevention, management, or treatment of chronic disease or its symptoms*" [29]. Functional food items are similar to conventional foods, but these contain a bioactive compound that may offer a wide range of physiological health benefits and nutritional properties. The most promising uses of functional foods are that these products help regulate intestinal functions by controlling transit time, bowel habits, mucosal motility, stimulating a healthy intestinal microbiome, and modulating epithelial cell proliferation [30]. Further, a healthy microbiome can improve nutrient bioavailability and modify GI immune activity. Systematic functions such as lipid homeostasis are indirectly influenced by fermented products or the dosage of certain nutrients. The awareness regarding various health benefits of yogurt, such as normalization or improvement in the intestinal flora, anticarcinogenesis, hypocholesterolemic effect, palliating effect on lactose intolerance, and antiallergic properties, led to its popularity as a functional food [31].

Moreover, the functional properties of this product can be augmented by adding probiotics and other nutrient-rich food items. Studies concluded that a daily intake of about 80 to 200g was significantly associated with a lower risk of CVD and Type 2 diabetes among healthy and older adults [32,33]. Additionally, yogurt has a positive role in weight management. Reportedly, yogurt consumption resulted in a more significant reduction in body weight by 33%, a 60% higher loss of body fat, and a reduction in lean body mass by 31% compared to the control group. It was also associated with lower body mass index, lower body weight/weight gain, smaller waist circumference, and lower body fat [34,35]. Yogurt consumption is associated with a reduced duration of infectious diarrhea, colonization by healthy gut bacteria, and reduced risk of development of food sensitivity and atopic dermatitis for both healthy and malnourished children [36]. The growth of bacterial cultures during the process of yogurt preparation facilitates auto-digestion of lactose which enhances its digestion and absorption in the body and makes it an easy option for people with lactose intolerance and milk allergy [37]. According to a review conducted by Sarkar (2019) [38], the functional properties of yogurt could be further improved as it can be utilized as a probiotic carrier. However, the bioactivity of probiotic cultures in the yogurt matrix must be evaluated before its commercial usage.

Consumption of Chickpea and Yogurt in Global and Indian Context

Chickpea

The world per capita chickpea consumption fluctuates between 1.29 to 1.61 kg/capita/year. India ranks second after Turkey in per capita consumption which is 5.37 kg/year and fluctuates between 5 to 6 kg/year. The high consumption of chickpeas could contribute to vegetarianism in the country, making it a preferred option to obtain vital nutrients for the normal functioning of the body. It is consumed in the form of grounded flour (besan), dals, and fermented products in snacks and main meals. Common preparations are curry, barfi, dhokla, cheela, and chapati. However, the manufacturers have developed new preparations such as garbanzo bean chips, bean bread, and bean soups [39]. A study by John *et al*. [40] revealed that the districts in Madhya Pradesh, Maharashtra, and Rajasthan produce a surplus quantity of pulses, *viz*. pigeon pea, chickpea, green gram, red lentils, black gram, dried peas, and grass pea, had per capita pulse consumption 50% lower than the recommended per capita consumption of 80 g/day. In these districts, the pulses expenditure accounted for 6.5% of the total food expenditure, and merely 9% of households reported consuming pulses from their production. The median per capita intake was significantly higher than in the low-producing districts. Despite higher production of pulses in rural areas, the per capita consumption has always been lower than the urban areas. However, the average consumption of pulses increased in rural areas between 2004-05 and 2011-12 from 22g to 26g. Similar to milk and milk products, the consumption of pulses shared a negative association with the increase in the price of commodities [41]. The feeding guidelines of countries like the United States, United Kingdom, Australia, Canada, and India recommend that pulses should be introduced to infants during complementary feeding before the first year of life due to its beneficial effects on body composition, gut microbes profile, and glucose-lowering effect for diabetic children [42]. Beckerman-Hsu *et al*. [43] reported that 80% of children did not meet the MDD criteria, and out of these, only 4.3% of children were fed legumes and nuts in their diet, while about half of the children those meeting MDD were given legumes and nuts.

Yogurt

Global demand for functional foods has increased dramatically with the advancements in technology, the development of a variety of products [44], and growing demand for healthy food [45], which could be parallel to the consumer's consciousness about maintaining good health. Yogurt is the most popular and acceptable among all fermented milk products because of the presence of health-promoting compounds [46], makes it a nutrient-dense probiotic food that enhances the bioavailability of some nutrients and thus improves overall health [47]. An animal feeding trial by Ghanem *et al*. [48] revealed that calcium absorption among the groups fed traditional yogurt was significantly higher than control.

Commercial yogurt manufacturers explore the value-added ingredient to intrigue the consumers, and researchers keep investigating and designing yogurts with improved functional properties continuously. While developing a new variety of yogurt, it is essential to select a suitable food ingredient in adequate proportion to retain its viability and sensory characteristics for better consumer acceptance. Significant factors affecting consumers' interest in functional food are rising health care costs that result in a trend of maintaining good health through self-medication [49], increasing age of the population, decreasing obesity and lifestyle diseases [50], and scientific evidence proving that diet can reduce the disease risks [51]. The consumption of animal protein-rich foods, including milk and milk production, is higher in urban areas due to a more diversified diet. There was an inverse relationship between the increase in the price of milk and milk products and their consumption in rural areas, and these food items are considered luxury goods [41]. A study that investigated minimum dietary diversity (MDD) among 6 to 23 months old children found that 82% of those who achieved MDD consumed dairy products. In contrast, the proportion was only 43% among children not meeting MDD [43].

Chickpea Isolates and Yogurt: Method of Preparation, Processing, and Changes in the Chemical Composition

Chickpea Isolates

Nowadays, protein isolates plays a significant role in developing new products due to their favorable characteristics of high protein content, color, flavor, and functional properties that make them a preferred option to improve the quality of any food product. As per Withana-Gamage *et al*. [52], the protein and fat content of chickpea isolates range from 72.8 to 85.3 g/kg and 74 to 98 g/kg, respectively, in different cultivars, which is almost equal to other pulse isolates such as soy, pea, and lentil. Removing seed coats in Kabuli and Desi chickpeas can result in better protein yield with minimal contamination. A study investigating the impact of processing methods (raw, soaking, soaking/pressure cooking, and soaking/roasting) before isolation reported 79 to 86% protein content, where thermal processing significantly reduced the output but improved the bioavailability [17, 53-55].

