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Study on Preparation of Vegan Oats Smoothie Blended with Flaxseed and Dates

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Abstract
The rising demand for plant-based functional beverages has created opportunities for clean-label, nutrient-rich product innovations. This study aimed to develop and evaluate a vegan oats smoothie enriched with flaxseed and date powder to enhance fiber content, natural sweetness, and product stability without refined sugars or added hydrocolloids. Key plant ingredients-oats, almonds, flaxseed, date powder, pineapple, and watermelon seeds-were analyzed for proximate and functional properties. A mixture design was used to optimize the proportions of oats, flaxseed and date powder to balance °Brix, pH, and viscosity. Compositional quality was assessed, energy value was estimated using Atwater factors, and sensory acceptability was measured using the 9-point hedonic scale, supported by instrumental rheology. Microbial quality was monitored during refrigerated storage, and techno-economic analysis evaluated production feasibility. The optimized smoothie demonstrated desirable sweetness-acidity balance, stable viscosity and high consumer acceptability while microbial counts remained within safe limits during storage. Oats provided β-glucan and avenanthramides for health benefits flaxseed mucilage improved stability and date powder contributed bioactive and minerals. Techno-economic analysis confirmed the formulation's commercial viability. Overall, the product aligns with clean-label trends, offering a stable, nutrient-dense and market-ready vegan beverage.

Keywords: Vegan smoothie, oats, β-glucan, flaxseed, mucilage, date powder, sensory evaluation, microbiological quality, refrigerated storage, techno-economic feasibility, clean-label formulation, plant-based beverage development

Introduction

In recent years the global shift toward plant-based diets has accelerated driven by growing health awareness, environmental concerns, and ethical considerations surrounding animal welfare (Vayalil, 2002; Mohamed *et al*., 2000) [13, 9]. Veganism, once considered a niche lifestyle, has emerged as a mainstream movement, prompting the food and beverage industry to develop innovative, nutrient-dense and sustainable products. Among these, smoothies have gained prominence as a versatile functional beverage, capable of delivering concentrated nutrition in a convenient, ready-to-drink format (Thakur & Handa, 2020) [12]. Their adaptability allows the incorporation of multiple functional ingredients, catering to the evolving preferences of health-conscious consumers seeking products that align with both nutritional adequacy and sensory appeal. Oats (*Avena sativa*) have been consumed for centuries in various cultural contexts, ranging from traditional porridges to modern health drinks. They are valued for their unique nutritional profile, which includes soluble β-glucan, a dietary fiber with cholesterol-lowering and glycemic control properties, and phenolic compounds such as avenanthramides that possess antioxidant and anti-inflammatory activity (Butt *et al*., 2008; Koerner *et al*., 2011) [3]. The smooth texture, mild flavor, and natural viscosity of oats make them an ideal base for plant-based smoothies. Beyond their fiber content oats are naturally gluten-free and contain a higher protein concentration compared to other cereals, making them suitable for individuals with celiac disease or those seeking high-quality plant proteins. Oat-derived proteins and peptides have also been investigated for their potential therapeutic effects, including antihypertensive, anti-diabetic and immune-modulatory benefits, though further clinical validation is required. Flaxseed (*Linum usitatissimum*), one of the oldest cultivated crops, has been recognized as a potent functional food ingredient due to its rich composition of α-linolenic acid (ALA), lignans, and high-molecular-weight mucilage.

These bioactive components contribute to cardiovascular protection, hormonal regulation, anti-inflammatory effects and digestive health. Flaxseed mucilage, in particular has demonstrated natural stabilizing properties in food systems reducing phase separation and improving texture without the need for synthetic hydrocolloids. Studies have linked flaxseed consumption to improvements in lipid profiles reductions in LDL cholesterol, and better glycemic management (Kapoor *et al*., 2011). Additionally, flaxseed is an economical and versatile crop, with applications in bakery, beverage and health supplement sectors.

Dates (*Phoenix dactylifera*), widely cultivated in Middle Eastern and North African regions, are a natural sweetener rich in polyphenols, minerals such as potassium and magnesium, and dietary fiber (Vayalil, 2002; Mohamed *et al*., 2000) [13, 9]. Their high natural sugar content, primarily glucose and fructose, provides immediate energy while maintaining a low glycemic index compared to refined sugar. Dates have been documented for their antioxidant and anti-inflammatory properties, with studies showing a significant reduction in oxidative stress markers upon regular consumption. Using date powder as a sweetener supports clean-label product development by eliminating the need for refined sugars, thereby aligning with consumer trends toward minimally processed foods.

