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AN OVERVIEW ON RECENT TECHNOLOGICAL ASPECTS AND HEALTH CONCERNS OF PLANT BASED MILK ALTERNATIVES

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ABSTRACT

Plant Based Milk Alternatives are the perfect solution for individuals opting for non dairyproducts and gaining immense popularity in last two decades. Plant-Based Milk Alternative is one of the rapidly growing segments in the functional and specialty beverage category across the globe. An Increasing number of health-conscious consumers choose Plant-Based Milk Alternatives (PBMA) due to various medical and ethical reason. The major advantages of consuming Plant based milk alternatives are the presence of micronutrients, heart healthy unsaturated fatty acids, bioactive compounds, phytochemicals and antioxidant properties. Irrespective of its appreciable nutritional profile, the major disadvantages of consuming Plant based Milk Alternatives are poor protein and high carbohydrate content, off flavor, presence of anti nutrients which has to addressed to improve the nutritional and sensory profile of the PBMA. Considering the nutritional advantages of novel and innovative plant based milk alternatives, this current research work aims to provide conclusive overview on the existing data pertaining to the types, processing techniques, merits and demerits and novel food product formulation of Plant based Milk alternatives

KEYWORD: *Plant based Milk Alternatives, Lactose intolerance, Extraction process and Blending*

INTRODUCTION

"Plant-Based Milk Alternative is one of the rapidly growing segments in the functional and specialty beverage category across the globe" (Sethi, Tyagi & Anurag, 2016). An increasing number of health-conscious consumers choose Plant-Based Milk Alternatives (PBMA) due to lactose

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intolerance, cow's milk protein allergy, hypercholesteremia, and interest towards vegan lifestyle (Mäkinen, Wanhalinna, Zannini, & Arendt, 2016).

ORIGIN AND HISTORY OF PLANT BASED MILK ALTERNATIVE

There is no standard definition of Non-Dairy Milk Alternatives. It can be defined as "fluids that result from the breakdown (size reduction) of plant material (cereals, pseudo-cereals, legumes oilseeds, nuts) and extracted in water which imitates cow's milk in appearance and consistency" (Sethi, Tyagi & Anurag, 2016) The most extensively consumed non-dairy milk substitute around the globe is soy milk. Soymilk is a white, aqueous, creamy extract with similar cow's milk appearance. Soy milk is still the most successful and dominating dairy analogue available in the market. The first dairy analogue (soy milk) was launched successfully in Hong Kong in the early nineties. Soy and soy products are traditionally consumed in China and other Asian countries. Soy milk entered the mainstream market of Asian countries during the seventies and early eighties after the development of large-scale manufacturing technologies (Chen, 1989). Soymilk was introduced in India during the mid-seventies as cow's milk alternatives (Reddy & Mital, 1992). The Worldwide sales of dairy analogues reached $21 billion and doubled between 2009 to 2015.

TYPES OF PLANT BASED MILK ALTERNATIVES

In general, PBMA are classified based on the food group of the raw ingredients utilized for the extraction process. The types of Non-Dairy Milk Alternatives are elaborated and exhibited in Figure 1.