There are majorly two methods used for protein extraction from pulses and legumes: dry and wet methods. Wet processing methods are more suitable for extracting isolates from legumes due to their high protein separation efficiency (PSE) compared to dry methods. The legumes have a relatively high-fat and fiber content, leading to a reduced PSE [56]. The wet extraction methods include acid/alkaline extraction-isoelectric precipitation, ultrafiltration, and salt extraction. Among these, alkaline extraction followed by isoelectric precipitation yields a protein with purity greater than 70% and is the most extensively used method for protein extraction [57]. It was reported by Karaca *et al*. [58] that isolates prepared by an alkaline extraction/IEP method had higher overall protein content (85.6%) than those prepared by a salt extraction method (78.4%). Ramani *et al*., [59] have also optimized the protein isolation. Additionally, it had a significant effect on physicochemical and emulsifying properties. In ultrafiltration and microfiltration methods, pressure is the driving force for separation.

The functional properties of chickpea isolate comprise solubility, oil holding, and water hydration capacities (OHC, WHC), emulsification, and foaming. The presence of thermal properties such as the capability of holding water, lipids, sugars, flavors, and other ingredients varies according to the type of legume, different varieties within the same pulse, and type of processing methods. A heating temperature of at least 80^0 C is needed for protein denaturation and to form a quality gel. The onset temperature for structural development ranged from

61.5 to 78^0 C [52]. Chickpea isolates (Kabuli) possess a significantly higher water holding capacity and oil absorption capacity as compared to other legumes and Desi chickpea, which could be attributed to different protein conformations and variations in the number and nature of water-binding sites on protein molecules and high levels of non-polar amino acid side chains in their protein molecules, respectively [52,60,61]. When compared the processing methods before isolation of protein, isolates from thermally processed seeds with pressure cooking showed to have a 62% and 70% increase in WAC and OAC, respectively which could be due to protein dissociation on heating and increased exposure of polar and non-polar amino acids [54].

Several research studies reported that Kabuli chickpea has a better or equal emulsifying property than soy protein or other legumes such as yellow pea and green and red lentils. It indicates that its protein has a better ability to reach the oil/water interface and stabilize the emulsion, making it potentially useful for applications such as mayonnaise, sausages, and seasonings [52,59]. The minimum solubility of the chickpea isolates is at pH 4.5, which is close to its isoelectric point (pH 4.3), and it increased significantly at higher (7 to 9) or lower pH values (pH 2). Similar to the protein content of isolates, thermal processing significantly reduces protein solubility, which could be attributed to protein denaturation and polymerization by the di-sulfide bond interchange reaction, altered exposure of hydrophobic groups, and aggregation of unfolded protein molecules into lower stable energy configurations. It has a similar impact on the emulsifying property [54,62]. The chickpea isolate possessed 62% foam capacity, which could be due to globulin fractions, which can encapsulate and retain air. The foaming stability was reported to be 94.49% due to the quality of keeping air. This property makes it suitable for bakery products and ice-creams [63]. The application of protein isolates has been seen escalating with the rising trends of introducing new food products as per the consumers' demands. It is added to food products such as beverages, baby foods, bakery products, snack foods, bars, and nutrition supplements for nutritional and non-nutritional properties like encapsulating agents, stabilizers, and emulsifiers [51,64].

Yogurt

The difference between the conventional and modern methods of yogurt preparation is presented in the flow chart below (Figure **1**). The early method was elaborated by Heineman [65], and the modern method was

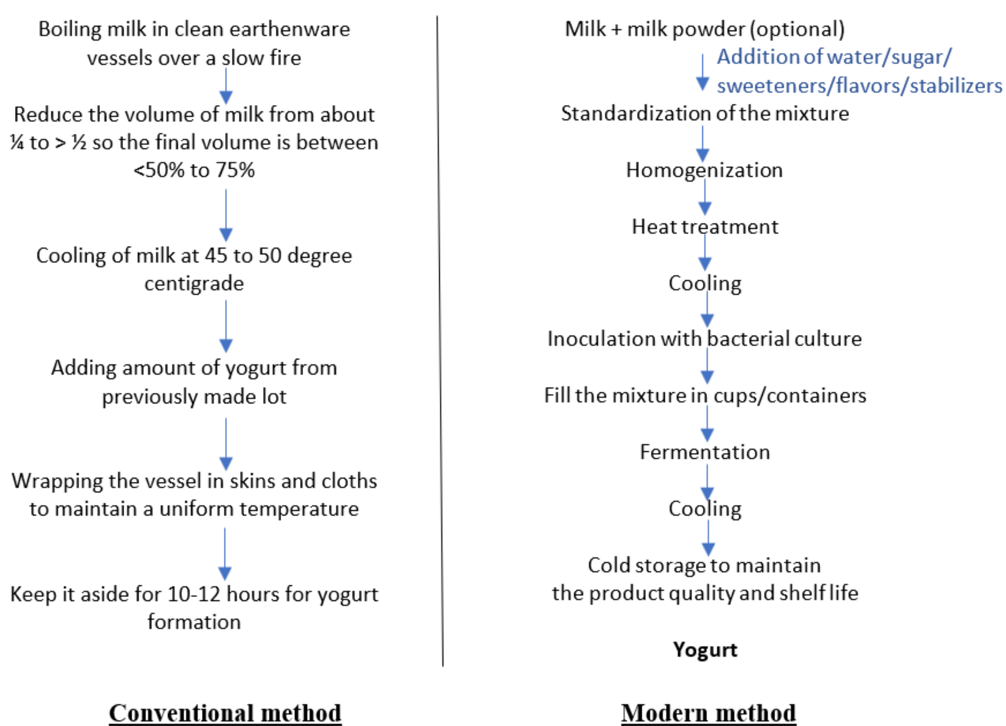

Figure 1: Conventional and modern methods of yogurt preparation.

explained by Nagaoka, [66]. The difference can be marked from the first step of the current preparation that involved supplementing the milk with milk products such as whey powder, whey protein isolates, or concentrates on increasing solid-not-fat. Cream or butter can also be used to fortify the fat content of the milk base. The addition of solid-not-fat in the yogurt preparation generates the need to homogenize the mixture that blends the ingredients thoroughly and causes all the milk fat to disperse into small globules, improving consistency and reducing syneresis, and preventing the creaming effect. Further, the addition of the previously made yogurt sample for curdling in the earlier method is replaced by inoculating the mixture with bacterial culture. Unlike the conventional method, the modern method listed the storage to increase the product's shelf life at a specific temperature of 5 degrees centigrade.

