A REVIEW: APPLICATIONS OF OATS IN FOOD AND BEVERAGE INDUSTRIES

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Abstract

The different industrial applications of *Avena sativa* (scientific name of oats) are reviewed in order to leverage the nutritional values and supplemental health benefits. Oats have a high level of lipase activity and a high lipid content. Its nutritional values include fats, proteins, and also bioactive substances such as dietary fibers, minerals, vitamins, and flavonoids, which gives health benefits like decreasing blood cholesterol level, risk of coronary diseases, and intestinal disorders. So, we analysed and tried to give an open picture of its benefits.

The applications of Avena Sativa in different food industries includes the process of flaking; preparation of bakery products, noodles, and fodder; and as emulsifiers. Oats can be used in various extrusion products as well as have a good approach to the beverage industries in malt formation for beer production, as oats are also applicable in brewing process, improving the quality of the beer, and being cost effective for the brewing industries. Oat bran as a by-product is being rich in various compounds like saponin-protein complex acts as a natural emulsifier, which is also effective in reducing the waste from cereal-based industries. Oat bran extract functions as a negatively charged ionic emulsifier that is effective over a wide pH and temperature range. Some of the stabilization techniques are used, like solvent extraction, steaming and sub-critical fluid extraction(defatting), in the production of fortified food like oat fortified noodles.

The review will address anonymous traditional applications of oats which are being produced and consumed in various forms like injera, kitta, anebabiro, gruel, porridge, enket, and tella.

Keywords: Oats, Bioactive compounds, Fortified, Emulsifier etc.

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1. INTRODUCTION

Oats is one of the cold climate crop, which is mainly grown in cold countries like Canada, Russia, Australia, Finland, and USA. As compared to other cereal grains, oats contain highest amount of unsaturated fat and protein (Chavan et al, 1993). The oat plant (Avena sativa) has its uniqueness in its crops since it has a number of nutrients which are valuable for food, animal feed, health care, and cosmetics. Cultivated from ancient period of time by our ancestors, it's a yearly crop that has been grown for more than 2000 years in various areas of the world. Compared to other grains like wheat and barley, it entered cultivation many thousands of years later. cereal is essential source of vitamins, minerals, dietary soluble fibre, lipids, appropriate macromolecules, and several phenoplast chemicals.

Oats have garnered excessive attention from scientific researchers and enterprises as a result of the general public's increased awareness of good eating practises. By adding oats in morning cereals, drinking beverages, bread, and child edible items, food-based businesses are generating unique food products while also taking into account better nutritional composition. Oats are mostly used in morning meal and snacks, but their introduction in more edible items considerably benefit people from their health-promoting qualities. the key components of soluble fibre are oat beta-glucan, a viscous saccharide made of a linear open chain D-glucose monosaccharides held organized by combinations and connections (Youssef MKE et al., 2016). It is set within the reproductive structure semipermeable membrane of kernel. It is thought about the foremost lively element in oats, varied useful besides nutritionary properties, primarily steroid alcohol dropping and antidiabetic drug properties (S. Sots et al., 2020). OBG content can range from 1.8 to 7- membered, according to reports. OBG content differs significantly between oat cultivar and is influenced by rising regions, storing options, and handing conditions. Oat groats contain thirteen to twenty macromolecules (Thakur S et al., 2017).

Proteins are largely gift within the seed (about 30%). Alternative minor parts in oats are inhibitor compounds like tocols, phenoplast complexes, sterols, that are related to health helpful properties (Dulinski et al., 2020).

The nutritional benefits of oats go beyond only fat and protein; they also contain bioactive substances such dietary fibres, minerals, vitamins, and flavonoids, all of which have positive health effects like decreasing blood cholesterol level, risk of coronary diseases and intestine disorders. Due to such remarkable nutritional values, oats are being added to diets of individuals. Oats include a significant amount of starch in the grain, which provides energy and affects the physical characteristics of oat products. Oats being used in beverage industry since Middle Ages oat act as a substitute or an additive for the beer production. Oat malt cause change in the colour of the beer produced.

