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Review Article

Issues, Challenges, and Recommendations on the uses of Sunflower Meal in the Developing World; a Case of Africa

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ABSTRACT

The current shift from animal based protein consumption to plant based protein sources is significantly attributed to the nutritional and functional benefits of the latter. Sunflower Meal (SFM) is one such protein source that has attracted food expert's attention in the contemporary global food market. SFM contains high amounts of proteins, fiber, fat, and phenolic compounds, albeit with low lysine levels. The meal is an excellent antioxidant and lacks ant nutritional properties, thus suitable for human consumption. However, the meal is underutilized due to the presence of phenolic compounds. Different techniques are essential in extracting proteins from SFM, including enzyme-assisted extraction, solvent, and ultrasound-aided processes.

Nonetheless, such technologies are yet to be implemented in Africa, limiting the use of SFM in human nutrition. This paper reviews the existing empirical research on the use of SFM for human consumption in Africa. The outcome of the review strongly indicates that Africa is yet to embrace the use of SFM for human nutrition. Indeed, this review has not established evidence suggesting that any country in Africa has embraced modern biotechnology tools to extract proteins from SFM for human consumption. Such technology should be utilized in obtaining SFM proteins for the human diet in Africa to ensure whole utilization.

Keywords: Sunflower meal; Sunflower oil extraction; Phenolic compounds; Protein isolate; Protein extraction; Livestock feed; Human diet

INTRODUCTION

As the world reports an unprecedented surge in population growth, so is the pressure exerted on natural resources, including but not limited to food sources. Such changes, coupled with improved living standards, have contributed significantly to the alarming increase and over-reliance on animal-derived protein foods [1-5]. However, there is a shift from animal-based proteins consumption to plant proteins as the contemporary global populace pursues functional foods with high quality and longer shelf-life. While Sunflower Meal (SFM) generated from sunflower oil production is primarily used as a source of animal feed in Africa, it is also a valuable source of proteins for the human diet. Currently, SFM is attracting food scientists' and human nutritionists' attention as a source of proteins for food formulations, among other beneficial attributes [6,7].

Previous empirical studies have estimated the protein content of SFM at 30%-50%, which can reach 66%, depending on the dulling and defatting process [8]. Indeed, reiterate that SFM has relatively balanced amino acid content, enhancing its attractiveness as a supplement in animal diets. According to, SFM by products can be wholly utilized if applied as an unconventional human protein source [9].

Unfortunately, there is no evidence of the use of SFM as a protein source for the human diet in Africa, an issue that this review seeks to explore. Importantly, though, the protein isolate extracted from SFM can be essential in addressing malnutrition, a problem that has adversely affected the continent. Previous scholars have reiterated the role of proteins in curbing malnutrition [10]. According to a 2007 technical report by the World Health Organization, the estimated daily nitrogen and protein requirement for the average population, the average is

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105 mg/kg body weight and 0.66 g/kg body weight. Unfortunately, the estimated protein consumption in developing countries, including Africa, is significantly lower than the required daily average levels indicated above [11]. In addition to the quantity of proteins, contemporary food biotechnologists are exploring ways of enhancing the availability of quality protein sources. These sources include those with increased digestibility and anti-oxidative properties like SFM sources.

The sunflower crop has been cultivated since time memorial and is predominantly used to produce edible oil and animal feed and as a source of biofuel [12]. Besides soybeans, cotton seeds, and rapeseeds, sunflower seed is one of the major oilseeds produced globally. Indeed, sunflower seed production was estimated at 37.8 million tones, producing approximately 15 million tones globally in 2012. Sunflower seed is the fourth major oilseed and the third-most consumed oil by both animals and humans.

LITERATURE REVIEW

As the food industry endeavors to increase its sunflower oil production to meet the ever-increasing global demands, the production of SFM surges, primarily because the meal is generated as a by product in the process. In Brazil, for instance, 23 100 tons of SFM were generated from 66 000 tons of grains during the oil extraction process in 2003 [13-17]. While SFM has been hailed as suitable for animal feed and human nutrition based on its nutritional value, the 25% lignin and 50% cellulose contents, low dietary metabolizable energy, and phenolic compounds have limited such usage [18]. The inclusion of SFM in swine and broiler diets should not exceed 20% and 16%, respectively, failure of which the performance would be compromised [19]. Therefore, immediate environmental concerns are emanating from the disposal of SFM, especially in the wake of increased sunflower oil production.

This study seeks to establish the use of sunflower meal in Africa, especially for human nutrition. This comes in the wake of widespread use of SFM for animal nutrition in Africa, without its consideration as a potentially viable nutritional component in the human diet, despite the vast empirical evidence to that effect. Mainly, protein isolates from sunflower meals can be fundamental in food formulations and salad dressings, thus bridging the protein gap witnessed in Africa and globally. In Africa, for instance, sunflower meals can be vital in addressing the problem of malnutrition that has since dogged the populace of the continent, as explained previously in this article. Indeed, it is wise to note that the use of sunflower cake for human nutrition rather than animal feed paves the way to pursue increased sustainability in food production globally, and Africa is not exceptional.