Before inoculation, the yogurt mixture is standardized to ensure standardized fat and non-solid fat content (SNF). The fat content of bovine milk ranges from 3.2% to 4.2% w/w, and for yogurt, from 0.1% to 10%, according to consumer demands. The standardization of the fat content is an essential step because it affects the quality of the yogurt, i.e., the viscosity and consistency of the final product improve parallelly to the fat content of the milk and vice versa. It also affects the maximum rate of pH decrease and pH lag phase during the yogurt fermentation [67]. The non-fat content of the milk comprises protein, lactose, and minerals; it varies from 11% to 14% of the total weight of the milk, while the SNF of yogurt ranges from 9% to 16%. The relation between the amount of SNF and the firmness and cohesiveness of the yogurt is similar to the relation between fat content and viscosity. Hence, yogurt manufacturers alter the SNF content by adding milk powder or protein concentrates to get the desired product. An increase in SNF also increases the duration of the fermentation process [68]. Nagaoka, [66] also elaborated on the preparation of stirred and drinking yogurt. The steps of preparation are entailed in Figure **2**. For stirred yogurt, the fruit preserves or flavors can be added after cooling the mixture.

The advancement in technologies has led to the commercial preparation of yogurt in a controlled atmosphere to develop desired and standardized texture and consistency. There are various heat treatments that are applied to milk or yogurt mixture during the preparation. Pasteurizing milk at 85 degrees centigrade and holding it for 5 minutes reportedly decreased coagulation and minimized syneresis for 20 to 30 minutes. Holding of mixture for a similar time at 90 to 95 degrees reported deteriorating the product quality [69]. However, the findings of Sfakianakis & Tzia, [68] revealed that treating milk at 90 to 95 degrees centigrade for 5 minutes or 85^{0} C for 20-30 minutes kills all pathogenic microorganisms and denatures whey protein.

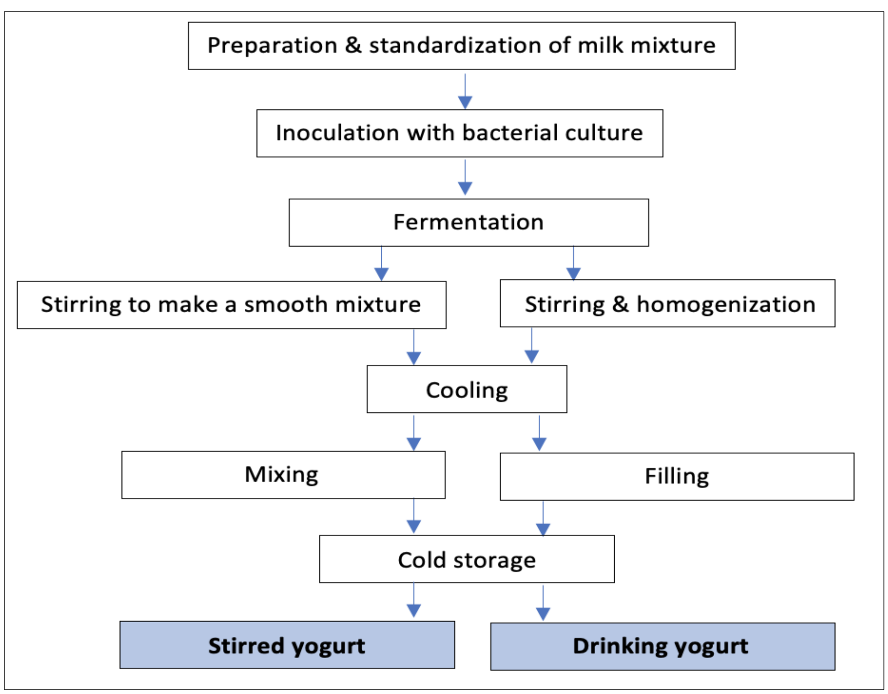

Figure 2: Preparation of stirred & drinking yogurt.

Less syneresis was found in yogurt prepared from UF- concentrated skim milk that was given heat treatment at 140^0 C or vat heated at 82^0 C for 20 minutes [70]. The pressure treatments applied to the milk mixture include homogenization, microfluidization, ultrasound milk treatment, and pulsed electric field application. These treatments modify the chemical structure of milk protein and fat along with alterations in the viscosity, firmness, syneresis, water holding capacity, and texture of the end product. The improvement in the yogurt quality is attributed due to the factors viz. milk fat globules (MFG) size reduction, casein micelle disruption, whey protein absorption to the MFG membrane, denaturation of protein, the interaction of whey proteins with MFG and casein micelles, stability of milk as an emulsion, and microbial content reduction. The manufacturers adjust the treatment intensity depending on the product's desirability as per the consumers' demand [68]. Pette & Lolkema [71] found that homogenization of the milk increases yogurt firmness and prevents creaming and whey separation in the yogurt. Low-fat milk microfluidized at 50 to 150 MP produced yogurt with creaminess and textural properties resembling full-fat yogurt. This results from modified microstructure and more interconnectivity in the protein networks with embedded fat globules [72,73]. Ultrasound milk treatment is given by propagating the mixture through ultrasound, a sound wave with a frequency higher than the humans' upper limit of hearing.