Beyond these major ingredients, underutilized seeds such as pineapple (*Ananas comosus*) and watermelon (*Citrullus lanatus*) seeds offer additional nutritional and functional benefits. Pineapple seeds are a source of protein, healthy fats, and essential minerals, and their inclusion supports sustainability by reducing agro-waste from fruit processing. Pineapple pulp also contains bromelain, a proteolytic enzyme with digestive and anti-inflammatory properties, which may influence beverage texture and health functionality. Watermelon seeds are nutrient-dense, containing protein, lipids, minerals, and phytochemicals such as citrulline, an amino acid linked to improved cardiovascular function (Milala *et al*., 2018; Nkoana *et al*., 2022) [8, 10]. Despite their value, these seeds remain underutilized in mainstream food products, and their incorporation into functional beverages could enhance both nutritional quality and sustainability credentials.

While the individual health benefits of oats, flaxseed, dates, and underutilized seeds are well documented, limited research exists on their combined application in a single plant-based beverage. A relevant study by Thakur and Handa (2020) [12] demonstrated the complementary effects of oats and flaxseed in enhancing both nutritional quality and sensory characteristics in cereal bars, suggesting potential synergy in beverage applications. Moreover, the growing prevalence of lactose intolerance, diabetes, and lifestyle-related diseases has increased demand for functional beverages that address specific dietary needs. The combination of oats, flaxseed, and dates in a smoothie offers a synergistic nutritional profile-providing soluble fiber for cholesterol and blood sugar regulation, omega-3 fatty acids for cardiovascular and cognitive health, and antioxidants for oxidative stress reduction. The present research aims to develop and evaluate a vegan oats smoothie enriched with flaxseed powder and date powder, incorporating pineapple and watermelon seeds to further enhance nutritional density and promote sustainable use of plant by-products. The study focuses on five core objectives: (1) characterization of the physicochemical properties of all raw materials, including moisture, protein, fat, fiber, ash, and carbohydrate content (2) formulation standardization to optimize flaxseed and date powder ratios for balanced sensory appeal and nutritional quality (3) physicochemical evaluation of the final product including pH, viscosity and energy value (4) assessment of sensory, textural, microbial and storage characteristics and (5) techno-economic feasibility analysis to determine production cost, pricing strategy, and market potential. By integrating traditional knowledge of functional ingredients with modern food science and processing techniques, this research addresses the dual goals of health promotion and sustainability. The outcome is expected to contribute to the growing segment of clean-label, plant-based functional beverages offering a formulation that is not only nutritionally beneficial but also economically viable and environmentally responsible.

Material and Methods

The present investigation was carried out in the Department of Food Science and Nutrition Collage of Community science and Department of Food Microbiology and Safety Collage of Food Technology VNMKV Parbhani

Materials

The raw material during the study such as oats, flaxseed, watermelon seeds, dates, almound and pineapple were purchase from the Parbhani local market.

Equipment and machinery

Equipment such as analytical weighing balance, hot air oven, grinder, muffle furnace, Soxhlet apparatus and Microkejaldhal digestion and distillation unit where available in the Department of food Science and Nutrition Collage of Community Science VNMKV Parbhani.

Physicochemical composition of vegan oats smoothie

Proximate composition of Vegan oats smoothie prepared with different incorporation levels of oats, flaxseed, watermelon seed, almound, dates and pineapple was examined according to Official method of analysis of A.O.A.C. (2005)

Vegan oats smoothie preparation

Four different formulation used for vegan oats smoothie preparation are reported in table Developing selected smoothie required the inclusion of particular ingredients. It started by the prepare the oats smoothie take 24 g of oats, boil them until soft, then dry and grind into a fine powder. In a blender, add the oats powder, 35 g of dates (Dates used as a natural sweetener to replace sugar in the control sample) and 25 g of pineapple, Flaxseed powder is included in 6 g the selected formulation. Blend all ingredients with chilled water or milk until smooth. Pour the smoothie into a glass and garnish with 2 g of chopped almonds and 3 g of watermelon seeds. This healthy smoothie is naturally sweet, fibre-rich, and refreshing. Serve chilled.

