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Effects of Gamma Irradiation on Physico-chemical, and Functional Properties of Irish Potato Tubers and flours is Dose and Varietal Dependent

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Abstract

Irish potato (Solanum tuberosum L.) is a globally significant food crop, serving as a staple for many populations and contributing to food security. Gamma irradiation has emerged as a promising postharvest technology to extend the shelf life of potato tubers by inhibiting sprouting, greening, and microbial spoilage. This review comprehensively analyzes the impact of gamma irradiation on the physical, chemical, and functional properties of Irish potato tubers and flours. Optimal doses of gamma irradiation (50-150 Gy) effectively control sprouting and maintain firmness by delaying metabolic processes. However, higher doses can negatively impact morphology, potentially reducing tuber size and weight. Texture is also affected, with irradiation potentially causing cell wall breakdown, leading to decreased hardness. Gamma irradiation can reduce moisture content due to increased water radiolysis. Protein content may decrease due to structural changes, while lipid content can be reduced through peroxidation or inhibited biosynthesis. Mineral content, such as sodium and potassium, may also decline. Interestingly, irradiation can decrease anti-nutritional factors like solanine and enhance antioxidant properties. Effects on reducing sugars are variable and dose-dependent, with potential for both increases and decreases. Water absorption capacity (WAC) generally increases following irradiation due to starch granule breakdown. Oil absorption capacity (OAC) can be enhanced through oxidation and degradation of starch components. Pasting properties, crucial for texture and consistency, are modified, with peak viscosity potentially increasing at lower doses but decreasing at higher doses. While gamma irradiation offers benefits in preserving potatoes and reducing postharvest losses, it is essential to optimize irradiation conditions to minimize any adverse effects on quality and ensure consumer acceptance.

Keywords: *Physico-chemical, Gamma irradiation, Functional properties, Irish potatoes, Proximate composition*

Introduction

The word potato was coined from the Spanish name "*patata*," a name they refer to for potatoes, while in South America, it is called "batata" (Grun, 1990). Irish potato (*Solanum tuberosum L.*) belongs to the *Solanaceae* family and originated from South America in Peru and has been adopted globally, except in Antarctica (Ndungutse *et al*., 2019). The Irish potato is a crucial source of carbohydrates, dietary fiber, and essential micronutrients, playing a vital role in global food security (Abong *et al*., 2009). The carbohydrate is starch which is composed of amylose (23-31%) and amylopectin (70-77%) in the ratio1:3 (Bonierbale *et al*., 2010). Less than 50% of potatoes produced globally are estimated to be consumed while fresh, with some used to make frozen fries, flakes, snacks, flour, and starch (Santos *et al*., 2016). Industrial processing adds value to tubers, extends the storage period, and minimises post-harvest losses and waste. This is important for countries like Kenya, where the ever-increasing towns and cities have placed a great demand for fast food, resulting in the growth of fast-food outlets. The outlets mainly deal in potato processing, which has stressed the potato value chain due to its high utilization in preparing French fries and frozen chips (Gikundi *et al*., 2021).

Irish potatoes are susceptible to postharvest losses due to sprouting, greening, and microbial contamination. Gamma irradiation, a non-thermal preservation technique, has gained attention for its potential to mitigate these losses and ensure a consistent supply of high-quality potatoes (Rezaee *et al*., 2011). While gamma irradiation has been shown to effectively extend the shelf life of potatoes, its impact on the tubers' physical, chemical, and functional properties needs to be thoroughly understood to ensure the safety and quality of irradiated potatoes and is the focus of this article.

Irish Potatoes Physicochemical and Functional Properties

Irish Potatoes Physical Properties

According to Githieya *et al*. (2021), potato tubers are categorised according to their shape, eye depth, texture, the colour of the flesh, maturity time, disease resistance, cooking quality, starch composition, and type. Other characteristics include average weight, greening, and sprouting, and they are critical in the selection of tubers for different processing applications (Gikundi, 2021). These characteristics allow potato breeding for specific functional, processing, and nutrition quality traits due to variations in the physicochemical properties. The physical properties of tubers are vital in designing the type of packages to be used, processing operations, and conveying and grading systems to be applied when sorting out the tubers (Abedi *et al*., 2019).