Fortification of Yogurt with Chickpea Isolates

The budding worldwide market of yogurt is a result of the tremendous efforts of food scientists and industrialists. The qualities of yogurt and chickpea discussed above make them suitable for developing different combinations of food products in terms of nutrient content, taste, flavor, consistency, and texture. One such combination is yogurt with added chickpea protein isolates. Yogurt fortified with protein concentrate or isolate augments its protein content. It positively impacts the sensory and physicochemical properties, mainly firmness, cohesiveness, viscosity, water holding capacity, syneresis, and emulsification activity. Apart from the mentioned qualities, chickpea isolates could be a cost-effective option to enhance the protein density of the yogurt due to its more than double protein content as compared to the dairy options such as skimmed milk powder which contains merely 35% of protein [74]. Preferring pulse protein over dairy protein for fortification will cater to almost the same sensory and physicochemical properties with higher protein at a lower cost. For instance, the market value of chickpea protein is Rs. 1.2/- and of skimmed milk powder is Rs. 1.9/- per gram of protein [75,76]. A study on the amino acid profile of legumes reported a higher proportion (8.3%) of arginine content in chickpea compared to green pea, cowpea, and lentils. However, chickpea was found to be most limiting in the sulfur-containing amino acids. Tryptophan was the limiting amino acid for the other three legumes [77]. Another comparative study for chickpea (CPI), soy (SPI), and pea protein isolates (PPI) explained the highest protein yield for soy protein isolates. However, the starch contamination of the protein fractions was lowest in chickpeas, and it had the highest proportion of crude fat. The CPI and PPI were found to have a higher content of beta-sheets, which could result in low digestibility in the human body [52]. The amino acid profile of CPI does not vary substantially from the PPI, including the sulfur-containing amino acids. Nonetheless, chickpea had a higher content of these amino acids as compared to PPI and SPI, along with the limiting amino acid Lysin [78,79]. The essential amino acid scores of chickpea and soy protein isolates met the FAO/WHO requirement for pre-school children, and the higher predicted protein efficacy ratio of chickpea indicated that it might have relatively higher digestibility. Moreover, Kabuli protein isolates had a better digestibility than the Desi protein isolates [79].

Although there is a glut of literature available on the combination of yogurt and pulses and pulse products such as flour and protein extracts in different formulations. However, to the author's knowledge, no studies were available on the fortification of yogurt with chickpea protein isolates to improve the protein content to a significant amount that could be utilized as therapeutic food for the vulnerable sections of society. Hence, Table **1** provides an overview of studies that used pulse products as fortificants in yogurt (other than chickpea isolate) and their impact on the properties of the fortified product.

The researchers have analyzed the willingness of people to afford fortified food products to achieve optimum health and address nutritional deficiencies. Notably, in low- and middle-income countries such as Uganda, China, and Kenya, the evidence suggests that the inhabitants were willing to pay 25%, 33%, and 24% of the premium,

Table 1: Summary of literature on yogurt and pulse/legume products

Dairy and Pulse Combination	Impact on Yogurt Properties	References
Buffalo milk + Chickpea flour, concentrates, isolates, fibrous residues (CFR)- 0.25%, 0.5%, and 0.75% each	• Improvement in the color, texture, and appearance at 0.25% fortification as compared with control. • Protein concentrates showed an effect in the texture at 0.25% and 0.75% and in the appearance at 0.25% only. • There was an enhancement in the organoleptic properties of all kinds of fortified yogurt. • Chickpea protein isolate CPI improved the color and appearance at 0.25% and 0.50% and the texture at 0.75% compared to control. • With CFR, the panelist detected taste improvement at 0.75%. • Yogurt fortification with flour (0.25%) increased the total bacterial and mold count by 103%, and it was lower than the samples prepared with isolates.	Nagib *et al*. [80]
Low-fat milk + Pinto bean protein concentrate- 2.5%, 5%, 7.5%, and 10%	• The fortified yogurt had comparatively low moisture content. • As compared to control yogurt, increase of 33%, 71%, 101%, and 129% were reported in the protein content at fortification level of 0%, 2.5%, 5%, 7.5% and 10%, respectively. • No impact on fat was observed. • Higher water holding capacity. • No significant impact on microbiological properties. • Increased consistency index, viscosity, and decreased flow behavior index.	Pahariya [81]
Low fat milk+ Kidney bean protein concentrate- 2.5%, 5%, 7.5%, and 10%	• Decrease in the moisture content with an increase in the fortification level. • Highest protein content was 14.43g/100g for the fortified yogurt, and the protein content of control was 4.44%. • Fat content increases with an increase in the fortification level. • Increased water holding capacity. • Total viable count of bacteria was higher in fortified yogurt, and an increase was noticed in storage time of 28 days. • Increased consistency, viscosity, and decreased flow behavior index.	Pahariya [81]
Whole milk powder- 15% + Soy protein isolate- 8% treated with high hydrostatic pressure	• Increased water holding capacity and emulsifying activity index. • Significantly higher resistance to shear stress in the fortified yogurt due to a stronger gel structure. • Increased viscosity, consistency index, and higher pseudo-plasticity.	Wang *et al*. [82]
Skimmed milk powder- 12% + Soy protein isolate- 4%	• Increased lactose metabolism by the yogurt starter during the fermentation process. • Insignificantly higher acetic acid and lower lactic acid concentration than control sample. • Survival of the starter bacteria in supplemented yogurt was significantly higher for the first seven days. However, it was significantly lower at day 14 of storage period but was within the reference range.	Pham & Shah [83]
Cow, goat, and ewe milk- 200 ml + Chickpea (direct/ boiled/ground)- 10 g	• A significant increase in protein, water holding capacity, viscosity, and penetrometer values. • Most liked fermented milk product in terms of appearance was the sample obtained from goat milk, and the sample cow milk sample had the lowest points. • The highest points in terms of consistency properties belonged to the ewe milk yogurt sample. • The sample obtained from cow milk was most liked in terms of odor and taste properties.	Guzeler *et al*. [84]
Chickpea yogurt- Raw cow milk 200 ml + chickpea 10 g, and Kefir yogurt- 200 ml raw cow milk + 5% kefir yeast	• The properties of both the yogurts were compared. • Higher viscosity and lower serum separation amounts were observed in chickpea yogurt. • It had a significantly higher water holding capacity. • It had low acetaldehyde content and bacteria count as compared to kefir yogurt.	Guzeler *et al*. [85]

Table 1 (contd….)

