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Flaxseed and chia seed as functional ingredients in omega-3 enriched Jellies: A critical review

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Abstract

This comprehensive review explores the health-promoting characteristics of omega-3 fatty acids and the nutritional benefits of integrating flaxseed and chia seeds into jelly formulations. Confectionery jelly is selected due to its favourable organoleptic properties, gel matrix structure, and consumer acceptability, which facilitate the stable incorporation and delivery of functional biologically active constituents including omega fatty acids. Both flaxseed and chia seeds serve as rich sources of alpha-linolenic acid (ALA), a plant-based omega-3 fatty acid recognized for its beneficial effects on cardiovascular health, inflammation modulation, and cognitive function. The review highlights how incorporating these seeds enhances jelly products with essential fatty acids, fibre, antioxidants, and proteins. Furthermore, omega-3 enriched jellies are highlighted as convenient functional foods that facilitate healthier dietary choices. The discussion further addresses the nutritional improvements achieved by integrating flaxseed and chia seeds in such formulations. Future research should focus on optimizing formulations to enhance omega-3 stability and bioavailability, maximizing nutritional benefits and supporting overall health.

Keywords: Alpha-linolenic acid, Omega-3 fatty acids, Chia seed, Flaxseed, Functional foods, Confectionery jelly

1. Introduction

Gummies and jellies are confections that include a hydrocolloid, which is often referred to as a stabilizer, which forms a networked structure that holds a high-moisture sugar syrup in place. This matrix imparts characteristic gel texture and a long-term stability to the product [94]. Most confectionery products including marshmallows, chocolates, hard-boiled candies, soft candies, nougats and turkish delights are mostly made up of sugar, water, artificial or natural flavoring and coloring [1]. These products fall into one of two categories: sugar-based candies like hard candies, jellies, and nougats as well as chocolate-based products like chocolate bars and candies covered in chocolate [2]. Jellies are generally defined as candies that contain various hydrocolloids [94]. Adults and children frequently consume confections. These products are consumed by eighty-six percent of Portuguese children aged six to eight on an average of three times a week [3]. Jellies are especially well-liked by those under the age of seventeen because they are chewy natural [3]. They are gel-like products made from fruits (at least 45 g per 100 g) and sugars (glucose or sucrose syrup at around 55 g per 100 g) and may also include fragrances, food colours, acids and gelling agents [4, 5].

However, excessive and widespread intake of jellies and gummies have a negative impact on consumers due to their presence of high sugar and food additives and undesirable compounds produced by heat treatment like hydroxymethyl-2-furaldehyde or acrylamide. In actuality, these products have been connected to high rates of obesity, dental decay, and hyperglycemia [6].

In light of this, functional foods have gained growing

attention in recent years, resulting in elevated interest in studies and technologies focused on their development. Moreover, there is a clear market trend favoring natural products, especially those offering specific health benefits for the human body [7].

Many food and beverage companies have made essential fatty acids (EFAs) a crucial part of their fortification strategies in an effort to increase the product's demand and health value. Increased consumer knowledge of EFAs and its health advantages, especially omega-3 fatty acids, has made numerous opportunities for their inclusion in functional foods [8].

Omega-3 fatty acids are abundant in seafood. However, frequent ingestion may expose the fetus to methylmercury, a neurotoxic chemical that poses major risks, particularly to the developing central nervous system. EPA levels are high in herring, wild sardines, and pollock roe [43, 104]. The primary sources of DHA include herring, pollock, salmon roe, flying fish [43]. Higher plants and algae are common sources of alpha-linolenic acid (ALA) [37]. Alpha-linolenic acid (ALA) is abundant in Chinese cucumber, paprika, flaxseed, and chia seeds. By contrast, fish typically have very low levels of ALA; for example, ALA makes up only 1.1 percent of the total fatty acids in the muscle of wild sardines [102].

In recent years, a broad range of omega-3-enriched consumable products has emerged on the market, including cereals, cereal bars, infant formulas, as well as meat, eggs, and dairy items [8].

Foods enhanced with omega-3 polyunsaturated fatty acids are known as functional foods because of their potential to improve human health. In addition to their function in preserving general health, omega-3 polyunsaturated FAs have been acknowledged for their therapeutic potential in the management of inflammatory conditions, such as cardiovascular and neurodegenerative diseases [9].