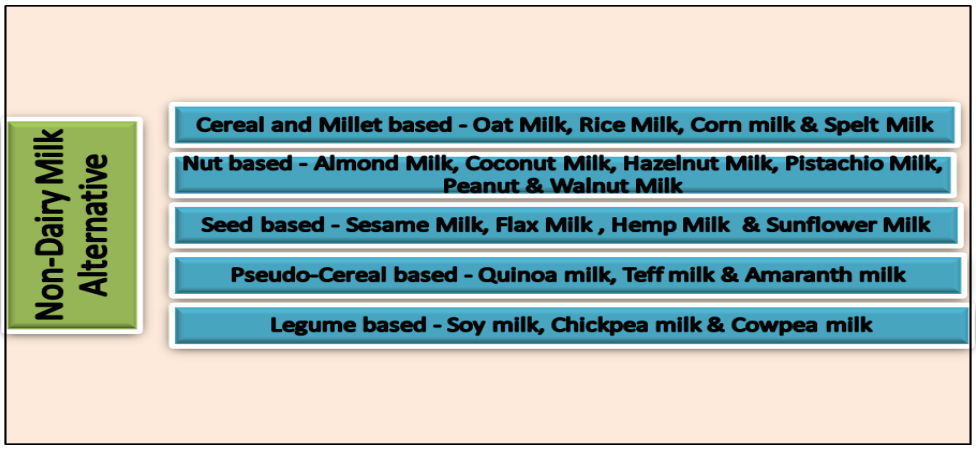

Fig 1: Types of Non-Dairy Milk alternatives

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NEED FOR PLANT BASED MILK ALTERNATIVES

Milk is an ancient food item enjoyed by people around the globe due to its nutritional benefits. "Nowadays consumption of cow's milk has raised concerns among the health-conscious and risk prone population as clinical researchers have demonstrated that some constituents of milk are associated with deleterious health effects such as cow milk allergy (CMA), lactose intolerance (LI) and coronary heart diseases" (Kundu, Dhankhar & Sharma, 2018). High quantities of casein and lactose content in milk make it allergenic and intolerable by some individuals (Granato, Branco, Nazzaro, Cruz & Faria, 2010).

About 75% of the world's adult population is lactose-intolerant (Silanikove, Leitner, & Merin, 2015). Tandon *et al*., (1981) conducted a multicentre study on analyzing lactose intolerance among north and south Indians. The study showed an incidence of 66.6 percent and 27.4 percent of the population from the southern and northern parts of India are lactose intolerant. The effective treatment for lactose intolerance is to completely replace dairy products with lactose-free non-dairy products. The cow's milk allergy (CMA) and cow's milk intolerance (CMI) are two different terms that are often mistakenly interchanged. CMA is a complex disorder with an immunologically mediated reaction to cow's milk protein whereas, CMI's are due to lactase deficiency (Crittenden& Bennett, 2005).

In recent years, consumers have shown great interest in the vegan lifestyle. Previous research work has proved the low incidence of many diseases and syndromes such as hypertension, heart disease, Type 2 diabetes, obesity, and certain types of cancers in the vegan population when compared with non-vegetarian consumers (Criag, 2009). Extensive research has documented the protective effects of plant-based eating against non communicable diseases in developed countries such as the United States (Fraser, 2009 and Orlich *et al.*, 2013).

The other problems related with bovine's milk consumption are presence of cholesterol, growth hormone, and antibiotic residue in cow's milk have pushed the people and the food industry to look for suitable alternatives (Valencia-Flores, Dora, Hernández-Herrero, Guamis, & Ferragut, 2013). Also, when the supply of the dairy product is insufficient and non-affordable by the people belonging to low socioeconomic status, these low-cost dairy analogues can be treated as an affordable choice (Yadav, Bansal, Jaiswal & Singh, 2016). The above-mentioned major factors have forced a specific population to opt for non-dairy milk alternatives thereby increasing the need and demand of the product in the market.

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OVERVIEW OF PLANT BASED MILK SUBSTITUTE EXTRACTION PROCESS

There are various methods to formulate Plant-Based Extract and the processing technique which has to be followed depends on the nature of the raw ingredients. "They are formulated by grinding the raw ingredients into slurry and then straining it to remove the coarse particles" (Sethi, Tyagi &Anuragh, 2016). All the raw material generally follows the same pattern of extraction process like soaking, grinding, filtering, pasteurization and addition of other ingredients to enhance the taste, colour, physical stability and shelf life of the final product (Yadav, Bansal, Jaiswal & Singh, 2016 and Aydar, Tutuncua&Ozcelika, 2020). The most commonly used ingredients are sweetener, flavouring agents, stabilizers, coloring agents, and preservatives. The raw ingredients undergo various sets of pre-processing treatments like dehulling, soaking, blanching, germination, and roasting. Each pre-treatment has a different effect on the final product (Sethi, Tyagi, and Anurag, 2016).