Dairy and Pulse Combination	Impact on Yogurt Properties	References
Roasted chickpea powder- 1g, 2g, 3g, 4g, 5g/100 ml of UHT milk	• Firmness significantly increases by increasing the addition levels of roasted chickpea powder. • Significant influence on the firmness of supplemented yogurt products. • Increased consistency and cohesiveness in the fortified yogurt. • Syneresis: decreasing tendency in supplemented yogurts with corresponding rises in added levels of roasted chickpea powder. • Supplemented samples exhibited less degree of shear-thinning. • Viscosity: gradual decline with corresponding rises in shear rate. • Overall, acceptability was higher for the yogurt supplemented with 3g of roasted chickpea powder in the sensory evaluation.	Raza *et al*. [86]
Cow milk- 250 ml + Roasted chickpea powder- 1%, 2.5%, 5% (w/v)	• Significantly increased the water holding capacity with higher percentage composition of chickpea flour (≥2.5%). • Viscosity was significantly higher with an increasing amount of chickpea flour. • Syneresis decreases as the concentration of chickpea flour increases. • Viability of S. thermophilus in yogurt formulations containing 0%, 1%, and 2.5% chickpea flour was relatively stable across the five-weeks storage period. • Addtion of 1% and 2.5% chickpea flour showed significant protective effects on Bifidobacterium (BB12) during the simulated gastric digestion. • Significant positive impact on probiotic survival when exposed to simulated intestinal juices with 0.3% bile salts.	Sidhu *et al*. [87]
Milk + Dry chickpea powder- 1%, 2%, 3%, or 5% (w/v)	• Addition of 1%, 2%, 3%, and 5% chickpea flour to plain low-fat yogurt may result in an increase in the protein content by 3%, 6%, 9%, and 15%, respectively. • A general increase (not statistically significant) in viscosity values up to 7 days. • Growth of L. delbruccki ssp. bulgaricus in yogurt supplemented with chickpea flour above 1% level was significantly greater. • Yogurt can be fortified with chickpea flour at the 2% level to enhance the nutritional and functional quality without affecting its appearance, aroma, texture, taste, and overall acceptability.	Chen *et al*. [88]
Raw cow milk + Chickpea flour- 1%, 2%, 3%	• Chickpea yoghurt 3%, 2% and 1% had a higher fat content of 3.3%, 3.26% and 3.2%, respectively. • Positive relation between chickpea concentration and survival of probiotic bacteria (B. animalissub sp. lactis and L. acidophilus) in stirred bio-yogurt during storage. • Samples made with chickpea flour have a higher level of antioxidant capacity as compared to control. There is also increased viscosity in stirred bio-yogurt. • Based on overall preference, bio-yogurt with 1and 2% chickpea flour has good sensorial properties.	Hussein *et al*. [89]

respectively, for foods fortified in carotenoids, folate, and fortified maize [90-92]. A recently published study by Agnew *et al*., [93] reported that 96% of the study population in Bangladesh were willing to pay the market price of 10 Bangladeshi takas (BDT) or the US $0.14 for a pack of 60g micronutrient fortified yogurt. The yogurt targeted children aged 3 to 12 years. The findings indicated that the product was recognized for its nutritional benefits to the children. Moreover, the result was driven by the influence of nutrition-related knowledge and attitude. As per the socioeconomic characteristics of the consumers, the product could reach households in the second poorest income quartile. Reportedly, a similar perspective was reflected by the consumers for yogurt fortified with soy protein isolates, where more than 50% of the population had a higher acceptability rate and were willing to purchase the product [94].

While designing a new formulation of a food product, it is important to explore the sensory performance of its variations by conducting a literature review or market research. Table 1 above provides insight into the impact of combining dairy with legume products, whereas Table **2** below expands the evidence on the sensory properties of some dairy-based and non-dairy-based yogurts and compares both types of yogurts. Overall, it can be concluded that the preference for yogurt was increased with the increasing proportion of cow milk or milk powder of similar taste when reconstituted. In the case of non-dairy-based yogurts, an additive is required for better sensory acceptability. Furthermore, soy milk yogurt was found to have relatively compromised digestibility.

Table 2: Evidence on sensory properties of dairy-based and non-dairy-based yogurt formulations

References	Title	Yogurt Composition	Impact on Sensory Properties
Donkor *et al*., [95] **Non-dairy-based yogurt experiment**	Rheological Properties and Sensory Characteristics of Set-Type Soy Yogurt	• Six batches of soy yogurt were prepared. • Three batches with the yogurt culture, and • The other three batches were made with yogurt and probiotic cultures. • Each batch was made with 2 L of commercial soymilk with 2% (w/v) inulin or 1% (w/v) each of raffinose and glucose or without any supplementation	• Probiotic fermented soymilk was more acidic than the corresponding product made with yogurt culture only. • All samples except control soymilk without supplementation, apparently had a weak gel after fermentation and during storage, 36.7% of panelists declared "liked very much". • All soy yogurts did not show syneresis after fermentation and during storage at 4 °C. • Control soy yogurts supplemented with inulin, raffinose, and glucose, or probiotic soy yogurt supplemented with raffinose and glucose had a better mouth feel than probiotic soy yogurt with no supplementation • Overall, based on the acceptability mean scores, the control soy yogurt appeared to be acceptable by the consumer panel as opposed to the slight dislike of the probiotic soy yogurt. • Adaption of recommended techniques to eliminate the antinutritional factors of soybean, use of sweetening agents, manipulation of starter combinations, and addition of flavors are recommended to overcome the problems of bitterness and the objectionable bean flavor in the product.
Martensson *et al*. [96] **Non-dairy-based yogurt experiment**	Formulation of an oat-based fermented product and its comparison with yogurt	• Fermented oats base (rolled oats + water), • Yogurt sample (control), and • Fermented mixture of soy and oats (non-dairy control) • Xanthan gum 0.03% + flavors (strawberry or mixed berry jam) were added to all samples.	• Adding xanthan gum as a stabilizer improved both the viscosity and consistency. • However, the consistency was not as thick and creamy as ordinary yogurt. • The fermented product had a more compact than creamy consistency and low susceptibility to syneresis. • Color of the fermented products was less white than the control yogurt. • Addition of flavors resulted in higher overall acceptability, although it was not as high as for the yogurt control. • Overall appearance, consistency, and sweetness were increased by adding strawberry jam to the products, and the panelists did not appreciate the oat flavor.
Trindade *et al*. [97] **Non-dairy-based yogurt experiment**	Development and sensory evaluation of soy milk-based yoghurt	• Soy milk yogurt was prepared. The experiments were conducted using soy milk at 9^0 Brix homogenized at 17 MPa and with the addition of sucrose in the concentrations of 2.0 or 2.5 g per 100g of soy milk. Fermentation times were 4, 5, 6, and 7 h periods.	• The coagulation of soy milk yogurt occurred within 4 hours of fermentation, with a pH of 5.5. • The panel preferred the favor of sucrose since it appeared to have the property of masking the usual beany flavor detected in soy-derived products. • The panel also described a decrease in chalkiness and an increase in astringency in the 7 h of fermentation samples. • Samples with 2.5% added sucrose & 5 h fermentation and with 2% sucrose and 6 h fermentation were selected as having better global quality. • In conclusion, soy milk yogurt prepared from a 9^0 Brix soy milk, with the addition of 2% sucrose before fermentation, homogenized under the pressure of 17 MPa, and fermented for 6 h was considered the better product and presented great potential for commercial production.