The adaptable plant flaxseed (*Linum usitatissimum*) is well-known for its culinary applications and significant health advantages. Alpha-linolenic acid (ALA), a necessary omega-3 polyunsaturated fatty acid (PUFA) for human nutrition, is abundant in flaxseed [10]. Chia seeds are also a great source of dietary fibre and alpha-linolenic acid (ALA). The polyunsaturated fatty acid (PUFA) content of chia oil is composed of 68 percent alpha-linolenic acid (ALA) and roughly 19 percent linoleic acid (LA), an omega-6 fatty acid. One of the plant-based foods thought to have the highest ALA content is chia seeds [11].

This review focuses on omega-enriched jellies, highlighting the benefits of flaxseeds and chia seeds. It explores the types of omega-3 fatty acids, its health benefits and the use in market. The article aims to provide insights for developing functional jelly products that effectively deliver health-promoting omega-3 fatty acids.

2. Omega-3 Fatty Acid

The presence of a double bond between the third and fourth carbon atoms from the methyl end (ω−1 carbon) of the molecule sets omega-3 fatty acids, also referred to as n-3 or ω−3 fatty acids (n-3 FAs), apart from other fatty acids. Monounsaturated fatty acids (MUFAs), which have a single double bond in their carbon chain, and polyunsaturated fatty acids (PUFAs), which have two or more double bonds, are the two main categories of fatty acids. Conjugated fatty acids (CFAs) are a particular class of polyunsaturated fatty acids that are distinguished by the presence of at least one pair of conjugated double bonds [12].

The importance of omega-3 fatty acids as dietary nutrients for promoting health and preventing a number of diseases is becoming more widely recognized [13, 14]. Because the human body is unable to produce omega-3 and omega-6 fatty acids they are considered as necessary and must be acquired through diet or supplements [15].

According to the current dietary guidelines, children between the ages of 4 and 8 should consume 10 grams of omega-6 fatty acid (linolenic acid) and 0.9 grams of alpha-linolenic acid (omega-3), as well as an additional 0.1 to 0.2 grams of docosahexaenoic acid (omega-3) and eicosapentaenoic acid (omega-3). As a result, the omega-6 to omega-3 ratio falls between 9.1 and 10.1 [16].

2.1 Omega-3 fatty acid-types

Omega-3 fatty acids are distinguished from other fatty acids by the double bond that exists between the third and fourth carbon atoms from the methyl end (the first carbon atom). They are usually separated into monounsaturated and polyunsaturated fatty acids according to the number of double bonds they contain [102]. Alpha-linolenic acid (ALA), docosahexaenoic acid (DHA), and eicosapentaenoic acid (EPA) are three vital omega-3 fatty acid shown in fig 1. The primary sources of EPA and DHA are seaweeds and unicellular phytoplankton. These fatty acids are produced from ALA through a sequence of elongation and desaturation processes. By lowering cyclooxygenase activity, EPA and DHA both aid in the inhibition of malignant growths. Additionally, marine-derived EPA and DHA offer protective benefits by significantly minimises the death rate from coronary heart disease [24].

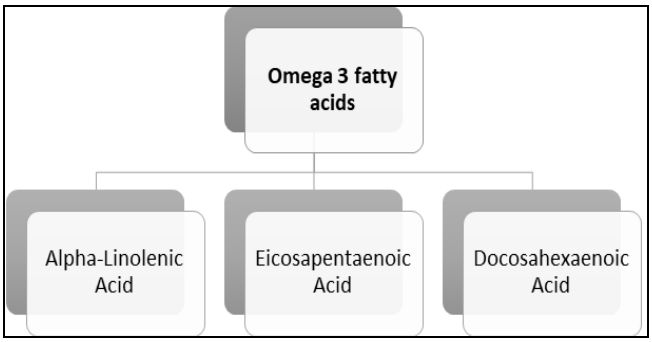

Fig 1: Types of Omega-3 Fatty Acid

2.1.1 Alpha-Linolenic Acid (ALA)

Because the human body is unable to produce alpha-linolenic acid (ALA; 18:3n-3), a polyunsaturated omega-3 fatty acid, it is classified as an essential fatty acid (EFA). Therefore, it is necessary to obtain sufficient ALA intake from exogenous dietary sources [17]. The main plant-based sources of alpha-linolenic acid (ALA) are flaxseed, green leafy vegetables, walnuts, and rapeseed (canola) [18]. To meet the essential fatty acid requirements, the European Commission advises that infant formulas include alpha-linolenic acid (ALA) at a minimum level of 50–100 mg per 100 kcal [17].