Processing of Raw Ingredients

Soaking leads to the softening of the grains which alter the structural properties and improves the extraction process leading to better yield and total solid content. Soaking also reduces the anti-nutrient factors that are present in the raw ingredients. Legume and nuts like soybean, almonds, and peanut are usually blanched to inactivate heat-sensitive trypsin inhibitors and lipoxygenase to minimize the off-flavours. On the other hand, the roasting of the raw material like nuts and oilseed was carried out to improve the flavour profile of the formulated plant-based milk. Shakeel, Saeed, Khuram, Aslam, & Naheed, (2015) studied about extraction process of soy milk from different variations of soybeans and concluded that preparation of traditional soy milk, soybean has to be soaked minimum for 7-8 hours before extraction process. Germination is an inexpensive and simple processing technique that can effectively enhance the bioavailability of the nutrients by lowering the antinutrient factors. The effect of short-time germination of soya beans on bioactive compounds of soy milk was observed by Jiang, Cai & Xu, (2013) and concluded that soymilk made from 28-hour germinated soybeans showed high protein content and the lower amount of carbohydrate and antinutrients.

Wet Milling and Extraction

The wet milling process is applied to all the soaked raw ingredients. The water is added to facilitate the grinding and extraction process in desired quantity. The proportion of water added plays a significant role and affects the nutritive value of the final product. Many researchers in the past

reported different wet milling conditions for different raw ingredients. Ahmadian-kouchaksaraei, Varidi, Varidi, and Pourazarang, (2014) extracted sesame milk utilizing wet milling for 20 minutes (5 water:1 sesame seed ratio). On the other hand, peanut milk was extracted with 9 water: 1 peanut ratio (Zaaboul, Raza, Cao & Yuanfa 2019).

Filtration & Pasteurization

The filtration process is applied to separate the slurry and extract of the ground raw material. "The different materials used for filtration are cheesecloth, muslin cloth, and filter paper" (Aydar, Tutuncua&Ozcelika, 2020). Filtration is generally followed by pasteurization or heat treatment. Thermal treatment is employed to prolong the shelf life of the product by reducing the micro-organisms. Nevertheless, excessive heating may result in cooked flavour and reduction in heat-sensitive vitamins, minerals, amino acid and gelatinization of starch molecules (Sethi, Tyagi &Anuragh, 2016). To overcome these advantages, other innovative processing techniques like UHT (Ultra High Temperature) and other non-thermal sterilization methods (pulse electric field processing, UHPH (Ultra High-pressure processing) and microfiltration) are being explored by the researchers to improve the shelf life of the dairy analogues (Hasan, 2012 and Valencia-Flores, 2013).

Homogenization and Cold Storage

The dietary fibre, protein and carbohydrate molecules present in the extracts have the ability to sediment which affects the stability of the product (Makinen, Wanhalinna, Zannini &Arendt, 2015). "The stability of the non-dairy milk alternatives greatly depends on three factors namely, size of the particle, the formation of an emulsion and solubility of the protein" (Sethi, Tyagi, &Anuragh (2016). Lack of creaminess and fat content also results in a product with poor stability (Civille & Szczesniak, 1973). Homogenization and addition of stabilizer and emulsifier can improve the physical stability of the extract. High pressure homogenization (150 and 300mPs) was applied to obtain peanut milk with improved physical stability by Zaaboul, Raza, Cao & Yuanfa (2019).

Technological Intervention to Improve the Dairy Analogues Quality

Different technological intervention had been adopted by researchers over the last four decades to overcome the problems associated with Plant Based Dairy Alternative (Physical instability, Unpleasant flavor, Presence of anti-nutrients and Poor shelf life). The various technological interventions followed by the researcher in the past to improve the quality of the products are Vacuum treatment at high temperature, blanching of raw ingredients, alkaline soaking, enzymatic hydrolysis of starch, decortication to remove antinutrients, addition of emulsifying agents, Inactivation of enzymes

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by pressure processing, pulse electric field, ohmic heating, solid-phase microextraction have been used to eliminate the off flavor of the final products (Paul, Kumar, Kumar & Sharma, 2019).