Table 1: Formulation of vegan oats smoothie with different level of oats, pineapple, flaxseed, almond, watermelon seed and dates.

Ingredients	Control	T_1	T_2	T_3	T_4
Oats	30	28	26	24	22
flaxseed	-	2	4	6	8
Pineapple	35	35	30	25	20
Sugar	30	-	-	-	-
Dates	-	30	35	40	45
Almond	3	3	3	3	3
Watermelon seed	2	2	2	2	2

Preparation flow sheet of vegan oats smoothie

Oats (24 %) +Flaxseed (6%) +Pine apple (25%) +Dates (40%) + Almond (3%) + Watermelon seed (2%)

⬇

Blending Pineapple and date

⬇

Adding roasted flaxseeds powder

⬇

Adding cooked oats powder

⬇

Adding Watermelon seed and Almond powder

⬇

Blending

⬇

Pour into glass jars

Fig 1: Flow sheet for preparation of vegan oats smoothie

Result and Discussion

Chemical Composition of Vegan oats smoothie: The data pertaining to various chemical properties such as moisture, fat, carbohydrate, protein, ash and crude fiber of selected product were determined and result obtained and illustrate are Table 2 respectively

Table 2: Nutritional composition of vegan oats smoothie

Parameter	Smoothie (Control)	Smoothie (T_3)
Moisture (%)	29.94±0.5	33.14 ±0.07
Ash (%)	2.38±0.02	2.52±0.12
Protein (%)	1.79±0.07	3.75±0.03
Carbohydrate (%)	3.22±0.02	5.35±0.05
Fiber (%)	3.38±0.1	6.73±0.04
Fat (%)	52.63±0.1	55.85±0.09

*Each value represents the average of three determinations

The nutritional analysis (Table 2) revealed that adding flaxseed and dates powder to the vegan oats smoothie improved all key nutritional parameters compared to the control. Moisture content rose from 29.94% to 33.14% due to water-rich pineapple and dates, which also enhanced texture and mouthfeel. Ash content increased (2.38% to 2.52%) because flaxseeds and almonds are high in minerals, improving micronutrient density. Protein nearly doubled (1.79% to 3.75%) from protein-rich flaxseeds and almonds, meeting plant-based protein needs (Goyal *et al*., 2014) [4]. Carbohydrates rose from 3.22% to 5.35%, mainly from oats and dates, contributing natural sweetness and quick energy. Dietary fiber increased (3.38% to 6.73%) due to fiber-rich oats, flaxseeds, and fruits, supporting digestive health. Fat content increased (52.63% to 55.85%) through unsaturated fatty acids from flaxseeds and almonds, which benefit heart and metabolic health. Overall, the formulation was nutritionally superior, demonstrating that flaxseed and dates enhance both the functional and sensory qualities of a clean-label, plant-based smoothie.

Textural parameters of vegan oats smoothie

The textural properties of prepared vegan oats smoothie such as appearance and packaging parameters which improve consumer attraction. The different textural parameter including springiness, cohesiveness, gumminess, adhesiveness factor of control and selected sample were evaluated and the data was presented in the table 3.

Table 3: Textural parameters of vegan oats smoothie

Parameter	Control	Selected T_3
Springiness (g)	0.042	0.177
Cohesiveness	0.035	0.014
Gumminess (g)	6.402	45.61
Adhesiveness (kg)/s	-52.012	29.409

*Each value average of three determinations

The texture profile analysis (Table 3) indicated that the springiness of the vegan oats smoothie increased from 0.042 g in the control to 0.177 g in Selected T3, suggesting improved elasticity and better shape recovery after deformation. This increase may be due to the incorporation of flaxseed and dates powder, which are rich in soluble fiber and polysaccharides that form a stronger gel network, improving the elastic properties of the product. Conversely, cohesiveness decreased from 0.035 to 0.014, indicating weaker internal bonding within the product matrix, possibly due to the presence of coarse fiber particles from flaxseed and dates, which interrupt the continuous gel structure. Gumminess showed a marked rise from 6.402 g to 45.61 g, reflecting a thicker and more resistant mouthfeel; this could be attributed to the increased water-binding capacity and higher viscosity contributed by the added fiber and natural sugars. Adhesiveness shifted from -52.012 kg/s in the control to 29.409 kg/s in T3, demonstrating greater stickiness, likely due to the presence of natural sugars from dates, which promote tackiness, and soluble fibers that enhance surface adhesion. These results indicate that formulation changes in T3 not only improved elasticity and mouthfeel but also altered the overall texture by reducing cohesiveness while increasing gumminess and adhesiveness (Bourne, 2002) [14].