Production of sunflower meal in Africa

SFM emanates from the sunflower oil production process and is often treated as a by-product [20]. According to, SFM can be generated using solvents or through mechanical means, primarily from decorticated or whole seeds. The quality of SFM hinges not only on the plant's attributes, such as seed composition, growth and storage conditions, and kernel ration but also on processing, including the dulling process and mechanical or solvent extraction.

The production of SFM has shown a steady growth trend in recent times, primarily attributable to the increase in the extraction of sunflower oil globally. According to statistics from the Murder intelligence report, the global market value of SFMs was estimated at USD 5.2 million in 2018 and is expected to grow at 6.05% between 2019 and 2024 to reach USD 6.9 million. Europe recorded the highest market value of SFM in 2018, generating USD 1.5 million in revenue, while Asia-Pacific ranked second [21-27].

The Sunflower is currently cultivated as an oilseed crop in warm-temperate, tropical, and sub-tropical climates across the world. African countries such as South Africa and East African countries, including Kenya, Ethiopia, and Tanzania, have mainly grown sunflower crops. According to the above author, oilseed production is less affected by drought, especially in the Sahel zone and the Eastern African countries, characterized by rampant famine-induced famine. Attributes the slow development in Africa's sunflower products to the deteriorated crop yield, mainly because of bird attacks.

However, the global market, including Africa, is currently witnessing an increase in the availability and competitiveness of the SFM. While provided relevant information regarding sunflower cultivation, the author fell short of explaining the potential use of SFM for human nutrition in Africa. Importantly, none of the reviewed empirical studies nor any other existing literature has explained such usage of SFM in the continent, an issue that calls for further research.

The upward trend in the production of SFM and the environmental concerns of the SFM calls for its complete utilization. The protein isolate/concentrate extraction from SFM is one of the effective and beneficial uses of the meal for the human diet. Such benefits are essential in the wake of the increased protein demand and low supply in the contemporary food industry. The subsequent section details the use of SFM as livestock feed, focusing on the African continent.

Major nutritional components of sunflower meal

Soybean, groundnut, rapeseed, cottonseed, and sunflower are the global primary sources of vegetable proteins. The meals' nutritional value is instrumental in ascertaining their quality, particularly regarding the anti-nutritional factors, amino acid, and fiber content. Notably, only SFM lacks anti-nutritional elements out of the five meals highlighted above, thus making it suitable for use for both animal and human nutritional purposes. The functional properties and nutritional value of SFM are as good as those of soybean, except for its deficiency in lysine content.

There are three types of SFM produced by the global sunflower oil extraction industry, namely, partially dulled meal (35%-37% protein), unshelled meal (28% protein), and double-hulled meal (40%-42% protein). A study conducted by also reiterated the potential of SFM to replace current familiar sources of protein, more so because of its nutritional attributes. Experts in the food industry have gained interest in sunflower protein because it is GMO-free and vegan and low in allergen content.

Experts have explored the use of SFM for human nutrition purposes, primarily as a result of its beneficial attributes. Several recent studies have highlighted various nutritional benefits of SFM, making it suitable for use in the human diet. A typical example is the high protein content, estimated to between 30% and 50% in dry matter. The percentage content of proteins in SFMs hinges on the oil extraction process, the region of cultivation, and the dulling approach. SFM also contains a substantial amount of relatively balanced amino acids, thus suitable for animal feed.

SFM also contains substantial amounts of phenolic compounds, including Chlorogenic and caffeic acids. Different SFMs contain diverse phenolic compounds, mainly due to differences in hulls content in the meal and the region in which the Sunflower was cultivated. Chlorogenic acid is the dominant phenolic compound in Sunflower, comprising up to 70% of the total phenolic compounds. Statistics show that SFM contains between 2% and 4% phenolic compounds. Therefore, meals derived from press residue might provide valuable antioxidants required in food technology.

However, empirical evidence shows that the presence of phenolic compounds in SFM has compromised its use, including in the human diet. The presence of chlorogenic acid in SFM inhibits protein isolate extraction by oxidizing to a permanent green color during the process.

Whereas experts have reported success in using modern biotechnology tools to extract protein from SFM for human consumption, the technologies are yet to be implemented in Africa. Various approaches have been utilized to extract proteins from SFM, including enzyme-assisted aqueous extraction, solvent extraction under alkaline conditions, and ultrasound based extraction processes. These approaches have reported different levels of effectiveness, and experts are in constant pursuit of more effective modern biotechnological tools to increase SFM protein extraction efficiency.