2. IMPORTANCE OF OATS

The value of oats Over 90% of those who took part in the research made oats a year-round staple meal. When other cereal crops are in short supply, only 1.6% of those polled claimed they still eat. The majority of study participants (88.7%) stated that oat consumption is higher in remote areas than urban areas (Getaneh Firew et al., 2021). This disparity in oat consumption between urban and rural areas may be due to the convenience of unlike foods in urban areas compared to rural areas. high concentrations of proteins, soluble fibre, essential amino acids phytochemicals unsaturated fatty acids, lipids, vitamins, and minerals, in oats are said to provide them a high nutritional value (Youssef MKE et al., 2016).

Compared to most other cereal grains, oats contain a lot more oils. Additionally, it has a nutritious value and a balanced amino acid composition. In great part, oats are thought of as a functional food because of their high concentration of soluble dietary fiber called glucan and an antioxidant called avenanthramide. Oats are a unique grain to utilize in food and baking items due to the presence of numerous health-promoting components.

There are some nutraceutical compounds present in oats, one of them is β-glucan. β-glucan provides beneficial effects on health which include prevention of hypertension, cardiac disorders, reduction in cholesterol level. β-glucan is majorly a cell wall component present in oats (Gleb Dotsenko et al., 2019). Amount of β-glucan present in oats varies from different kind of its genotypes, from 10.7-30mg/g (Vita Sterna et al., 2016).

Another compound is avenanthramides which is found to have a antiproliferative effect on vascular muscles units, with reduced rick for chronic disease, anti-inflammatory and protect against colon cancer (Lin Nie et al., 2006). Even the commercial oats products that are present in market such as oats flakes, oats bran extract or oats four are source foe avenanthramides (Gulten soycan et al., 2019). Avenanthramides content depends on genotype of oat grain, consuming 40g of commercial oat product will provide 1.1-2mg of avenanthramide (Gulten soycan et al., 2019).

3. APPLICATIONS

3.1. Traditional Oats Products 3.1.1-Injera

A thin, fermented flatbread called injera is created using flour, water, and ersho (a mixture of bacteria which are present in lactic acid, Entero bacteriaceae, yeast in addition Bacillus species, and spontaneous fermentation). With the exception of certain research districts, injera made of oat grain is not common in different regions in Ethiopia. Every household has a different traditional way of making injera, but it usually involves combining the flour and water, a back- slathered culture. Water, ersho, and oat flour are needed ingredients. When making comparatively white injera, flour of maize (1/3 amount) is typically mixed to oat flour. Oat flour that has been ground to a medium fineness is sieved before the dough is made. A thick paste is created by thoroughly kneading the flour with water and gradually adding more water. The paste is permitted for spontaneously fermentation for 72–96 hours room condition.

A piece of the dough was taken after 72–96 hours of fermentation, mixing 1:3 (v/v) with hot water(100°C), and heated for 15 minutes while stirring for creating hot prepared absit (less thick, prepared dough from first fermentation). After baking for two to three minutes, then dough is kept onto a hot, even clay griddle that has been greased with rapeseed powder as a source of oil. This will create injera that is circular in shape. The bottom of the injera, which comes into contact with the clay griddle, is smooth, while the upper part is porous. Round, pliable, durable, and roughly 6 mm thick, traditional injera then evenly dispersed on honeycomb likely top.

Customers frequently like injera having properly spaced surface gas pores, roundness, non-stickiness with a little sugary flavour (Thakur S et al., 2017).