The shape and size of tubers are vital characteristics to consider during tuber selection. The shape of tubers is classified as either round, oval, elongated, or oblong, and each shape determines the trimming and peeling efficiency during potato processing (Kumari *et al*., 2018). According to Abong *et al*. (2010), round-shaped tubers are best used in making crisps, while oval-shaped tubers are best in making French fries since they give the best product characteristics in terms of diameter and length, respectively.

Another vital physical property of irish potatoes is colour. Colour is an essential attribute of tubers since it influences consumers' decision to buy. The skin and flesh colour of tubers vary by variety from white to purple, which also influences the end product of the tubers (Oliveira *et al*., 2020). Coloured potato tubers, such as the yellow-coloured, purple, and red-fleshed, are an excellent source of anthocyanin and carotenoid pigments, which can be used as natural colourants, and these antioxidants play a significant role in the human body (Subía, 2013).

Eye-depth is an equally important trait for tubers, especially in the processing industry, where the tubers have to be peeled and prepared into consumable products. Eye depths are classified as deep if they measure >0.6 mm, shallow 0-0.2 mm, and medium if measuring between 0.3-0.5 mm (Abong *et al*., 2010). Shallow to medium eyes are preferred since they minimize wastage during peeling compared to deeper eyes, which affects the appearance of the tubers and result in additional peeling costs in industries (Subía, 2013; Kumari *et al*., 2018).

Specific gravity is the average estimation of tubers' total solids or dry matter content. Tuber-specific gravity is the quickest and easiest way of determining its suitability in preparing certain food products. According to Wayumba *et al*. (2019), tuber-specific gravity is one of the best way to determine potatoes' mealiness and dry matter content since tubers with high dry matter content and high specific gravity produce French fries that are crispy, mealy, and golden in colour. On the other hand, low-specific gravity potatoes are suitable for canning since they do not disintegrate quickly during processing and do not fall apart easily after preparation (Saad, 2009; Ndungutse *et al*., 2019).

Effects of Gamma Irradiation on the Physical Properties of Irish Potatoes

The effects of gamma irradiation on the physical properties of Irish have garnered significant attention in recent years, particularly due to its implications for food preservation. Gamma irradiation, when applied in the right amounts, can improve the shelf life of tubers by inhibiting greening, sprouting, and rotting with no adverse effects on the nutritional and sensory quality of the tubers. Proper irradiation rates can eliminate the need for preservation chemicals (which can produce undesirable side effects) and have sterile products that can be stored for extended periods under ambient temperatures (Sarkar & Mahato, 2020; Rezaee *et al*., 2011). According to Rezaee *et al*. (2011), extending potato shelf life through irradiation treatment during post-harvest storage reduces losses and helps to ensure a steadier and more stable supply of tubers. Previous studies by Joshi *et al*. (1990) and Hayashi (1988) found that the application of gamma radiation (100 Gy) on tubers that were stored for six months under temperatures of 15°C resulted in tubers with low sugar levels, inhibited sprouting, reduced rotting and maintained the weight of the tubers. Conversely, lower doses of gamma irradiation (3 to 9 Gy) have been associated with an increase in plant height and tuber weight, suggesting a dose-dependent response that can be harnessed for crop improvement (Chepkoech *et al*., 2022).

According to the International Atomic Energy Agency (IAEA) and other research findings, including Lu *et al*. (2012), gamma irradiation with doses between 50 to 150 Gy is optimum for controlling tuber sprouting, especially during the dormancy period. A study by Rezaee *et al*. (2011) among Agria potato tubers widely grown in Iran also found that applying 50 -150 Gy of ionizing gamma radiations to potato tubers maintained the tuber’s firmness and suppressed sprouting during long-term storage at about 8°C. This was attributed to the radiation's ability to delay metabolic processes that lead to sprouting, thereby preserving the tubers' quality during storage. Munir *et al*. (2015) also noted that gamma irradiation at 0.1 kGy reduced microbial contamination and sprouting significantly as well as rotting among Irish potatoes stored for over 12 months, indicating that it can easily be adapted to maintain tuber’s quality over a long period. Similarly, Ara *et al*. (2023) established that gamma radiation effectively controlled post-harvest rot and extended the shelf life of potatoes, making it a viable option for food preservation (Ara *et al*., 2023). This is particularly relevant in the context of increasing food safety concerns and the need for effective preservation methods.