Table 2 (contd….)

References	Title	Yogurt Composition	Impact on Sensory Properties
Isanga *et al*. [98] **Dairy & non-dairy-based yogurt comparative study**	Production and evaluation of some physicochemical parameters of peanut milk yogurt	• PMY- Peanut milk (approximately 12 g/100 g total Solids) + 4 g/100 g skimmed milk powder. • CMY- Cow milk (approximately12 g/100 g total Solids) + 4 g/100 g skimmed milk powder	• CMY had higher scores than PMY in terms of appearance, flavor, and overall acceptability. However, it was not significant. • PMY had higher texture scores than CMY, making the yogurt creamier than CMY, which has a lower fat content. • Some panelists appreciated the PMY flavor better than CMY, but most panelists preferred the CMY flavor. These findings suggest that if the flavor of PMY could be improved upon, this yogurt could become more acceptable and appealing to potential consumers. • Both PMY and cow milk contain almost all the essential amino acids and non-essential amino acids though PMY had more and even higher amounts of essential amino acids than CMY. However, both yogurts can be considered to be composed of good protein quality due to their rich composition of essential amino acids.
Supavititpatana *et al*. [99] **Dairy & non-dairy-based yogurt comparative study**	Characteristics and Shelf-Life of Corn Milk Yogurt	• Comparison between corn milk yogurt and cow milk yogurt	• The panelists preferred cow milk yogurt in texture and mouth feel attributes. • The higher whey drainage of the corn milk yogurt may be responsible for the lower scores. • A better taste result of corn milk yogurt could have been achieved by adding sugar that reduced the sour taste. • The corn milk yogurt had higher amounts of starter cultures, but its reduction of starter cultures was faster.
Sanful [100] **Dairy & non-dairy blended yogurt experiment**	Promotion of coconut in the production of yogurt	• Sample A: 100% cow milk • Sample B: 75% cow milk and 25% coconut milk • Sample C: 50% cow milk and 50% coconut milk • Sample D: 100% coconut milk	• The panelists accepted the appearance of all the samples as good. There was an insignificant difference between the mean of the values of the samples. • The analysis of the sourness revealed that samples A and D were very good. The composite samples (B and C) relatively had lower sourness. • The aroma of all the samples was accepted with a slight preference for sample A. • 98% of the panelists accepted the mouth feel of samples A and B better than samples B and C. • 98% of the panelists accepted sample A while 95% accepted sample D. Sample B was also preferred to sample C. Thus, there seems to be a slight preference for pure cow milk yogurt and pure coconut yogurt. • Yogurt produced from skimmed cow milk did not differ organoleptically from those produced from coconut and cow milk composites and pure coconut milk in all the sensory quality attributes.
Yilmaz-Ersan *et al*. [101] **Dairy & non-dairy blended yogurt experiment**	Evaluation of instrumental and sensory measurements using multivariate analysis in probiotic yogurt enriched with almond milk	• Reconstituted skim milk- Skim milk powder + distilled water at 10.70% (w/v) to yield the same overall composition as raw skim milk. • Five proportions of reconstituted skim milk to almond milk were prepared- 100:0, 75:25, 50:50, 25:75, and 0:100.	• Reconstituted milk contains less yellow pigment carotene and appears whiter than almond milk. • As the almond milk rate of samples increased, the firmness values of samples decreased. • Yogurt with a higher ratio of reconstituted milk had a higher firmness than almond milk yogurts due to its higher protein and total solids content. • As the almond milk rate of samples increased, the consistency values of samples value decreased. Supplementation of almond milk resulted in an unstable system and the formation of a weak three-dimensional network in yogurt. • The panelists appreciated that almond milk could be incorporated into yogurt to a level of 25%.

Table 2 (contd….)

References	Title	Yogurt Composition	Impact on Sensory Properties
Fatima *et al*. [102] **Dairy & non-dairy blended yogurt experiment**	Microbial and sensory analysis of soy and cow milk-based yogurt as a probiotic matrix for Lactobacillus rhamnosus GR-1	• Skimmed cow milk + unsweetened soy milk + Sucrose (5%w/v)- • Treatment 1- 100% (w/v) cowmilk (control), • Treatment 2- 75% (w/v) cow milk and 25% (w/v) soymilk, • Treatment 3- 50% (w/v) cow milk and 50% (w/v) soymilk, and • Treatment 4- 20% (w/v) cow milk and 75%(w/v) soymilk	• The sample with a higher percentage of cow milk was most appealing. • The second preferred was treatment 2, followed by treatment 3. Treatments 2-4 were slightly off-white and less viscous, which may not be appealing to the participants. • Flavor- No significant difference in the treatment samples. • Texture- treatment 1 (control) score was the highest among all samples. Treatment 2 was the most preferred among the blended samples. • Overall acceptability- Treatment 4 was the most preferred due to its mildly sweet and nutty flavor, lack of aftertaste, and thin texture. Treatment 3 was the least preferred sample among the panelists. • The sensory appeal of soymilk is low amongst most consumers due to beany flavor, which is attributed to the presence of unsaturated fatty acids and lipoxygenases that give rise to volatile compounds. Some individuals reported abdominal discomfort, diarrhea, and flatulence following soybean consumption due to indigestible oligosaccharides.
Kim *et al*. [103] **Dairy-based yogurt experiment**	The quality characteristics, antioxidant activity, and sensory evaluation of reduced-fat yogurt and non-fat yogurt supplemented with basil seed gum (BSG) as a fat substitute	• LFY- 0.5% BSG added to reduced-fat yogurt, • LFY- 1.0% BSG added to reduced-fat yogurt, • SY- 0.5% BSG added to non-fat yogurt), and • SY- 1.0% BSG added to non-fat yogurt. • FFY- yogurt made from full-fat milk: a control group, • LFY- yogurt made with Low-fat milk: a control group, • SY- made with non-fat milk: a control group	• The highest scores for appearance, color, texture, and overall acceptability were assigned to FFY. • The flavor was the highest in FFY and lowest in LFY at 0.5%, but at a concentration of BSG 1%, the flavor was improved compared with the control group of LFY. • Sourness was highest in FFY and lowest in SY. • Between the SY samples, as the concentration of BSG increased, the flavor, texture, and overall acceptability were improved compared with the SY group. • The reduction in fat content significantly influenced the sensory perception of the yogurt samples, and the addition of BSG had a positive effect on sensory properties
Salvador *et al*. [104] **Dairy-based yogurt experiment**	Textural and sensory characteristics of whole and skimmed flavored set-type yogurt during long storage	• Artificially sweetened, strawberry flavored, 2 types of set-style yogurts: • Whole milk yogurt- 3.5 g of protein, 13.4 g of carbohydrates, and 1.9 g of fat/100 g • Skimmed milk yogurt- 4.4 g of protein, 4 g of carbohydrates, and 0.1 g of fat	• The panelists' scores for "syneresis," "firmness," "maintenance of shape," and "chalky taste" showed significant increases in relation to storage time for both types of yogurt. • No significant changes in relation to storage time were found in "color," "flavor intensity," or "sweetness" for either type of yogurt. • The only differential behavior between the 2 types of yogurt was that skimmed yogurts showed increases in "acidity" and "astringency" with time. • Greater firmness and the rise in negative attributes such as "astringency" or "chalky taste" were associated with the lower acceptability of the skimmed yogurts. • Attributes that are considered negative, such as syneresis or the appearance of atypical texture/mouth-feel characteristics, increase with storage time.