3.1.2-Oat kitta

Kitta is a chewy, flat, dry bread resembling a thin pita. When injera is not easily accessible, kitta is frequently cooked as a fast lunch for children and family members. The ingredients for instant oat kitta are oat flour, water, and a little salt. Alternately, maize might make up one- third of the powder. In comparison to injera, kitta is smaller in size, somewhat tougher, and thicker, and roughly the thickness of a pizza foundation. It can be eaten with butter, milk, and linseed paste or on its own. In a bowl, thoroughly combine the flour and water by adding the water gradually while thoroughly kneading the dough until it is elastic and smooth. The dough is flattened into a thin layer and slowly put into the heating pot. The quality of the kitta increases with sheet weight. pan cooked bread (kitta) is then taken off the temperature and typically assisted by scrubbing it's top with blend of nitir qibe (old-style ghee made by heating Ethiopian butter till boiling point with various spices) and awaze (traditionally fermented condiment that is typically eaten with other desirable aroma and flavour). It results from microbial fermentation of vegetable-based spice blends (Asta et al., 2013).

3.1.3-Oat gruel

Gruel (Atmit), viscous beverage made from cereal flour, is made by simmering oat flour wit h H2O, sugar, salt, and "ghee" (clarified spiced butter of Ethiopia) until
the mixture reaches the desired consistency.

In Gozamin communities, oat gruel is a common beverage. People who live in city prefer this dish more than those who live in rural regions (Salwinder Singh Dhaliwal et al., 2020). Gruel is made by combining oat flour, which comes from grain that has been mildly roasted, in a one- to-one ratio with other cereal flours, such as maize or rye. Gruel is frequently prepared to nourish nursing mothers after giving birth and for anyone with a decreased desire for other solid meals (Priyanka Vishwajeet Shukla et al., 2020).

3.1.4-Oat enket

One of the odd traditional dishes eaten by residents of the region is oat enket. Sama leaves (Utrica simensis Steudel) and water are used to make it. Ethiopian indigenous plants include sama. The dehulled oat grain is currently cracked and milled using a mechanised mill, while breaking has historically been done using a traditional stone grinder. Sama leaves are harvested from the field by the twig portion, placed out on a tray made of rattan, and with a traditional mesh to removing spines. The sama leaves then placed in a kettle made of clay and brought to a boil with water. The leaves are pressed after being removed from the heat, and the residue is then collected for added processing. The residue is combined with ground oats and heated by gradually adding small amounts of water (McClements, D. J et al., 2017). Alternatively, the crumpled oats can be further added and prepared if the sprouts leaves are tender and young enough. Butter that has been seasoned and salt will be added after cooking for 5 to 10 minutes. Injera is eaten with the ensuing green jelly sauce once it has been taken off the fire.

3.1.5-Oat porridge

Another of the most popular dishes in Ethiopia is porridge. Porridge is a typical cuisine in Gozamin district, much like in other regions of Ethiopia. The choice of components makes a difference; in this

region, oat is preferred above other cereal crops. So, in a 1:1 ratio, toasted oat flour and supplementary cereal grains (rye, maize, in addition wheat, barley,) are used to make the porridge. Breakfast or a special occasion dinner can both be served with porridge (after birth or holiday). This dish is most frequently. Additionally, it is utilised to supplement the diets of young youngsters under the age of five (Zdaniewicz et al., 2020).

In order to create the flour for oat porridge, the husk must first be removed from the grain. Then, in the boiling water with a little salt, the flour is added and cooked while being constantly stirred. Typically, sticky elements like spicy butter combined with hot common pepper or chili powder, honey or linseed are used in a porridge dish (Salwinder Singh Dhaliwal et al., 2020).

3.1.6-Oat tella

One of the classic alcoholic drinks in Ethiopia is called oat tella, and it is made from a variety of ingredients. It is produced using a variety of grains, including tef, wheat, corn, barley, millet, and sorghum. It's alcoholic drink that Ethiopians drink the most frequently. In the Gozamin region, oat is habitually used to make yetella kitta, a form of leavened kitta cooked into thin flatbread on a large metal pan. It serves as a substrate for fermentation and is one of the substances used in the production of tella. It is also infrequently used to make asharo, which are deep-roasted grains used in the manufacture of tella. The most common source of the fermentable grains for making tella is yetella kitta.