Nevertheless, this review has not established any previous or current project (s) in Africa involving the extraction of protein components from SFM. In doing so, there is a need to carry out empirical research to establish the reasons behind such shortcomings. The outcome of such studies would be vital in informing stakeholders in the continent's food industry of the possible measures to improve its protein production, especially from sunflower meal.

Other than sunflower meal for animal nutrition, the by products can also enrich human diets with valuable nutrients, including minerals, proteins, vitamin A and E, phenolic compounds, condensed tannins, flavonoids, and polyphenols. Further, argue that using organic solvents in extracting sunflower meal provides valuable protein extracts that can be utilized in spiced meat, bakery products, and potato-based products.

Interestingly, the above study uncovered remarkable outcomes regarding the use of synthetic Butylated Hydroxytoluene (BHT) and Butylated Hydroxyanisole (BHA) in the stabilization of the stored sunflower oil. According to the findings of this study, the addition of whole sunflower meal to the stored sunflower in the amount of 20 g/kg^{-1} was more effective in increasing sunflower oil stability compared to 0.1 g/kg^{-1} addition of BHT. On a similar note, de Leonardis, Macciola, and concur with the above findings, noting that sunflower polyphenols can be viable antioxidants for the sunflower oil stabilization endeavor, especially their chlorogenic, caffeic, and ferulic components. Reiterate the necessity of sunflower meal and hulls in providing phenolic compounds usable as natural antioxidants.

Scholars have also cited the importance of SFM in the bakery, including bread and cookies, among other products. In their study on the production of SFM derived protein isolate and its application in the preparation of functional wheat bread, established technological feasibility in the production of bread integrated with SFM isolate. The study involved incorporating the isolate to dough formula, comprising between 8% and 12% of total wheat flour. A similar survey by Martins, Pinho, and Ferreira also supported the viability of incorporating functional ingredients from industrial by-products into bakery products. The authors contended that such an initiative is essential in enhancing health-promoting attributes and improving traditional bakery products' nutritional value. The protein, minerals, and dietary contents of by-products, including SFM, are crucial in determining their values.

The use of SFM as a source of animal nutrition

Animal feed provides the largest market for SFM. Notably, the high protein content in SFM makes it a suitable and valuable source of protein for different categories of livestock. Several previous empirical studies have highlighted the use of SFM in livestock and poultry feeds across the globe.

Africa is not exceptional in the use of SFM as livestock and poultry feed. In the wake of high livestock feed ingredients, farmers across the continent are constantly pursuing a more economical and nutritional source of proteins for their livestock. SFM remains a potential alternative to the existing poultry and livestock feeds, such as soybean. Typically, it has lower lysine, with high fiber content, thus cheaper than meals derived from other significant oilseeds.

Not only does SFM contain high protein (between 30% and 50%) and nutritional value, but it also exhibits antioxidant properties and is free of anti-nutritional components. Adejumo and note that the meal has been instrumental in replacing approximately 50% of soybean in broiler rations. Indeed, the fortification of the SFM with amino acids or enzymes can increase its potential to replace soybean meal completely.

Nonetheless, the utilization of SFM as a source of proteins is limited by specific attributes of the meal. Kreps, affirm the existence of phenolic compounds in SFM, such as caffeic and chlorogenic, which inhibit the meal's consumption to a large extent. According to, defatted SFM contains approximately 4200 g/100 g. The content of hulls in the SFM and the variety of Sunflower based on their region of cultivation may determine the differences in phenolic compounds content. These compounds inhibit the utilization of proteins from the SFM, particularly for human nutrition.

The current review has not established any empirical evidence on the use of SFM for human nutrition in Africa. Such a lack of efficient utilization of SFM is probably attributable to the lack of modern biotechnology tools or expertise to extract the nutrient from the by-product. In so doing, SFM remains underutilized in Africa and primarily fed to animals, albeit with challenges mentioned previously in this research. With the increase in protein demand and scarcity of nutrients in the human diet across the globe, the continent must explore multiple alternatives to increase its supply, including but not limited to the extraction from SFM.

The upward growth trend of sunflower oil production across the globe is an additional advantage, particularly given the concurrent generation of SFM as a by-product. Extracting proteins from the protein-rich SFM may help bridge the protein gap and address the potential environmental concerns associated with the by-product. Indeed, explained that the amount of rapeseed and sunflower defatted seed meals had increased recently. Therefore, there is an increasing opportunity to valorize these products, more so on environmental and economic fronts. Recent scholars have highlighted various methods of extracting protein isolate from SFM, including using solvents and mechanical means such as ultrasound-aided processes, among other technologies.