Despite the positive contributions of gamma irradiation on improving shelf life and preventing tuber susceptibility to pests and diseases, applying the rays can also confer unfavourable characteristics to the tubers by interfering with some tuber physical properties. One of the primary effects of gamma irradiation on Irish potatoes is the alteration of their morphological and physical characteristics. Studies have shown that exposure to gamma rays can significantly influence tuber size, weight, and overall yield. For instance, research by Sarkar

& Mahato (2020) and Kara & Arıcı, (2019). demonstrated that doses exceeding 20 Gy were lethal to micro-propagated potato plants, indicating a threshold beyond which physical properties are adversely affected.

The impact of gamma irradiation on the texture and firmness of potatoes has also been extensively documented. Liu *et al*. (2022) reported that irradiation at 15 kGy resulted in a significant reduction in hardness, with mean values decreasing from 229.96 g in non-irradiated samples to 166.54 g in irradiated ones (Liu *et al*., 2022). This reduction in hardness can be attributed to the breakdown of cell wall components, which affects the overall texture of the tubers. Such changes in texture are crucial for consumer acceptance and marketability, as they directly influence the culinary applications of potatoes. Similarly, the IAEA (1997) noted that exposing Irish potatoes to gamma irradiation can significantly reduce weight lost during storage. The agency suggested that irradiation dosages ranging from 0.1 kGy to 0.5 kGy were highly effective in preventing sprouting and reducing weight loss compared to samples that had not been irradiated. They documented that those non-irradiated potatoes showed weight reductions ranging from 28% to 51% over six months.

Ezekiel *et al*. (2008), in a study to determine the effects of gamma irradiation dose on chips quality, found that 0.01 and 0.05 kGy of irradiation resulted in an increase in weight by about 23% in stored potatoes. Sarkar & Mahato (2020), in their study noted that irradiation of tubers with doses of 100 and 200 Gy, resulted to colour and weight changed of those tubers irradiated with 200 Gy, unlike those with 100 Gy. They also demonstrated that although skin colour remains consistent after irradiation, the colour of the flesh changed due to the amount of radiation exposure and storage conditions, and these can affect how consumers perceive and accept the product. Optimal irradiation doses are dependent on storage temperature and the intended use of the tubers, with 15-25 Gy suitable for mature potatoes stored at 6-7°C and 50 Gy for potatoes intended for frying stored at 9-10°C (Maltsev *et al*., 2022).

Irish potatoes Proximate and Chemical Composition

Irish potatoes are important in human health and general nutrition since they contribute to the physical requirements of proteins, dietary fibre, and essential micronutrients (Abong *et al*., 2009). Carbohydrates in potatoes make up for up to 80% of the total dry matter. The dry matter of potatoes is primarily composed of starch, which acts as the primary energy store for the plant and gives the tubers the most desirable characteristics, including good mouthfeel, gelling, thickening, coating, bulking, and adhesion properties (Santos *et al*., 2016). The proximate and nutrient composition of Irish potatoes when fresh and under different processing application is summarized in Table 1.