The yetella kitta is made from completely combining toasted oat flour with water, baking it on a large metal skillet, and breaking it into little pieces. Water is completely included with malt flour (bikil), yetella kitta, , and crushed gesho (Rhamnus prinoides), then the mixture is allowed for fermentation for a couple of days. Tinsis is a frequent name for the fermenting combination. When the tinsis and adjuncts alike asharo are added, a viscous mixture of materials recognized as difdif is created, and the second phase fermentation begins (Salwinder Singh Dhaliwal et al., 2020). Depending on the temperature of the surroundings, Difdif is kept covered for three to seven days to allow the fermentation (Priyanka Vishwajeet Shukla et al., 2020).

Tella is made similarly to beer where grain starch transforms' by malting into pure sugar. Tella, however, uses the natural yeast already existing in the grains and the environment; no more yeast is introduced during the fermentation process. Unfiltered tella typically has an alcohol concentration of 2-4% but filtered tella has a 5-6% alcohol content. Ethiopians who live in rural and small towns favour traditional alcohols, and even in the metropolis, its ubiquity is growing. It is typical for people to consume locally produced alcoholic beverages at various cultural and religious celebrations.

3.2. Oat Flakes

Oats can be utilized in various edible forms some of them are flakes, flour, breads, beer manufacturing, oats milk and instant breakfast cereals which are rich in nutritive values. Oats go through various processes, such as steaming. Steaming causes decrease in nutritional values due to high temperature processing protein and starch structures break down (S. Sots et al., 2020).

Before flaking of oats, grading, and cleaning of grains are done as pre-treatment process, now dehulling and pearling of grain is done which forms 15-35% of by product as husk and particles of crushed kernel. Dehulling reduces the overall mass of the grain which results in reduction of various nutritive components like protein, β-glucans, vitamins, minerals etc. The benefit of hulling is that it only removes the hard hulls which gives a good quality in final product. Processing of hulled and unhulled oat cultivars revealed that owing to the need for dehulling and other difficult technical activities. Processing of the naked types of oats is much less expensive than that of the traditional varieties. To reduce unwanted enzymatic activities in oats and oats products, there are some stabilization techniques to improve processing, cooking, shelf life and product qualities. To reduce the peroxidase and lipase enzyme activity can be inhibited by steam treatment. Some stabilization techniques were used during processing of oat for production of flakes. Steam treatment is one of the most common techniques used for the inactivation of enzymatic activities in food products. Steaming is done at 105°C in a cabinet dryer having moisture content of the oat products (oats flour) 8% for about 50 minutes. Groats that had a moisture level of 15, 17, and 19% was steamed for five minutes at 0.10-0,20 MPa before being delivered to the drying stage. Flaking is done by roller mill having pair of rollers 150mm length, 220mm in diameter and operating at a gap set of 0.3-0.5mm. After the flaking process drying is done on fluidized bed dryers, during the drying process temperature of air and the time period of drying is important aspect for final product quality. Flakes are dried to a moisture level of 14%. A large quantity of husking ban, which is created by flaking, indicates that lowering the amount of moisture of pearled groat at 15.4% does not permit for a significant change in

physio-chemical and technical qualities (S. Sots et al., 2020).

Additionally, the pearled groats made in this manner are flaked by breaking off pieces of the flakes, and the finished result has an asymmetrical form. The production of flaked groats can be increased by raising the humidity to 19.1%, but too much moisture before steaming strengthens the grain and degrades its plasticity; as a consequence, the flakes produced in this manner are flaked groats for organoleptic evaluation and surface character. Production of pearled groats flakes has 1.7-1.9 times higher yields in comparison to flakes obtained from hulled oats (S. Sots et al., 2020). The parameters of toughness and thickness are interconnected; flakes with low strength are typically characterized by low thickness, and on various phases of the technological method, they are capable of being destroyed, which raises the proportion of husking bran and lowers the nutritional value of the product.