MERITS & DEMERITS OF NON- DAIRY MILK ALTERNATIVE

Merits

Legume based milk generally contain high protein (4%) when compared to cereal and nut-based milk. Unlike conventional dairy products, nuts and oil seed-based dairy analogues are low in saturated fats and predominantly contain beneficial unsaturated fatty acids. These imitation milks are lactose and cholesterol-free making it a suitable option for patients suffering from lactose intolerance and hypercholesteremia. Furthermore, non - dairy milk alternatives are rich in a micronutrient, bioactive compounds, and phytochemicals which have favorable health effects on hosts when consumed regularly (Aydar, Tutuncua&Ozcelika, 2020). The additional advantage of choosing plant-based milk is the presence of dietary fibre. An appreciable amount of dietary fibre has been documented by previous researchers in tiger nut milk, walnut milk, oat milk, and almond milk.

Cereals, millets, legumes, nuts, and oilseeds are rich in antioxidants. Phenolic acids, flavonoids, tannins, insoluble fiber, and carotenoid and vitamin E present in millets, legume, and nuts exhibit antioxidant properties. In general, decortication of raw ingredients significantly decreased the crude fibre, dietary fibre, minerals, total phenols, and antioxidant content (Lestienne, Icard-Vernière, Mouquet, Picq&Trèche, 2005). Numerous researches have documented the antioxidant capacity of millets, legumes, nuts and oil seeds in the prevention of certain cancers, osteoporosis, chronic renal disease, coronary heart disease (Pellegrini*et al.*, 2015).The merits and demerits of theNon – Dairy Milk Alternative are listed in Figure 2.

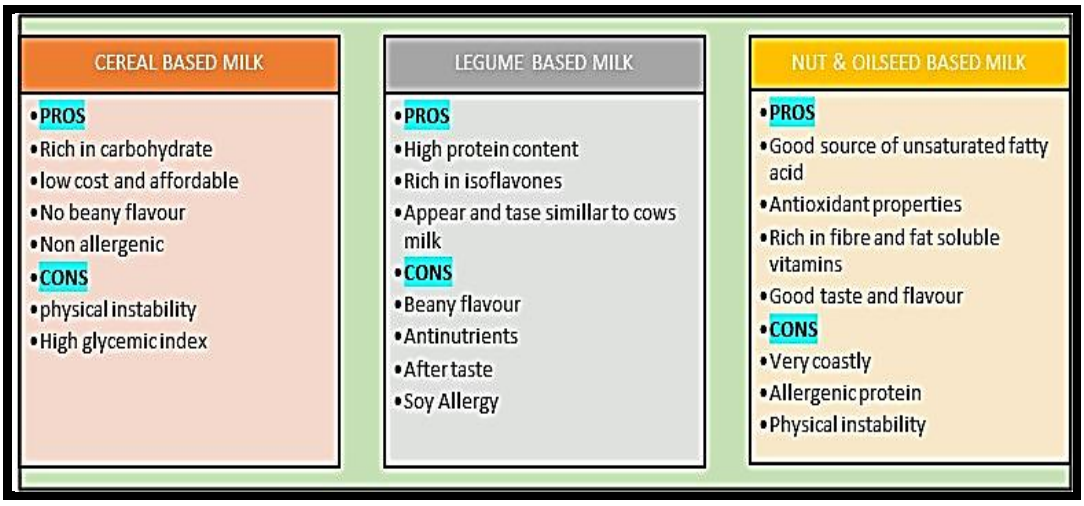

Figure 2: Pros and Cons of Non – Dairy Milk Alternative

Demerits

Non-Dairy milk substitutes are often perceived and marketed as a healthy product. In reality, the nutritional composition of the product strongly depends on the raw ingredients, processing condition, and other added ingredients (Yadav, Bansal, Jaiswal &Singh, 2016, and Mäkinen, Wanhalinna, Zannini &Arendt, 2015).