The National Institute of Health (NIH) suggests a sufficient

intake of ALA for adult males-1.6 grams and for adult females it is 1.1 grams.

2.1.2 Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA)

Eicosapentaenoic acid (EPA) is a polyunsaturated fatty acid (PUFA) present in aquatic organisms, including fish and phytoplankton [20]. Along with α-linolenic acid and docosapentaenoic acid, two vital omega-3 fatty acids are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [21].

For DHA and EPA, the World Health Organization (WHO) suggests consuming 250mg to 2g per day.

2.1.3 Market Products Fortified with Omega-3

Several omega-3 products are produced in the market that gained the attention of the consumers because of its numerous benefits as shown in table 1.

Table 1: Omega-3 Enriched Market Products

Products	Omega Enrichment
Bread and Bakery	For each 100 grams of omega-3 bread, there are 100 milligrams of microencapsulated omega-3 fish oil [22].
Diary Products	Products high in omega-3 have entered the global market, such as cheese (which contains 130 mg of EPA and DHA per 100 grams), mayonnaise, sweetened nutrition bars, and cream cheese [23].
Beverages and Juices	One 120-ml bottle of Big Shotz, an effective vitamin drink sold in the UK, provides more than 70 percent of the new daily allowance for omega-3 fatty acids recommended by the European Union [22].
Infant Food and Juices	The growing popularity of DHA-fortified baby formula has led to the development of DHA-enhanced foods and beverages for kids of all ages. Products like Gerber DHA and Probiotic Cereal (available in oatmeal and rice varieties) and 2nd Foods Smart Nourish Purees (available in a variety fruit flavors) are fortified with tuna oil [25].
Omega-3 Eggs	Poultry products can include omega-3 fatty acids by feeding layer birds diets rich in these fats. Generally speaking, a "Omega Egg" is a large egg (60 g) that contains at least 350 mg of omega-3 fatty acids [26].
Infant Formula	The amount of dried milk produced for infant formula has increased dramatically. India currently produces about 185,000 metric tons of infant formula, which accounts for 3.8 percent of the country's total milk production [27].

2.1.4 Omega-3 Products in Global Market

Omega-3 food products have major market share across world has shown in table 2.

Table 2: Global Market Share by Category for EPA/DHA Omega-3 Products, 2016 [25].

Omega-3 EPA/DHA Products	Global Market Share (%)
Food and Beverage	29.50
Pet Food Supplements	3.00
Nutritional Supplement	13.20
Instant Formula	40.70
Clinical Nutrition	5.30
Pharmaceuticals	7.50

2.1.5 Health benefits of omega-3 fatty acid

Omega-3 fatty acid has been escalated in recent years because of their capability in reducing the health disease that have shown in table 3 and 4.

Table 3: Effect of omega-3 fatty acid in tissues [29].

Tissue	Effect
Liver	Reduce the production of triacylglycerol
	Slight increase in gluconeogenesis
Artery	Reduces the blood pressure
	Reduce the systemic vascular resistance
	Boost the vasodilatory response
	Boost the compliance of the arterial wall
	Reduce the dysfunction of endothelium
Heart	Reduce arrhythmia
	Reduce the heart rate
	Boost the effectiveness of the heart
	Enhance the diastolic filling of the left ventricle
	Raise vagal tone and autonomic function
Blood	Minimize thrombosis
	Reduce the synthesis of eicosanoids derived from arachidonic acid
	Boost the synthesis of metabolites derived from omega-3