Cereal flakes are developed from various crops having thicknesses of 0.2-1.0mm traditionally. Meant for oats, flakes thickness varies from 0.5-0.9mm. The moisture content of the flaked product affects the Strength of the flakes, flakes with high humidity possess higher strength than flakes with low humidity, and the end product of flakes must not exceed 12% of moisture level. Pearled groats are treated with hot water treatment and then flaking uses its overall ash content of oats flakes from 1.8% to 1.5%. The ash content of flaked oats having moisture content of 17% and 19% can be steamed under vapour pressure of 0.15MPa results in 1.6-1.8% of ash content with composition of vitamin B1 0.52-0.55mg/100gram and vitamin B2 0.2- 0.15mg/100gram.

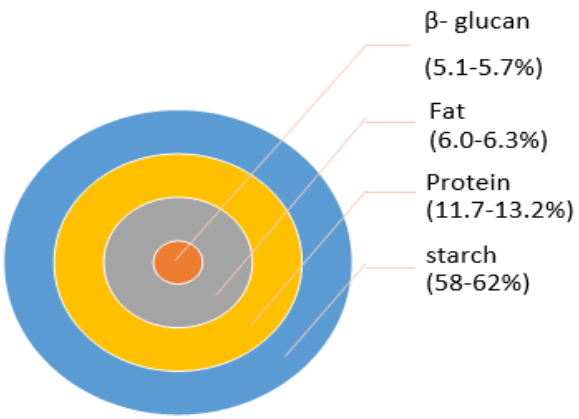

Table.1. Nutritional composition of oat flakes (S. Sots et al., 2020).

3.3. Oats Malted Beer

Oats can be utilized as an additional ingredient in malt production for the beer. they were utilized even in the early Middle Ages for the production of beer, oats are attracting people due to their rich physiological properties. mainly barley is utilized for malt, oats have an advantage as they can be used as an additional substance of a gluten-free diet, oats crop produce three times more husk than wheat or barley crop. As a vision on behalf of a brewer oats comprises a high quantity of β-glucan (Here, the creation of beer depends significantly on the moisture, so moisture quantity of oats malt checked, and it was 3.3% and glassiness was 1.4%). This represents that the proper storage of grain and process under proper condition is done. High amount of glassiness in the grain represents the high amount of the protein in the grain with low starch content which is unsuitable for the brewer or the brewing process of malt (Zhuang, S., 2017).

Nutrients	Amount
Glucose (µg/mL)	521.6
Maltose (µg/mL)	964.9
Mg (mg/L)	92.1
Zn (mg/L)	0.3
Ca (mg/L)	86.1
Colour (European brewery convention)	9.0

Table.2.oat malted beer nutritional values (Zhuang et al., 2017).

Studies on the creation of 100% oat malt beers often demonstrate that barley worts have a similar or slightly greater degree of fermentation than oat worts. The fermentable sugars acquired during mashing are converted into ethanol, co2, and other fermented products during fermentation (Zhuang, S., 2017; Klose et al., 2011)
According to the study, maltose, glucose, and fructose are examples of these sugars. During the early fermentation stage, it is believed that 80% of the sugars are used. (Zhuang et al., 2017).

The more fermentable carbohydrates exist in wort, the greater alcohol concentration of the finished beer. The yeast starts on glucose in addition with fructose. Maltose and sucrose stand as classified as primary fermentation carbohydrates and are rapidly fermented by yeast downstream. It is worth noting that glucose concentration of oat wort was half that of barley wort. Melanoidin molecules, oxidizing and sugar caramelizing products of malt constituents, and adjuncts all contribute to the color of the resultant worts and beers. Beers brewed from 50% to 100% oat malt stood darker (7.7 and 9.0 European brewery convention). The color quality of worts prepared with the inclusion of oats increased. discovered that barley wort is paler in color than oat wort. The sample created with 100% oat malt contain 2.51% alcohol (Marek Zdaniewicz et al., 2021) and 4.34% v/v (Klose et al, 2011).
As per Klose's research 2011 residual values for the controlled samples, the highest residual extract was seen in the sample with 10%.sample containing 50% oat malt having a lower level than the sample having 0 and 10% oat malt, and the residual extract of the sample having 100% oat malt results in the lowest residue content. The concentration of suitable ions influences the fermenting progression and the value of the biomass, among other things. Calcium is another essential component of wort. Its activity against yeast is centred on the preservation of the plasma membrane structure. Many enzymes use zinc as a catalytic cofactor. Concentration aids yeast progress and alcohol generation, although both lack and surplus Zn2+ have a detrimental impact on the brewing process, biomass quality, and cell wall.