Nutritional status of prepared smoothie

It is important to analyze the relation of mineral in the final product. The present investigation evaluated the presence of minerals in the organoleptic ally proved the best sample of vegan oats smoothie. Table 4 shows the result of mineral content in the vegan oats smoothie.

Table 4: of Mineral composition of prepared vegan oats smoothie

Minerals	Nutrient Content	
	Smoothie (Control)	Smoothie (Selected)
Calcium (mg/100g)	17.4±0.08	55.83±0.06
Phosphorus (mg/100g)	163±0.7	168±0.05
Iron (mg/100g)	2.83±0.1	5.53±0.07
Copper (mg/100g)	0.22±0.09	0.43±0.03
Zinc (mg/100g)	1.14±0.05	1.45±0.05
Magnesium (mg/100g)	55.67±0.03	79±0.1

*Each value average of three determinations

The mineral composition of the vegan oats smoothie (Table 4) showed substantial enrichment in the selected formulation compared to the control, likely due to the addition of ingredients such as almonds, flaxseed, and dates. Calcium increased from 17.4 to 55.83 mg/100 g, reflecting contributions from almonds and dates, both of which are rich sources of calcium (Barreca *et al*., 2020; Barakat *et al*., 2023) [20, 19]. Phosphorus rose slightly (163 to 168 mg/100 g), while iron nearly doubled (2.83 to 5.53 mg/100 g), consistent with the high iron content of dates and flaxseed (Kajla *et al*., 2014; Dghaim *et al*., 2021) [21]. Copper (0.22 to 0.43 mg/100 g), zinc (1.14 to 1.45 mg/100 g), and magnesium (55.67 to 79 mg/100 g) also increased, aligning with the mineral profiles of nuts, seeds, and dried fruits, which supply bioavailable trace elements and enhance overall mineral density (USDA Food Data Central, 2020; Aljaloud *et al*., 2020) [18]. These changes improve the nutritional quality of the selected smoothie.

Organoleptic evolution of vegan oats smoothie

The four samples (T_1, T_2, T_3, and T_4) and control were made differently with different level of oats, pineapple, flaxseed and dates. The organoleptic evolution of vegan oats smoothie carried out by 30 semi trained panel members based on 9 points hindonic scale and score were given by evaluating the sensory attributes for vegan oats smoothie such as colour, appearance, flavour, texture, test and overall acceptability which was compaired with controlled sample was expressed Table 5.

Table 5: Sensory analysis of prepared vegan oats smoothie

Smoothie	Mean values of organoleptic score				
	Colour & Appearance	Flavor	Texture	Taste	Overall Acceptability
T_0	8.5	8.6	8.6	8.7	8.7
T_1	8.2	8.2	8.6	8.3	8.3
T_2	8.6	8.3	8.5	8.6	8.8
T_3	8.7	8.8	8.7	8.9	8.9
T_4	8.1	7.9	7.9	7.7	7.9
CD@%5	0.613	0.386	0.355	0.508	0.433
S.E±	0.221	0.139	0.128	0.183	0.156

The organoleptic evaluation of smoothie was judged based on 9-point hedonic scale. The results for the formulations were made on the bases of highest scores received by 30 semi-trained panelists. The sensory score of colour from Table 3.4 represents that T_3 combination for overall acceptability got highest scores as compared to other treatments. Lowest overall score found in T_1, T_2, and T_4.

Conclusion

The present study successfully developed a vegan oats smoothie enriched with flaxseed and dates, offering enhanced nutritional, functional, and sensory qualities. The selected formulation (T3) demonstrated improved proximate composition, higher mineral content, and favourable textural properties compared to the control. Sensory evaluation confirmed its superior acceptability in terms of colour, flavor, texture, taste, and overall appeal. The addition of flaxseed and dates not only enhanced fiber, protein, and mineral levels but also improved product stability and natural sweetness without the use of refined sugar or synthetic stabilizers. Techno-economic analysis indicated commercial viability, highlighting the potential of this clean-label, plant-based beverage as a nutritious and market-ready product.

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