Based on the literature review, it can be assumed that the combination of a regular bovine milk yogurt and chickpea protein isolate will result in the end product with the following properties (Figure **3**):

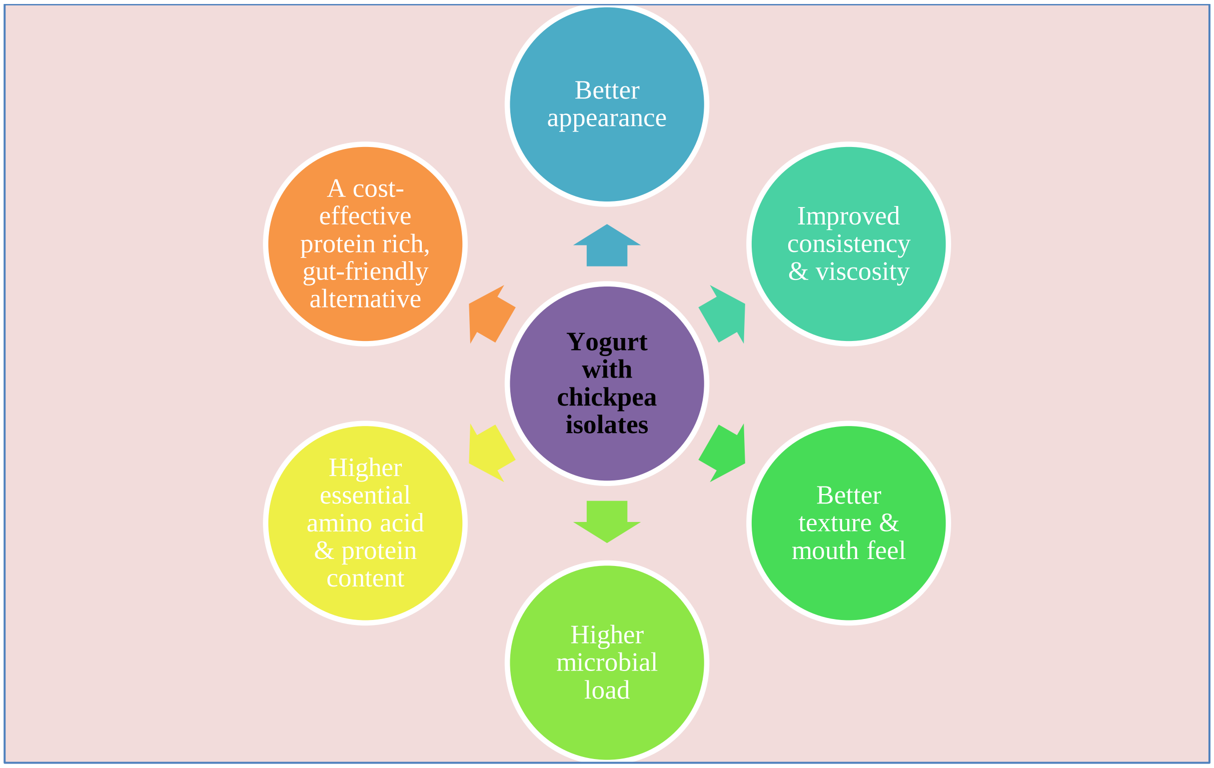

Figure 3: Properties of the proposed fortified yogurt.

As per the presented research findings, legume protein isolates, when added to yogurt, enhance the consistency of the fortified product. Thus, it is presumed that the better texture of the end product will be due to the emulsifying properties of the isolates. Moreover, the product will balance the intake of protein from dairy and vegetarian sources and promote the intake of vegetarian protein. Introducing dairy protein at an early age has been warned by international experts due to a positive relationship between milk consumption and type 1 diabetes in children. Further, it contributes to chronic conditions and diseases in adults [105].

Ongoing Program and Monitoring Systems for Human Hunger Mitigation

India is at101thpoint out of 116 countries in the Global Hunger Index (GHI), 2021 [106] with a score of 27.5. A score of more than 20.0 is considered a serious public health concern, and more than 35.0 indicates an alarming situation in a country. There has been a markable deterioration in the country's rank when looking at the data of the last ten years, when the GHI was 67 out of 122 countries. The GHI of India is calculated based on data on four indicators drawn from the United Nations and other multilateral agencies: undernourishment, child stunting, child wasting, and under-five mortality. The recent NFHS-5, 2019-21 [107] data reported an improvement in the prevalence of all four indicators from NFHS-4, 2015-16 [108], as presented in Table **3**. However, a marginal increase has been noted for cases of severe wasting, which is an area of concern because developing countries like India account for the majority of the global malnourished population that is negatively impacting the quality of life of individuals as well as the overall growth of a nation.