3.5. Oats Bran Extract

Product category of food and beverage produced from emulsions are thermodynamically unsteady that gradually discrete into non-miscible phases. Emulsifiers, frequently of synthetic origin, can be added to delay this inescapable change in spatial distribution. However, people are becoming more interested in "natural" items that do not contain artificial food additives.

The amphiphilic saponins cluster, which can be derived from several diverse variety of plants including Quillaia, sugar beets and asparagus, is another newly studied "natural" category of bio emulsifiers (Mitra & Dungan, 1997). These amphiphilic, low molecular weight secondary plant metabolites are particularly surface-active because they have polar sugar moieties coupled to nonpolar triterpene or steroid backbone (Mitra & Dungan, 2000).

One of the most important cereal grains, oat (Avena sativa L.) is primarily used as food and animal feed and has a yearly worldwide making volume of around 22 million tonnes (FAO, 2014). Oats bran is a typical by-product of milled oats, which, depending on dry matter content, accounts for around 50% of the whole grain and is regarded as healthful due to outstanding presence of β-glucans, which have cholesterol dropping properties. We proposed that oat bran extract, which contains proteins and surface-active saponins, can be utilized as a natural emulsifier resultant oat bran extract for its chemical makeup and surface characteristics. Oat bran can be extracted by producing oil-in-water emulsions with varying extract concentrations using various homogenization pressures under high pressure. Before the product formation there are some stabilization methods for the grains, one of them is defatting. Defatting refers to the reduction or removal of lipid content from the oats is necessary due to high enzymatic activity. It is mainly done after steam treatment of oat grains having moisture content of about 13-15%, then grains are compressed to flakes and then main extraction process is followed in an extraction tank having material and solvent (1:3) respectively (w/v). Collected oats are further stored at -20°C for after use. Butane is most commonly used subcritical fluid for extraction, solvents like pentane and methanol can also be used.
A quantity of oat bran (Avena sativa L., 100 g) was treated(defatting) three times while being stirred in 140 mL of purified n-pentane at room temperature. The remaining oat bran has taken out three times with methanol (340 mL each), then three times with a combination of methanol and water (70/30, v/v), after stirring for 30 min, using an Avanti J-E centrifuge (10 min at 10,000 rpm, Beckman Coulter GmbH, Krefeld, Germany). A Buechner funnel (Carl Roth, Germany, 111A, 110 mm) lined with filter paper was used to mix and filter the methanol & methanol/water extracts. The mixed filtrates were filtered, parted from the methanol under vacuum at 40° C, and then freeze-dried.