Table 4: Health Benefits of Omega-3 Fatty Acid

Diseases	Effect
Atherosclerosis	Omega-3 fatty acids (ω-3 FAs) may help prevent atherosclerosis, an inflammatory disease, because of their ability to reduce inflammation [30].
Hypertension	Omega-3 fatty acids (ω-3 FAs) have been demonstrated to lower blood pressure at both the diastolic and systolic levels. Regular consumption of ω-3 FA is associated with a decreased risk of hypertension [31].
Diabetes mellitus	The Diabetes Autoimmunity Study in the Young (DAISY) found that omega-3 fatty acids (ω-3 FAs) significantly decreased the incidence of pancreatic islet-cell autoimmune diseases in children at elevated risk for type 1 diabetes [32].
Obesity	If omega-3 FAs were included in a weight-loss diet, obese patient's fasting plasma concentrations of insulin, glucose, and triglycerides decreased more [33].
Metabolic syndrome	It has been demonstrated that dietary supplements containing omega-3 fatty acids (ω-3 FAs) improve every facet of metabolic syndrome. Additionally, studies have shown that people receiving ω-3 FA treatment have improved endothelial function. As a result, ω-3 FAs might be suggested as a crucial element in the treatment of individuals with metabolic syndrome [34].
Rheumatological conditions	Omega-3 fatty acids (ω-3 FAs) have demonstrated potential in the management of pain related to various inflammatory joint conditions. For patients with rheumatoid arthritis, fish oil supplements can be used in place of NSAIDs, also known as non-steroidal anti-inflammatory drugs [35].
Eye diseases	A meta-analysis of data pooled from nine studies found that a high dietary intake of omega-3 fatty acids (ω-3 FAs) was linked to a 38 percent lower risk of developing late-stage age-related macular degeneration (AMD). A lower risk of age-related macular degeneration (AMD), both in its early and late stages, has been linked to eating fish at least twice a week [36].

3. Sources of plant-based omega-3 fatty acid-Flaxseed, Chia seed

3.1 Flaxseed

A blue-flowered yearly herb belonging to the Linaceae family, flaxseed (*Linum usitatissimum*) produces tiny, flat seeds that range in hue from reddish brown to golden yellow. Flaxseeds have a nutty flavor and a crunchy texture [37]. Whole flaxseeds have pointed ends and an oval, flat shape. They are made up of an embryo axis, two cotyledons (embryos), a thin endosperm, and a seed coat or true hull (called the testa) [38]. Alpha-linolenic acid (ALA, 18:3n-3) and lignans are two of the oilseeds that make flaxseed unique. It has an oil content of 35–45 percent, of which 45–52 percent is made up of ALA [37].

Flaxseed originated from Mesopotamia and cultivated since 5000 BC, flaxseed was mainly used for cloth and paper production until the 1990s. Today, it is grown on over 2.6 million hectares, with primary producers including China, the United States, Ethiopia and India. Nearly 80 percent of the world's flaxseed trade is supplied by Canada, the largest producer with 614,000 metric tons in 2013–2014 [40].

3.1.1 The nutritional profile of flaxseed

Flaxseed has gained recognition as a valuable choice among functional foods due to its high content of lignans, alpha-linolenic acid, superior protein, soluble fiber, and phenolic compounds [41]. As it contains three important bioactive components-dietary fiber, lignans, and alpha-linolenic acid, flaxseed is considered a functional food.

3.1.1.1 Alpha-linolenic acid

Alpha-linolenic acid, the primary active component of flaxseed, offers vegetarians a unique source of omega-3 fatty acids [41]. A low n6:n3 fatty acid ratio, when paired with fish or flaxseed oil, improves plasma lipids and favourably alters the composition of tissue fatty acids in mice fed with high-fat diet [43].

The ALA in flaxseed helps blood lipids. In healthy men between the ages of 20 and 34, ALA was found to be equally effective as oleic and linoleic acids in lowering plasma total cholesterol, low-density lipoprotein (LDL) cholesterol, and very low-density lipoprotein (VLDL) cholesterol [44]. Since flaxseed is an essential fatty acid, consuming products made from it can help to meet ALA requirements [45].

3.1.1.2 Lignans

The most prevalent source of plant lignans is flaxseed [46]. Flaxseed contains 75–800 times higher lignans than legumes, cereal grains, fruits and vegetables [47, 48]. The antioxidant qualities of lignans may contribute to the anticancer properties of flaxseed [49]. Mammalian lignans aid in the synthesis of sex hormone-binding globulin, which binds reproductive hormones and lowers their blood levels and biological processes, thereby lowering the risk of cancer [50].

