Noval concept of functional food products: An advanced application of nutritional research for perishable and underutilized therapeutic foods

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Introduction

Anything that once consumed and ingested does not lead to any toxicity in the body is categorized as food. A food provides the basic nutrition and feeling of satiety to any individual. However, since a long time the food sciences has been flourishing and the concept of "food as a medicine" is well known. This led to the birth of concept called "functional foods." Initially bought into limelight in Japan to reduce the increasing cost of healthcare, the concept of functional foods spread entirely around the globe due to the significant expected outcomes of its application viz., low health cost, prevention of disease, post-disease relief etc (Chhikara and Panghal, 2022). A functional food is something that provides benefits beyond basic nutrition specially in terms of health ameliorating effects (Ashaolu, 2020).

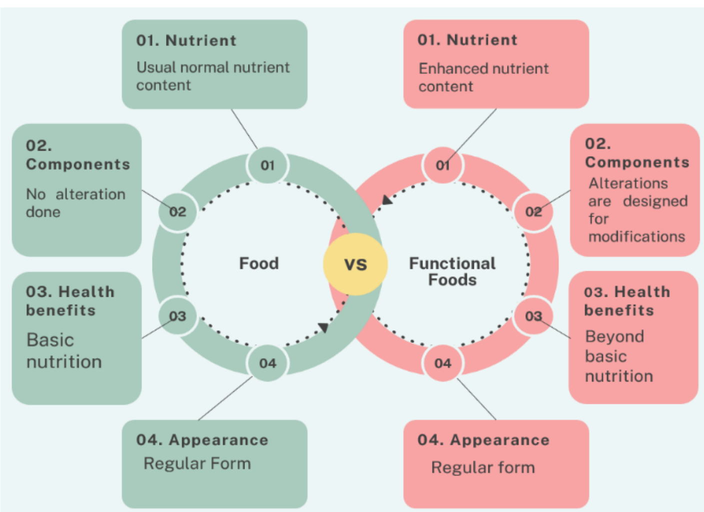

Figure 1. Food v/s functional foods

Further, a functional food is often misinterpreted as a nutraceutical however, a nutraceutical is more towards pharmaceutical form of nutrients. In order to be a categorised as a functional food it must remain in its regular or normal form and not in appearance of pills or capsules (figure 1). It is also consumed as a part of usual diet in order to have beneficial effects. However, a functional food is still different from normal food although it may appear as a regular food due to the modifications that are done for its development. These modifications are either alteration in concentration such as substitution, removal, and enhancement of a component of food responsible for health benefits or modifying the bioavailability of any already present nutritional or bioactive component in food by using various potential processing techniques or addition of any external agent such as probiotic bacteria or inoculum (Granato et al., 2020; Frakolaki et al., 2021). Hence, the commonly consumed classes of functional foods are probiotics, prebiotics, value added products, and valorised products.

Development of various functional foods from moisture rich perishable nature fruits has also been done wherein the developed products such as jam, RTS beverage, squash, syrup, and jelly etc were developed (Younas et al., 2020; Rolim et al., 2020; Bhama et al., 2013). In the studies, the developed products were analysed for nutritional parameters such as proximate composition, total sugars, reducing sugars, non-reducing sugars, and bioactive compounds. Depending upon the nature of developed products the products were also analysed for shelf-life study from few days up to few months. Further, to sensory evaluate the developed food products, 9-point hedonic scale was utilized for the analysis which is often used to grade the developed food products in terms of sensory parameters such as colour, taste, texture, aroma, and overall acceptability. Microbiological parameters to detect any spoilage of the developed product during study are also analysed. These products are developed with an aim to aim to fulfil consumers need beyond basic nutrition and therefore requires optimization or standardization accuracy (Topolska et al., 2021). The shelves are often crowded various convenience products. In such a scenario, the food industry focuses on promoting the popular products among the various target groups of the consumers. Intermediate moisture food products such as jam, jelly, and squash etc. are most popular among all the age groups especially children. Development of such products will aid to initiate the concept of optimum nutritional needs fulfilment since the very beginning. Some of the previous studies focusing development of similar products from various fruits and their seeds have been listed below:

a) Jam

In a study conducted by Bekele et al. (2020) , physico-chemical properties such as ash 0.29±0.02 to 0.71±0.02 %), TA (0.36±0.01 to 0.71±0.02 %), total sugar (44.45±1.10 to 63.72±0.55 %), reducing sugar % (27.1±0.1 to 35.70±0.02), and vitamin C (17.23±0.31 to 23.99±0.07 mg/100g) were observed for mango jam developed from various varieties viz. tommy, keitt, kent, and dodo etc. In another study, quality evaluation of peach jam was performed wherein incorporation of aloe vera gel was also done. The prepared treatments i.e., T_0, T_1, T_2, T_3, and T_4 were analysed for TSS i.e., total soluble solids (65.26±0.45 to 67.13±0.81), pH (3.05±0.10 to 3.51±0.10), ash (0.36±0.00 to 0.53±0.02%), moisture (29.03±1.86 to 35.77±0.93%), protein (0.38±0.01 to 0.56±0.01%), fat (0.12±0.00 to 0.17±0.00%), fibre (1.03±0.05 to 1.83±0.11%), and carbohydrates (62.31±0.87 to 67.86±1.96%). Organoleptic evaluation was also performed of the developed treatments for the parameters viz. color (5.66±0.57 to 7.66±0.57), flavour (7.16±0.76 to 7.66±0.57), taste (6.83±0.76 to 7.83±0.28), texture (5.66±0.57 to 7.83±0.28), and overall acceptance (6.49±0.21 to 7.79±0.25) (Ali et al., 2021). Furthermore, another study conducted by Chandrajith et al. (2016) also highlighted the physio-chemical properties of bilin jam formulation T_2 with pulp to sugar ratio as 1000g:1100g as best. The TA (%), pH, moisture (%), TSS (^{0}Bx), ascorbic acid (mg/100g), and fibre (%) for this formulation were 1.58±0.04, 3.26±0.15, 26.57±1.83, 68.20±0.50, 8.15±0.42, and 1.06±0.08, respectively. The colour, odour, texture, spreadability, taste, and overall acceptability were also recorded highest for T_2. Different jams from pulp of sapota were also prepared in a study by Ahmed et al. (2011) with pulp concentration of 100 % (A_1), 75 % (A_2), and 50% (A_3). The average of these three formulations were recorded for moisture (%), ash (%), acidity (%), pH, total sugar (%), vitamin C (mg/100g), and TSS (0Bx) as 28.57, 0.42, 1.05, 3.1, 61.64, 3.36, and 67, respectively.

b) Jelly

Dragon fruit jelly was developed and analysed for chemical composition and sensory scores in a study. Three different jelly formulation A (0.5%), B (1.0%), and C (1.5%) were developed depending upon varying pectin (%). The moisture (%), ash (%), reducing sugar (%), non-reducing sugars (%), total sugars (%), pH, acidity (%), TSS (^{0}Bx), and vitamin C (mg/100g) were recorded for the blends as 28.96±0.05 to 30.12±0.15, 0.59±0.01 to 0.62±0.01, 27.36±0.01 to 28.04±0.03, 36.99±0.01 to 38.06±0.12, 64.01±0.01 to 65.02±0.07, 4.20±0.00 for all three, 0.44±0.01 to 0.46±0.00, 66.67±0.57 to 67.00±0.57, and 2.61±0.01 to 2.79±0.01 (Islam et al., 2012). Another study also focuses on development and evaluation of dragon fruit (*Hylocereus undatus)* based jelly wherein, prepared jelly was evaluated in terms of nutritional and sensory parameters for 90 days of storage interval. The TSS (^{0}Bx), TA (%), reducing sugars (%), and total sugars (%) increased from 67.26 to 68.16, 0.51 to 0.65, 27.77 to 29.74, and 65.10 to 66.70 respectively. On the other hand, the ascorbic acid content decreased from 2.96 to 2.45 mg/100gm. The sensory quality of jelly also decreased in terms of colour (8.93 to 8.65), flavour (8.89 to 8.48), taste (8.55 to 7.96), consistency (8.71 to 8.04), transparency (8.93 to 8.35), and overall acceptability (8.77 to 8.11) (Panchal et al., 2018).

c) Syrup

Harendra and Deen (2022) developed ten different treatments of syrup (T_1 to T_{10}) using the mango pulp, kagzi lime juice, ginger juice, and aloe vera juice in different concentrations. The developed syrups were evaluated in terms of nutritional and organoleptic scoring for 5 months of storage. For samples in glass bottles, the TSS (^{0}Bx), acidity (%), reducing sugars (%), and total sugars (%) increased from 70.00 to 71.42, 1.20 to 1.81, 1.65 to 3.93, and 69.75 to 70.91 respectively. However, the vitamin A (I.U), vitamin C (mg/100mL), and non-reducing sugars (%) decreased from 664.50 to 661.74, 23.41 to 21.87, and 68.10 to 66.98, respectively. The organoleptic scoring also decreased from 8.16 to 7.08. Similar observations were recorded for syrups in polypet bottles.