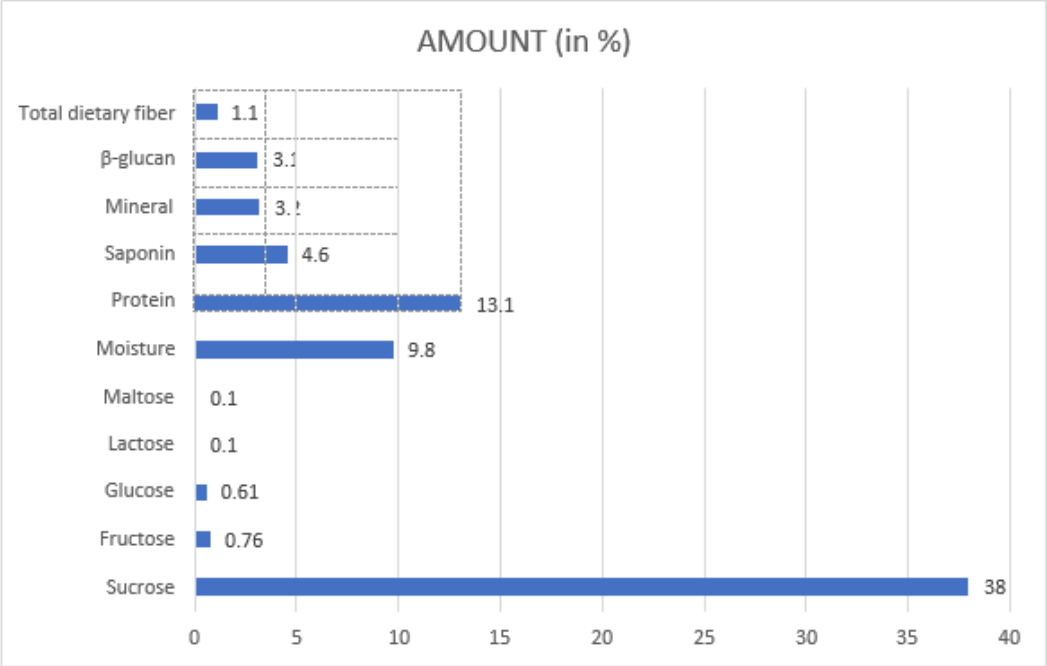

Table.3. Nutritional composition of oat bran extract (Theo Ralla et al., 2016)

Minerals Ca 0.029%, K 2.142%, Na 0.020%, P 0.709%, Mg 0.106%, Mn 0.002%, and Fe0.001% made up the mineral composition (Theo Ralla et al., 2016). The extract's composition was different from that of unprocessed oat, which typically contains 64% carbohydrates, 17% protein, 10% fibers, 7% lipid, 2% ash, and 0.1% saponins. This suggests that certain components, like saponins, were present.

These naturally occurring saponin-protein complexes may serve as an "anchor" in the interface and reinforce the interfacial network through forces of interaction like hydrogen bonds. By the side of the oil-water and air-water interfaces, biogenic saponin-protein complexes have been shown to have this kind of synergistic impact.

4. CONCLUSION

Traditional application of oats were studies in this review, which involve injera, kitta, anebabiro, gruel, porridge, enket, and tella.

The defatting process is effective for oats and the lipid amount decreases with the increase in defatting times, but it is only effective till 2 times, as there is no such difference scene in 3,4, or in 5 times (Shuyi Liu et al., 2019). To increase the effectiveness of the defatting process there is a need of having an optimum moisture content in the oats. The most acceptable moisture content of oats during defatting is 6%. In the defatting process, there is a need for a solvent that is effective in terms of movement and solubility, the optimum temperature for lipid extraction is 35°C, where lipid residues are minimum.

We can also conclude that the molecular properties as well as the concentration ratios affect the adsorption processes of saponin-protein combinations. Pure saponins and saponin-protein complexes attach by same rates to the air-water interface, indicating that small-molecule saponins predominate in the adsorption behaviour. To completely comprehend the intricate creation and stabilisation of the interface and are able to distinguish between pure saponin interfaces and interfaces covered with biogenic saponin-protein complexes, additional research examining the composition of the interfaces are required.

The addition of 10% oat malt to a beer formula has no detrimental influence on the beer manufacturing process or the end product quality. It might contribute to a mild, gritty flavour and provide a unique texture. Increasing the quantity of oat malt (50% and 100%) results in a considerable reduction in the yield (less wort). Higher oat malt proportions may be advantageous in the manufacture of beers with reduced alcohol content since much lesser amounts of the extract are produced.

For some applications in the food and beverage industries, potential substitute for conventional natural emulsifiers is oat bran extract, and it might be utilized to reduce food waste and assist to boost the efficiency of the food industry.

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