3.1.1.3 Dietary Fibre (Mucilage or Gum)

Crude fibre, acid detergent fibre, neutral detergent fibre, and total fibre-which consists of cellulose, lignin, and hemicellulose-are all abundant in flaxseed meal. It has between 22 percent and 26 percent fibre, which is about twice as much as high-fibre beans. 20 percent to 25 percent of the daily required fibre intake can be obtained from just half an ounce of whole dry flaxseed. The ratios of soluble to insoluble dietary fibres in flaxseed range from 20:80 to 40:60. Mucilage gums make up the majority of the soluble fibres, whereas cellulose and lignin are the main insoluble fibres [51, 52]. Flaxseed-derived dietary fibres have been shown to improve health, particularly in relation to weight control, by reducing nutrient absorption and appetite suppression [53]. A key component in reducing blood glucose levels is flaxseed fibre. According to research, insoluble fibre helps significantly lower blood glucose levels by delaying the release of sugar into the bloodstream [54].

3.1.1.4 Protein

According to reports, flaxseed's protein content can range from 10.5% to 31% [55]. It has been demonstrated that flaxseed protein lowers plasma cholesterol and triglyceride (TAG) levels more effectively than soy and casein proteins [56]. The nutritional profile of flaxseed shown in table 5.

Table 5: Nutrient Composition of Flaxseed [37].

Nutrients	Amount per 100 g of edible flaxseed
Protein (g)	20.30
Fat (g)	37.10
Total dietary fibre (g)	24.50
Carbohydrates (g)	28.90
Thiamine (B1) (mg)	0.23
Riboflavin (B2) (mg)	0.07
Niacin (mg)	1.00
Biotin (µg)	0.60
Folic acid (µg)	112.00

3.1.2 Health Benefits of Flaxseed

3.1.2.1 Antioxidant properties

It has been researched that flaxseed's antioxidant qualities can help reduce platelet aggregation and total cholesterol levels [58]. It has been demonstrated that the mammalian lignans enterodiol (ED) and enterolactone (EL), as well as the flaxseed lignan secoisolariciresinol diglucoside (SDG), are strong antioxidants that efficiently guard against lipid peroxidation and DNA damage. Both type 1 and type 2 diabetes have been shown to be prevented or their onset postponed by flaxseed [59]. It is thought that SDG's antioxidant qualities cause its hypoglycaemic effect in type 2 diabetes. Phosphoenolpyruvate carboxykinase, a crucial rate-limiting enzyme in the gluconeogenesis pathway, may also be suppressed [99].

3.1.2.2 Infant allergies and respiratory diseases

The impact of PUFA intake throughout pregnancy and initial stages of childhood on the development of allergies and respiratory conditions was examined. It is well known that long-chain polyunsaturated fatty acids (LCPUFAs) have immunomodulatory properties. The study suggests that consuming more omega-3 PUFAs, which contain anti-inflammatory qualities like that is found in flaxseed (ALA), and fewer omega-6 PUFAs may help prevent respiratory and allergic diseases. Omega-3 PUFAs alter the balance of T-helper cells and modify immune responses in a variety of ways by preventing the production of cytokines, which reduce immunoglobulin E synthesis and Th2 cell differentiation.

Furthermore, PUFAs impact immune function by altering cell membranes, controlling eicosanoid metabolism, and influencing genes expression [60, 107].

3.1.2.3 Anti-diabetic functions

Incorporating lignans regularly improved the control of blood sugar in individuals with type 2 diabetes in a modest but statistically significant way, but it had little to no effect on fasting glucose, lipid levels, or insulin sensitivity [61]. In healthy individuals, flaxseed fiber consumption reduced peak blood glucose levels [62]. Daily lignan supplementation led to modest but improvements in glycemic control that are statistically significant among patients with type 2 diabetes without substantially altering insulin sensitivity, lipid profiles, or fasting glucose levels [97]. Peak blood glucose levels improved in healthy individuals who ingested flaxseed fiber [98].

3.1.2.4 Flaxseed in bone health

Flaxseed has alpha-linolenic acid, an omega-3 fatty acid that maintains the bone health by lowering excessive turnover of bone. Consuming foods high in omega-3 fatty acids increases this effect and lowers the dietary ratio of omega-6 to omega-3 fatty acids [63]. In one study, women who had at least 14 hot flashes a week for a month and were not on estrogen therapy took two tablespoons of flaxseed that is crushed twice a day for six weeks. Their daily hot flashes were consequently half as frequent and 57 percent less intense. Eight women reported mild diarrhea, and fourteen reported abdominal bloating [95].