d) Ready to serve (RTS) beverage

Pavithra and Minni (2023) developed RTS beverage with dragon fruit as a value-added product. In the study, the dragon fruit juice was blended in different concentration with pineapple juice, watermelon juice, and acid lime each for preparations of ten different treatments of RTS beverage (T_1 to T_{10} for each paired blending). The treatments were evaluated for sensory quality parameters viz. appearance (6.62 to 8.00), colour (6.56 to 8.12), flavour (5.69 to 7.68), texture (6.50 to 7.68), taste (5.2 to 7.65), and overall acceptability (6.0 to 7.86). Nutritional parameters such as TSS (^{0}Bx), acidity (%), reducing sugars (g/100g), total sugars (g/100g), ascorbic acid (mg/100g), β-carotene (mg/100mL), were also evaluated wherein ascorbic acid and β-carotene decreased with increase of storage interval of 60 days. However, the TSS, acidity, reducing sugars, and total sugars increased with increase of storage interval. A three months storage study was also performed in a study focusing the development of black mulberry based RTS drink. Treatment T_1 to T_4 were prepared depending upon varying fruit pulp concentration (10-25%) in RTS drink. Reducing sugar and total sugar increased with increase of storage intervals with recorded observations varying from 7.20 to 9.25% and 12.52 to 15.54%, respectively. However, non-reducing sugar content decreased as storage interval increased with values ranging from 5.21 to 6.26%. Furthermore, the highest sensory scoring was recorded for T_4 treatment with 25% fruit pulp concentration in terms of color, taste, flavour, and overall acceptability (Parveen et al., 2023). In another study, melon by-products viz. peel and seed powder were used for development of value-added functional drink. The drink was prepared in nine different treatments (T_0 to T_8) and was evaluated for nutritional parameters for a storage study of 90 days. The parameters such as titrable acidity (%), TSS (^{0}Bx), and pH were recorded with values ranging from 0.15±0.003 to 0.29±0.005, 1.72±0.01 to 2.62±0.01, and 4.01±0.06 to 4.97±0.05, respectively (Namet et al., 2023). Blends (T_0 to T_{10}) with varying concentration of strawberry pulp, guava pulp, and apple pulp were also prepared in a research study for development and evaluation of RTS beverage. The developed RTS beverages were evaluated for four months of storage interval at ambient and refrigerated temperature. At ambient temperature, the TSS (^{0}Bx), acidity (%), reducing sugar (%), and total sugar (%) increased from 13.00 to 14.25, 0.20 to 0.42, 1.80 to 2.53, and 2.45 to 2.78 respectively. However, vitamin C (mg/100mL) and non-reducing sugar (%) decreased with increase of storage interval with values decreasing from 21.52 to 21.09 and 0.65 to 0.25, respectively after four months of storage. Similar trends were observed for RTS beverages stored at refrigerated temperature (7-9°C) (Hassanazai et al., 2024).

e) Seed based sweet (Pinni/Ladoo)

Pinni from flour of various kidney varieties (Kanchan, Jwala, Buspa, Him 1, Triloki, and Chamba etc.) were developed by Kimothi et al. (2020). The developed treatments (Control, F_1, F_2, and F_3) were evaluated for crude protein (7.88±0.09 to 8.35±0.01%), crude fat (30.86±0.08 to 32.36±0.02), crude fibre (1.48±0.00 to 1.82±0.01), crude ash (2.97±0.03 to 3.90±0.00), and total carbohydrates (47.11±1.12 to 52.04±0.48). Organoleptic evaluation of developed pinni was also done wherein, the score for color, taste, flavour, and texture varied from 7.05 to 8.01, 6.65 to 7.97, 6.62 to 7.82, and 6.98 to 7.81, respectively. Germinated pumpkin seed flour was also utilized for preparation of laddoo after supplementing it to whole wheat flour and Bengal gram flour. Four different treatments of laddoo (Control, type I, type II, and type III) were prepared and evaluated for proximate composition and overall acceptability. The best organoleptic acceptability was recorded for type I treatment for color (8.20±0.25), appearance (8.30±0.21), aroma (8.30±0.26), texture (8.40±0.16), and taste (8.50±0.22). Moisture, ash, crude fat, crude protein, crude fibre, and total carbohydrates of prepared treatments of laddoo varied from 3.17±0.11 to 3.69±0.15%, 3.66±0.04 to 8.19±0.07%, 21.46±0.13 to 31.52±0.21%, 16.53±0.22 to 25.59±0.24%, and 1.64±0.03 to 3.24±0.08%, respectively (Kumari et al., 2021). Nutra laddu with variable concentration of falx seeds were also prepared along with amaranth seed, jaggery, and honey in a research study. The prepared treatments of laddu (control, C_1, C_2, C_3, C_4, and C_5) were evaluated for moisture (3.05 to 3.30 g/100gm), protein (8.09 to 9.02 g/100gm), fat (22.50 to 23.60 g/100gm), ash (1.10 to 1.48 g/100gm), crude fibre (1.21 to 1.85 g/100gm), and carbohydrates (59.37 to 61.55). In terms of sensory characteristics, the scores varied from 6.8 to 8.1, 6.6 to 8.0, 6.2 to 8.2, 6.0 to 8.1, 6.2 to 8.1, and 6.5 to 8.0 for appearance, colour, taste, flavour, texture, and overall acceptability, respectively (Ghatge et al., 2020).