The major drawback of consuming dairy analogues is its protein content. Most of the products are poor sources of protein except soy milk which contains nearly 4 percent of protein (Patisaul& Jefferson, 2010 and Aydar, Tutuncua&Ozcelika, 2020). The quality of plant protein is generally considered as poor and incomplete when compared to animal proteins. The amino acid lysine is deficit in Cereals and millet, whereas sulfur-containing amino acid (methionine) is deficit in legumes.

Most of the non-dairy products predominantly contain sugar originating mostly from the added sweeteners and the inherent carbohydrate content of the raw ingredients itself. They also have a comparable calorific value equal to skim milk mostly contributed by the carbohydrate content of the products (Mäkinen, Wanhalinna, Zannini, and Arendt, 2015). The additional disadvantage of non-dairy milk substitutes is the low bioavailability of vitamin and mineral. Although raw ingredients like millets, nuts, legumes, and oilseed are a good source of essential mineral and vitamin, antinutrients like phytic acid, tannins and saponins can affect the bioavailability of the minerals. Former research works have demonstrated the low bioavailability of calcium from sesame milk due to the presence of phytate and oxalate (Dubey & Patel, 2018, and Aydar, Tutuncua&Ozcelika, 2020). The decortication of sesame seeds reduced the oxalate and phytate content in sesame milk as they are confined to outer hull (Kapadia *et al.*, 2002).

Plant-based milk lacks in high-quality proteins, omega-3 fatty acids, vitamin B12, riboflavin vitamin D, iron, calcium, and iodine. The complete replacement of milk and its product may result in macro and micronutrient deficiency. To overcome these disadvantages, dairy analogues can be fortified with essential minerals and vitamins, mainly B12, B2, D, and E. Consumers should be aware of nutritional imbalance existing in plant-based milk substitutes (Aydar, Tutuncua&Ozcelika, 2020). The polyphenol content of raw ingredients can cause the inactivation of thiamine and also decreases the protein digestibility (Gibson, Perlas & Hotz, 2006). Processing techniques such as soaking, germination, fermentation, thermal application can effectively decrease the antinutrient content and improve the bioavailability of the minerals. (Chauhan & Sarita, 2018 and Chaudhary & Vyas, 2015)

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BLENDING OF PLANT BASED EXTRACT FROM DIFFERENT SOURCE

The two-fold objective of blending two different plant sources is to improve the nutritive value as well as the sensory attributes of the product. The nutritional composition of the dairy alternatives directly depends on the raw ingredients used for the formulation.In general, it can be observed from previous research work that cereal and millet-based milk are rich in carbohydrate, legume-based milk are good sources of protein and nuts-based extracts contain a high amount of fat. A combination of millets/cereals with legume protein would compensate for the deficiency of lysine making it a high-quality complete protein.

Cereal based milk alternatives (quinoa milk, millet milk, oats milk, corn milk) are highly accepted by consumers owing to its affordable cost and less beany flavour when compared to nut based and legume-based milk alternatives. The major problem associated with the consumption of cereal/millet milk was poor protein quality and quantity. A simple technique and affordable technique such as blending of legume-based milk alternative with cereal milk can drastically improve the sensory profile and nutritional composition of the final product. Many researchers have attempted to formulate blended beverages from two different plant sources in the past.

Soycorn milk was formulated by Kolopa& Oladimeji, (2007) and stated that the addition of corn milk to soymilk resulted in increased nutrient content and better organoleptic attributes of the final product. Chocolate-flavoured peanut and soy beverages were developed by Deshpande, Chinnan& Philips, (2008) and it was concluded that the optimized peanut-soy beverage was more acceptable by the panellist.