3.1.2.5 Cancer

In animal models, flaxseed has been shown to lower the incidence of colon and breast cancer as well as early risk indicators [100]. Flower et al. (2013) conducted a systematic review that assessed the potential effect of flaxseed components, including lignans, alpha-linolenic acid (ALA), and fiber, on breast cancer risk and recurrence as well as their efficacy in reducing menopausal symptoms in breast cancer patients. The authors came to the conclusion that flaxseed might be related with a lower risk of breast cancer based on their analysis of the studies. Furthermore, flax showed anti-proliferative effects in the breast tissue of women who were at risk, and it might also help reduce the risk of death for those who have breast cancer [96]. Numerous health advantages of lignans are getting increasingly evident. Dietary fiber and phytoestrogens are known to have potential cancer-preventive qualities. According to studies, eating flaxseed considerably increases premenopausal women's lignan excretion in their urine without changing their serum hormone levels. This implies that mechanisms other than hormonal activity might mediate flaxseed's chemoprotective effects [101].

3.1.3 Flaxseed gum

Flaxseed gum is also known as mucilage which is present on the outmost layer of the seed [64]. As this gum is considered as a hydrocolloid it is used for various applications such as thickening and emulsifying [65]. Conlinin is the main protein present in FG [66]. A hydrocolloid with a high viscosity when dissolved in water and a strong swelling capacity, flaxseed gum is renowned for its exceptional water-holding capacity [67].

3.1.4 Market Applications of Flaxseed Gum

The market applications of flaxseed gum are [68].

- Gelling agent
- Edible coating
- Fat replacer
- Stabilizing agent
- Structure foaming

3.2 Chia seed

Chia seeds belong to the Lamiaceae (Mint) family and are derived from *Salvia hispanica* L. Native to Mexico and northern Guatemala, chia is a yearly herb that flourishes in the summer (69, 70). Chia seeds are usually oval, flat, and small, with dimensions of 0.8–1.0 mm for thickness, 1.2–1.5 mm for width, and 2.0–2.5 mm for length. Both black and white seeds are produced by the daylight-sensitive chia plant, though black seeds are more prevalent. The appearance of the two seed varieties varies slightly; white

seeds are typically bigger, thicker, and wider than black ones. Black seeds have an average moisture content of 7.2 percent, while white seeds have an average moisture content of 6.6 percent. White and black seeds yield roughly 33.8 percent and 32.7 percent oil, respectively, and their protein and fatty acid profiles differ significantly from one another [71].

3.2.1 Chia seed mucilage

Chia seed gum has the potential to be used in industry because of its viscous qualities, which are apparent even at low concentrations, and because the American native plant grows well in semiarid areas where few other crops can. The instant the seeds come into contact with water chia gum begins to form. It appears to be in either the surrounding layer or the seed coat. The gum is difficult to separate from the seed because it is either partially crosslinked or adhered to the seed surface [72].

The extracted gum is suitable for a broad variety of industrial uses, especially in different food products and preparations, because it has a slimy, mucilaginous texture even at very low concentrations. Chia gum consists of α-D-glucopyranosyl, β-D-xylopyranosyl and 4-O-methyl-α-D-glucopyranosyluronic acid units in a 2:1:1 ratio [72].

3.2.2 Nutritional Composition

3.2.2.1 Total Fats: The average percentage of total lipids in *Salvia hispanica* is 30.74 percent [73]. On average, chia seeds have 40 percent oil by weight, with omega-3 unsaturated fatty acids making up almost 60 percent of that oil [74]. High blood pressure, high blood sugar levels, and high lipid levels can all be prevented and managed with the help of omega-3 unsaturated fatty acids [75, 76, 77]. Omega-3 fatty acids are more abundant in chia seeds (63.8 percent) than flaxseeds (57.5 percent) [78].

3.2.2.2 Antioxidants

Chia seeds are rich in phenolic ingredients, which have been shown in studies to possess antioxidant properties. These phenolic compounds and antioxidants are known to support health and offer defense against degenerative diseases like diverticulosis, diabetes, cancer, and cardiovascular disease [79].

3.2.2.3 Micronutrients

Additionally, chia is a great source of many vitamins and minerals, particularly zinc, calcium, phosphorus, magnesium, and niacin. Its levels of riboflavin and thiamin are identical to those of rice and corn, but its niacin content is higher than that of other cereals like rice soybeans and corn. Additionally, compared to 100 grams of milk, chia has four times the potassium, eleven times the phosphorus, and six times the calcium [80]. The nutritional profile of chia seed is shown in table 6.