f) Leaf based herbal infusion

Dev and Iqbal (2015) developed tea from green papaya leaves in a study. The fresh papaya leaves were dried in a cabinet after washing, air drying, and chopping at 60°C for 4 hours. The cabinet drying was followed by hot air oven drying at 110°C for 10 minutes to make the leaves moisture free. The crushed leaves were then stored in a polythene bag as tea in cool and dry place. The developed papaya leaf tea was then evaluated for moisture, protein, fat, ash, total carbohydrates, and vitamin C content with recorded values as 4.7%, 26.2%, 2.6%, 10.8%, 55.7%, and 35.5 mg/100gm. The tea was also subjected to sensory analysis after brewing for 1, 2, and 5 minutes at 9-point hedonic scale. The tea with brewing time of 2 minutes received highest sensory scores in terms of colour (7.7), flavour (5.7), taste (4.7), and overall acceptability (6.1). In another study, the green and black teas were developed from *Moringa oleifera* leaves. For green tea development, the leaves were plucked, destalked, and steamed at 100 °C for 3 minutes. The leaves were then cooled and dried at 50 °C for 6 hours. Further, the green tea was subjected to nutritional analysis in terms of protein (22.36±0.00%), moisture (10.37±0.10%), fat (2.74±0.04%), crude fibre (18.64±0.44%), ash (9.45±0.21%), and carbohydrates (44.90±0.16%). The green tea was also analysed for flavonoid (%), saponin (%), steroid (%), and terpenoid (%) content with values recorded as 6.50±0.01, 2.25±0.00, 4.00±0.00, and 0.70±0.65. Further, when subjected for analysis of mould growth, the microbial analysis revealed absence of any mould growth in green tea developed from *Moringa oleifera* leaves (Okafor and Ogbobe, 2015).

g) Response surface methodology (RSM) based food product

A recent advancement observed in the field of food sciences is utilization of response surface methodology for optimization of process for development of functional food product development. A statistical and mathematical method called response surface methodology (RSM) models and examines the connection between a response and several variables. Depending upon the sweet spot of dependent variables a suitable process is optimized for development of the product. The best suited concentration of the product development is then utilized for development and further investigation of nutritional and sensory parameters. RSM based optimization for development of RTS beverage from dragon fruit was done in a research study by Jalgaonkar et al. (2018). Using box-behnken design (BBD) various juice concentration combinations of dragon fruit, grape fruit, and sugar syrup were designed. The obtained 17 sets of experimental run were analysed for identifying RTS with best/highest nutritional characteristics viz. TSS, pH, titrable acidity (%), ascorbic acid, colour, and other sensory parameters. As per the observations, the blend with 70% dragon fruit, 5% grape fruit, and 3% sugar syrup was the optimum blend with pH, TSS, acidity, ascorbic acid, and overall acceptability of 4.67±0.2, 11.90±0.98, 0.22±0.03, 8.37±1.84, and 8.50±0.74, respectively. Another research also focused on development of palmyra palm (*Borassus flabellifer*) based RTS beverage using RSM based design (CCRD: Central composite rotable design). Varying levels of palmyra fruit pulp and sugars were given in the form of experimental rum (13) by CCRD design application. The optimization responses were recorded in terms of pH, TSS, acidity, total sugars, reducing sugars, non-reducing sugars, and sensory attributes. According to the established objectives of 0.3% as the maximum TA, 10% as the minimum TSS, and 10% as the minimum palmyra pulp level, the ideal levels of pulp and sugar for making 100 mL of RTS beverage were 13.71 g and 18 g, respectively, with a desirability of 0.713 (Saranya and Vijayakumar, 2015).

Various products have been developed from fruit, seed, leaf, and other parts of plants. This indicates the potential application of nutritional research especially for perishable and underutilized foods to ensure food and health security.

Note: Authors are awarded scholar and assistant professor from Department of Nutrition Biology, Central University of Haryana, respectively.

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