An experimental study done by Kundu, Dhankhar, & Sharma, (2018) in the preparation of plant-based beverages by blending soymilk with almond milk in different proportions observed better nutritional as well as a sensory profile in the blend. Blending of Tigernut – Soymilk beverage was formulated by Awonorin& Udeozor, (2014) and noticed high protein, fat and calorific value with reduction in off flavour of the soymilk.

NOVEL PRODUCT DEVELOPMENT FROM PLANT BASED EXTRACT

Over the past two decades, the health-conscious consumers are constantly seeking for plant based functional food. "Functional foods can be defined as any food which contains health-promoting

components (probiotic bacteria, dietary fibers, unsaturated, phytochemicals, and polyphenols) along with basic nutrients" (Matos, Cardoso, Bandarra, & Afonso, 2007). The process of food product development requires the intimate blending of research findings, science, technology, imagination, experience, and skills. It is the process of initiation and advance, error, iteration, adaptation, and reiteration directed towards an exclusive goal of a nearly perfect manifestation of the product concept (Segall, 2000).

Dairy products such as ice cream, milkshake, and yogurt cannot be consumed by people suffering from lactose intolerance and cow's milk protein allergy. In the past, large bodies of research work have been documented about plant based non-dairy products. Yadav *et al.,* (2010) developed peanut milk based fermented curd product whereas, Bernat, Chafer, Chiralt, & Gonzalez-Martinez, (2015) formulated a plant based probiotic fermented beverage using almond milk and inulin.

Sakhale, Pawar, & Ranveer (2012) developed vegan RTS beverage by blending soymilk and mango pulp at various combinations and concluded that 50:50 (Mango pulp: Soymilk) combinations provided better sensory and physicochemical attributes. Likewise, Verma, Chauhan &Nanjappa, (2019) developed a soy milk strawberry flavoured RTS beverage. This was more essential and useful for children suffering from lactose intolerance and cow's milk protein allergy. The present study was conducted to reduce the beany flavour of soymilk and develop soy integrated strawberry rich beverage.

The soy ice cream was developed by Sutar, Sutar, &Singh (2010) by completely replacing cow's milk with soy milk and stated the formulated soy milk ice creams possessed good textural properties and nutritional compositional similar to conventional dairy ice cream. On the other hand, plant based vegan ice cream was formulated with soymilk and pumpkin seed milk by Bisla, Archana& Sharma, (2012). Fuangpaiboon&Kijroongrojana (2015) examined the qualities and sensory acceptance of low glycemic index coconut milk ice cream with addition of sweeteners and concluded that the formulated coconut ice cream had appreciable nutritional and sensory parameters.

CONCLUSION

Plant-based protein plays a pivotal role in the diet of mankind for more than thousands of years. Due to deficient protein intake in developing countries, there is always a demand for a sustainable and cheap source of plant-based protein to combat malnutrition. Non - dairy milk substitute has been a new interest to consumers and gaining immense popularity around the globe. Non - dairy milk alternatives cannot be considered as an effective substitute for cow’s milk as these

products may lack nutritional balance. The dairy analogues available in Indian markets are predominately soybean and almond based and generally priced high. Research focus must be geared towards the formulation of dairy analogues using low cost locally available indigenous ingredients such as millets, pseudo cereal, nuts and oil seeds. In recent years, many factors have strongly influenced the consumers to choose dairy analogues (Lactose Intolerance, Cow's Milk Protein Allergy, and Prevalence of hypercholesteremia, obesity and vegan lifestyle, adulteration of cow's milk).Therefore, from the review it can be concluded that Plant-Based Extracts can be considered as potential and affordable protein source which can alleviate malnutrition and micronutrient deficiency in developing countries where cow's milk supply is insufficient. These non-dairy gluten free products can serve as the perfect substitute for people suffering from Lactose intolerance, Cow's Milk Protein Allergy, Hypercholesterolemia, Celiac disease and by consumers opting for vegan life style.

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