Table 6: Nutritional Composition of Chia seeds [81].

Nutrients	Amount per 100 g of chia seed
Protein (g)	16.54
Fat (g)	30.74
Energy (kcal)	486.00
Carbohydrates (g)	42.12
Thiamine (B1) (mg)	0.62
Riboflavin (B2) (mg)	0.17
Niacin (mg)	8.83
Calcium (mg)	631.00
Magnesium (mg)	335.00
Potassium (mg)	407.00
Zinc (mg)	4.58

3.2.3 Effect of Chia on Human health

Chia seeds have anticoagulant and anti-inflammatory qualities that help people with type II diabetes by lowering their risk of heart attacks and strokes [82].

It has been shown that chia seeds have health benefits, such as lowering systolic blood pressure and postprandial blood glucose levels shown in table 7. [83, 84].

Table 7: Nutritious bioactive substances of Chia seeds

Phytochemical	Health benefit
Linolenic acid	It has anti-inflammatory qualities and promotes muscle growth rather than fat storage. It also forbids cancer.
Linolenic acid	Gaining weight, preventing strokes, mental health, cancer, and visual acuity prevention of cancer, Lower the chance of developing coronary heart disease.
Gallic acid	Antioxidative and cytotoxic properties, antileukemic, anti-cancer, anti-tumor, anti-inflammatory, and antidiabetic.
Myricetin	Possesses anti-gonadotropic and antibacterial properties.
Caffeic acid	Hypoglycemic action and memory preservation antioxidant activity, antihypertensive, neuron-protective, and anti-carcinogenic properties.
Dietary-fibre	Prevent the conditions affecting the digestive and circulatory systems, kidney stones, diabetes, colorectal cancer, hemorrhoids, and metabolic disorders.
Glutamic acid	Healthy brain function.

3.2.4 Chia and flaxseed's omega-3 fatty acid contents compared to other seeds and grains

Chia seeds and flaxseeds are rich in omega-3 fatty acid compared to other seeds and grains s shown in table 8.

Table 8: Omega Fatty Acid Content of Flaxseeds and Chia Seed to Other Seeds and Grains [85].

Seeds and Grains	Omega-3 Fatty Acid Content
Flaxseed	5.90
Chia seed	5.83
Quinoa	2.97
Guar gum Seeds	0.06
Oats	2.42
Mustard Seeds	5.92

4. Possible synthesis pathway of EPA and DHA from α-linolenic acid

The main sources of EPA and DHA are seaweeds and unicellular phytoplankton. Alpha-linolenic acid (ALA), a short-chain omega-3 fatty acid, is common in flaxseed and chia seeds. But the long-chain omega-3 fatty acids docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are not naturally present in them. ALA is enzymatically bioconverted in the human body through a process of elongation and desaturation reactions after ingestion, leading to the endogenous production of DHA and EPA shown in fig 2.