Overview of the SFM protein extraction techniques

The conventional techniques of extracting food components from sunflower meal have contributed immensely to the substrate's destruction. Typically, these techniques utilize heating, solvent, and acidic conditions, thereby compromising the original functionality by damage, as mentioned above. The heating mechanism and the application of organic solvents in the extraction process often contribute to the denaturation of the protein structures and a decline in oil quality, thereby lowering the substrate's functionality.

Although both aqueous fractionation and cold pressing are suitable replacement techniques for the conventional approaches, they produce a fraction of proteins, phenolic compounds, and lipids rather than the intended protein isolate. Such strategies have put much emphasis on functionality by producing fractions of proteins and not isolates. Highlighted the various factors determining protein extraction from the sunflower meal. According to the above authors, sunflower-derived proteins have low solubility features, especially in mildly acidic conditions, thus the justification of its extraction under alkaline conditions. Nonetheless, such a condition encourages the interaction between protein and phenols, causing a dark coloration that is not appropriate for human consumption.

DISCUSSION

Besides, protein isolates have been extracted from sunflower meal using ethanol precipitation and isoelectric techniques. The approach involves supplementing the protein isolates with NaCl under specific pH to ascertain the optimum condition's extraction process. Knowing the effects of the factors mentioned above on SFM protein isolates' functionality is essential to the future application in the food sector.

Also, food scientists have utilized enzymatic hydrolysis to extract protein isolates and concentrate from sunflower meal. Experts have used Flavourzyme and Alcalase enzymes through two-step hydrolysis to obtain protein isolates or concentrate from defatted SFM. Recently, food scientists have embraced the use of ultrasound in optimizing the extraction of protein isolate from sunflower meal. Instead of using heat, the technology employs frequencies under optimum temperatures, pH, and time to obtain optimum and high-quality protein isolate yield during the extraction process. Malik, Sharma, and conclude that high-intensity ultrasound technology helps obtain protein isolate with great functional features.

Issues and challenges

While protein isolates extracted from SFM presents an array of benefits, including its use as a food additive in different mediums, lament that there is limited use of the isolate resulting from its anti-nutritional properties. The anti-nutritional compounds present in the SFM derived protein isolates include polyphenols, of which coffee acids and chromogenic acids are the most dominant. The change in color of the SFM-based proteins, the SFM, and food matrices during extraction is attributed to the polyphenols.

Additionally, the interaction between methionine and lysine and these substances lowers the nutritional content of the protein isolate or concentrates extracted from the SFM. The failure to remove the substances above will limit the application of SFM in the human diet. Notably, the lack of advanced technologies and equipment for protein extraction from SFM in Africa is, indeed, a pressing issue as the continent aspires to address the protein gap, malnutrition, and food security in general. Other than the lack of resources mentioned above, there are highly limited literatures in Africa that highlight the use of SFM for human consumption. Most of the existing studies on SFM have solely concentrated on using the meal for animal nutrition.

CONCLUSION

SFM presents a broad range of nutritional benefits, therefore a viable protein source for human and animal nutrition. The meal has high protein content estimated to be between 30% and 50% subject to the dulling and defatting process. Also, the meal contains fiber and phenolic compounds. Although phenolic compounds are known to be good antioxidants, studies show that they limit the consumption of SFM by causing oxidation to irreversible green pigment. SFM has been used dominantly as animal nutrition globally, particularly in Africa. There has been growing interest in the use of SFM for human consumption as experts explore ways of extracting protein isolates and concentrate from the meal.

Still, such technologies are yet to be implemented in Africa, an issue probably attributed to lack of expertise or inadequate technologies in the continent. Essentially, this review has not established any empirical studies on the human consumption of SFM in Africa, despite the increasing protein demand across the globe. SFM exhibits anti-nutritional properties, and the protein isolate extracted from SFM may be applicable for multiple food purposes such as salad dressings and meat products. As Africa embraces sunflower oil extraction, there is an increased need to explore the use of SFM for human consumption to ensure wholesome utilization of the by product.

Modern technology has become fundamental to the food industry, thus should be embraced in extracting protein from SFM for food purposes in Africa. The initiative would be vital in bridging the global protein gap and efficiently utilizing SFM and addressing potential environmental concerns associated with the by-product. Furthermore, empirical research is necessary to ascertain individual African countries' progress in using SFM for the human diet, especially those involved in the large-scale production of sunflower oil.

HIGHLIGHTS

- There is an upward trend in sunflower meal generation as a result of increased sunflower oil production in Africa
- Sunflower meal is primarily used for livestock and poultry nutrition without evidence of human consumption in Africa
- Sunflower meal is underutilized in Africa because of the presence of phenolic compounds and the lack of modern biotechnological tools to extract protein isolates and concentrates
- Africa should embrace contemporary technologies in extracting proteins from sunflower meal for human nutrition

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DECLARATION OF INTEREST

None

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