The underlying causes of hunger include falling per capita crop and food production, increased export of food crops, increasing inequality in share of expenditure on food with medical care, education, transport, electricity, etc., poor access to expensive foods, low social status of women in society, inadequate child care practices, an insufficient supply of healthcare services, and inefficiency of food-based government programme [109]. The

Table 3: Prevalence of Indicators for Global Hunger Index in the Indian Context

Indicators	NFHS- 4 (2015-16)	NFHS- 5 (2019-21)
Stunting	38.4%	35.5%
Wasting	21.0%	19.3%
Severe wasting	7.5%	7.7%
Undernutrition	35.8%	32.1%
Under-five mortality	49.7%	41.9%

government of India has continued its efforts to develop strategies and amend the current program to address this problem. At present, a couple of programs running in the country are directly or indirectly working towards the same goal of improving the overall well-being of the vulnerable groups of society by ensuring better nutrition and health services through inter-sectoral convergence. The list of ongoing programs is as follows [110]:

- Integrated Child Development Services Scheme
- Midday Meal Programme
- Special Nutrition Programme (SNP)
- National Nutritional Anemia Prophylaxis Programme
- National Iodine Deficiency Disorders Control Programme
- National Goitre Control Programme
- Mid-Day meal programme
- Applied Nutrition Programme
- Akshaya Patra Programme
- Poshan Abhiyaan

Apart from these programmes, there is increasing awareness about community-based management of severely acute malnourished children (CMAM). The evidence suggests that about 20% of children with severe wasting do not possess any medical complications; hence, they can be treated at the community level [111]. The states with a relatively high prevalence of severe wasting, such as Madhya Pradesh, Telangana, Jharkhand, Odisha, and Chhattisgarh, already have a CMAM programme in a few districts and these states are now investigating the suitability for the scale-up [112,113].

These programs target the population at risk for nutritional deficiencies and health problems, i.e., women of reproductive age and children below six years of age. There is a provision of nutritious meals to fulfill a certain proportion of energy and protein for both groups and nutritional supplements for vital micronutrients for women of reproductive age group as preventive measures for undernutrition. Programs for anemia, iodine deficiency, and goiter mainly cater to interventions and awareness for preventing and managing these nutritional problems. For malnourished children, the states focus on early identification through intense screening drives followed by distributing energy-dense foods, hot meals, or take-home rations developed as per state-specific CMAM guidelines from locally available food ingredients. Recently, the government has started promoting the distribution of fortified grains in the public distribution system (PDS), and state governments are rolling out pilot studies to explore the feasibility and impact of distributing fortified mid-day meals in government schools [114,115].

Although numerous policies and programmes have been developed as a combat strategy for acute and chronic malnutrition where the vulnerable population is receiving food intervention, complementing these interventions with added nutritional benefits can result in a better nutrient intake by consuming the same amount of food which can expedite the rate of achieving developmental goals. The NFHS-5 data explains the variability in the prevalence of malnutrition among the states, implying that the states with a high prevalence require a more focused approach. A fortified yogurt could be an alternative with high protein content for the malnourished vegetarian population in government programmes such as supervised supplementary feeding programme (SSFP) and supplementary nutrition programme in the states Telangana and Odisha, respectively, which are providing eggs as a source of good quality and quantity of protein [116,117].

Impact on Human Health and Achieving UN –SDG-2 Goal for “0” Hunger

The United Nations shaped the sustainable development goals (SDGs) in 2015 as a universal call to culminate poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. There are seventeen integrated SDGs, out of which the second goal targets “0” hunger by ending all forms of hunger and malnutrition and ensuring that all people, especially children, have sufficient and nutritious food all over the year [118]. Achieving SDGs in developing countries will require enormous efforts by international institutions regarding facility engagement, dialogue, capacity building, and innovation, involving key stakeholders such as local governments, NGOs, private sectors, minority, and disadvantaged groups [119,120]. India’s contribution to the global burden of malnutrition makes its success a considerable aspect in achieving these goals. In a study, the public health experts from seventeen states shared some roadblocks in achieving SDGs in India and reported that hunger is one of the goals that require the most attention by the government and consider SDGs as an effective medium to address critical issues such as poverty, hunger, education, health, and well-being [121].

Researchers have explored the impact of achieving “Zero” hunger on the environment, economy, food patterns, and overall human life. A study investigated the effect and reported that meat and fish consumption will grow in all the targeted countries by 2030. In the context of India, there will be a considerable increase in dairy consumption and per capita consumption of vegetable oil and fats. In contrast, other foods' consumption will remain at a similar level. The depth of food deficit was reduced across all the countries, including India. The environmental impact upon reaching the average dietary energy requirement as a consumption level for all undernourished populations would be close to the per capita impact of the total population, and the overall environmental impact would be negligible. The calorie consumption would be increased by 2.67%. The study also revealed that the health improvement in human life would be similar across all the countries with prevented Disability Adjusted Life Years (DALY) between 0.08 to 0.12 per undernourished person, and overall health improvement was reported most significant in India [122]. According to Popkin, 1993 [123], the overall dietary development of the human species has five distinct patterns: (1) collecting food, (2) famine—a monoculture diet dominated by cereals, (3) receding famine—a starchy non-diverse diet high fiber and low fat, (4) chronic diseases—a more diversified diet with increased uptake of sugar, (animal) fat and processed foods and (5) behavioral change—increased intake of fruit, vegetables, and whole grains. The nutrition transition is shifting from traditional diets to higher consumption of sugars, fats, processed foods, and animal-source foods. The researchers implied that India’s transition progress is at a moderate pace and would be transitioned towards the fourth pattern later. The transition pattern of India was reported to be different from other countries as meat consumption grows slowly [122], particularly beef consumption, which is limited due to religious and cultural restrictions [124]. However, there is a steady shift from consuming dairy products to meat, fish, and eggs with rising income [125].

Conclusion and Recommendation

It can be deduced that the fortification of chickpea isolate can improve yogurt's nutritional and functional properties. The role of yogurt and chickpea isolates in enhancing the protein content and overall sensory properties has been demonstrated. Hence, different formulations could be explored to develop a therapeutic combination concentrated with high quality and quantity of protein and healthy gut flora. The product could help mitigate country-level public health challenges such as the constantly increasing load of the malnourished population in the country, prevention of diarrhoeal deaths among children, and maintaining optimum health during pregnancy, lactation, sporty and elderly stages of life as all these age groups demand the intake of foods with high nutrients stocks to nourish the body even if consumed in small amounts. Further, certain physiological conditions in this population often lead to the inability to gobble the quantity of food that is nutritionally required and end up developing nutritional deficiency disorders.

Conflict of Interest

The authors declare no conflicts of interest.

Ethical Approval

Not applicable.

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