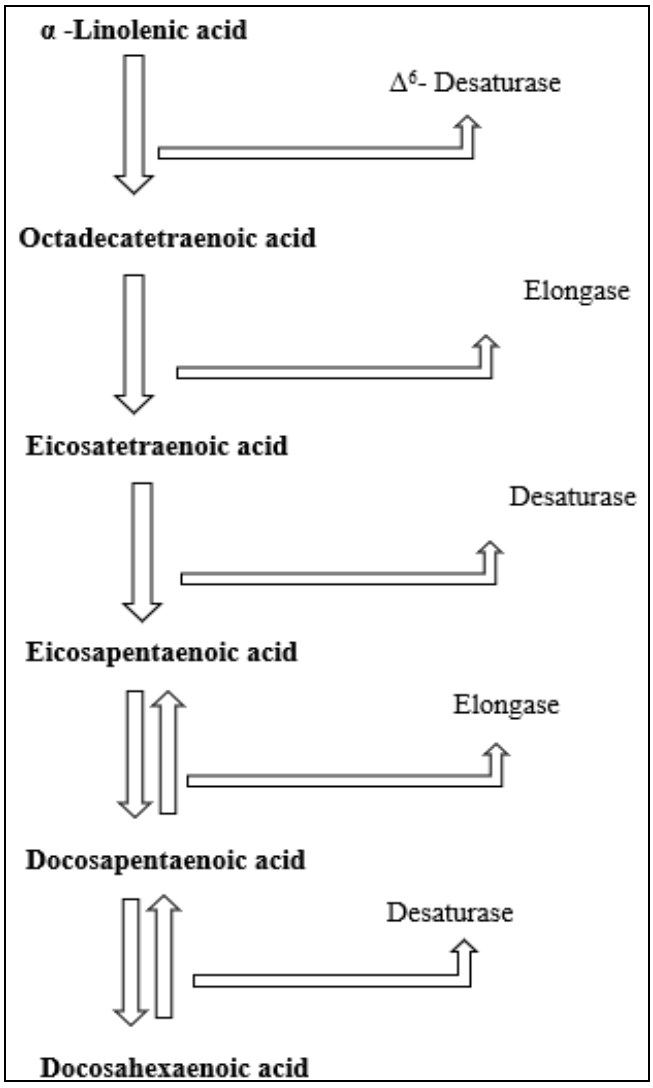

Fig 2: Possible synthesis pathway of EPA and DHA from α-linolenic acid [86].

5. Omega-3 enriched jelly

Omega-3 polyunsaturated fatty acid (ω-3 PUFA)-enriched foods are regarded as functional foods because of their capacity to support human health. It is well known that omega-3 polyunsaturated fatty acids (PUFAs) have therapeutic potential, promoting general health and being important in the treatment of inflammatory conditions, such as cardiovascular and neurodegenerative diseases [87]. Manufacturers are looking more closely at ways to include omega-3 fatty acids in their products as consumer demand for healthier food options increases [88].

5.1 Properties of jelly

Fruit juice that has been clarified or strained is used to make jellies [89]. For jelly, an acidity level of about 3.2 is ideal. Lower pH causes a gradual decrease in gel strength, while higher pH causes a rapid drop. At pH values above 3.4, jelly formation still takes place within the normal range of soluble solids [90]. The process of making jelly involved extracting the pectin from the fruit with 1.5 times as much water, then adding sucrose and letting the water evaporate to increase the mixture's total soluble solids. Because bruised or overripe fruits have less pectin and acid, they are not suitable for making jelly, so fresh and slightly underripe fruits were used [91]. The refractive index and Brix value of the jelly samples were measured using a refractometer. Brix is a measure of the product's sugar content [92].

5.2 Market Drivers for Omega-3-Fortified Products

5.2.1 Improved Awareness of Consumers

Customers are growing more aware of the advantages of omega-3 fatty acids and more health-conscious. The demand for foods enriched with omega-3 is being driven by this increased awareness.

5.2.2 Omega-3 Dietary Inadequate Intake

The majority of people fail to consume enough omega-3 fatty acids each day. The necessity of dietary sources and fortified foods is highlighted by this deficiency.

5.2.3 Omega-3s' Proven Value in Combating Serious Illnesses

Scientific research has connected omega-3 fatty acids to the prevention and treatment of diabetes, heart disease, and inflammation. Their inclusion in functional foods is supported by their therapeutic potential.

5.2.4 The Fortification Trend Helps Increase Acceptance of Omega-3-Fortified Foods

Omega-3 food fortification satisfies consumer demand for easy-to-access health solutions. It improves the market appeal and nutritional profile of common foods [93].

6. Conclusion

In summary, adding flaxseed and chia seeds to omega-3 enriched jellies is a viable way to improve the nutritional value of functional foods. These seeds offer substantial levels of proteins, dietary fiber, antioxidants, and alpha-linolenic acid (ALA), which helps prevent and treat chronic illnesses like inflammation and cardiovascular disease. A tasty and easy way to deliver vital nutrients, omega-3 enriched jellies promote better eating practices. To optimize the health benefits of these products, future developments in formulation techniques targeted at enhancing omega-3 stability and bioavailability will be essential. Omega-3 enriched jellies will be further established as beneficial elements of a balanced diet and public health nutrition strategies with further research and development in this field.

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8. Ethical Acceptance

The authors did not undertake any new research involving human or animal subjects; instead, this review is based on previously published studies. Therefore, the current investigation did not require ethical approval.

9. Conflicts of Interest

No conflicts of interest are disclosed by any of the writers.

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