Table 1: Nutrient Composition of Irish Potatoes (g/100g)

Nutrient	**Raw (Flesh and Skin)**	**Boiled (Flesh Only) Cooked Without Skin**	**Boiled (Flesh Only) Cooked in Skin**	**Baked (Flesh and Skin)**	**Microwaved (Flesh and Skin)**	**Oven-Baked Chips [1]**	**Fried Chips 2**	**Daily RNI; (M/F)**
Water (g)	79.3	77.5	77.0	74.9	72. 0	64.4	38.6	-
Energy (kcal)	77	86	87	93	105	158	312	-
Protein (g)	2.1	1.7	1.9	2.5	2.4	2.8	3.3	-
fat (g)	0.1	0.1	0.1	0.1	0.1	5.5	14.7	-
Carbohydrate (g)	17.5	20.0	20.1	21.2	24.2	25.6	41.4	-
Fiber * (g)	2.1	1.8	1.8	2.2	2.3	2.0	3.8	-
Minerals								
Calcium (mg)	12	8	5	15	11	12	18	700
Iron (mg)	0.81	0.31	0.31	1.08	1.24	0.57	0.81	8.7/14.8
Magnesium (mg)	23	20	22	28	27	24	35	300/270
Phosphorus (mg)	57	40	44	70	105	87	125	550
Potassium (mg)	425	328	379	535	447	478	579	3500
Sodium (mg)	6	5	4	10	8	324**	210**	1600
Zinc (mg)	0.30	0.27	0.30	0.36	0.36	0.35	0.50	9.5/7.0
Vitamins								
Vitamin C (mg)	19.7	7.4	13.0	9.6	15.1	8.7	4.7	40
Thiamin (mg)	0.081	0.098	0.106	0.064	0.120	0.130	0.170	1.0/0.8
Riboflavin (mg)	0.032	0.019	0.020	0.048	0.032	0.032	0.039	1.3/1.1
Niacin (mg)	1.061	1.312	1.439	1.410	1.714	2.077	3.004	17/13
Vitamin B6 (mg)	0.298	0.269	0.299	0.311	0.344	0.261	0.372	1.4/1.2
Folate (µg)	15	9	10	28	12	23	30	200
Vitamin B12 (µg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5
Vitamin A (µg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	700/600
Vitamin E (mg)	0.01	0.01	0.01	0.04	0.01	0.39	1.67	-
Vitamin D (µg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
Vitamin K (µg)	2.0	2.2	2.2	2.0	2.0	7.4	11.2	-

Sources: Ooko (2008); Abong *et al*. (2009); Bonierbale *et al*. (2010); Subía (2013); Ramadan (2016); Waglay & Karboune (2016); Robertson *et al*.(2018); USDA, (2019); Wayumba *et al*. (2019)

Effects of Gamma Irradiation on the Proximate and Chemical Properties of Irish Potatoes

Gamma irradiation, when done as a post-harvest handling strategy, can result in reduced moisture content when done at higher doses (> 50 Gy), as documented by Soares *et al*. (2016). This is because gamma irradiation tends to boost water's radiolysis, which increases the rate at which the moisture is lost from the tubers during storage (Soares *et al*., 2016). A study by Ara *et al*. (2023) also indicated that gamma irradiation can lead to a reduction in moisture content, which is crucial for extending the shelf life of potatoes. This reduction in moisture is often accompanied by changes in the carbohydrate content, as lower moisture levels can concentrate the remaining nutrients. Similarly, gamma irradiation has been reported to decrease the total protein content (Jan *et al*., 2012). For instance, a study by Maltsev *et al*. (2022) found that gamma irradiation significantly reduced the total protein content of Irish potato tubers exposed to gamma doses of between 25-50 Gy. The reduction in proteins content is due to structural changes to proteins, including the unfolding of protein molecules which can lead to the loss of functional properties and a decrease in overall protein content as the structural integrity is compromised (Jan *et al*., 2012). Contrary to their findings, other studies by Nouri & Toofanian, (2001), Costa *et al*. (2013), and Soares *et al*. (2016) found no significant differences between the total protein content of gamma-irradiated tubers compared to their parent tubers despite the different radiation levels used in the respective studies hence the need for more investigations of how the protein content is impacted especially for tubers subjected to gamma irradiation.

Crude lipid content has also been documented to be affected variedly by gamma irradiation, depending on the dosage used. The lipid content of harvested tubers that were irradiated at 1 kGy and 0.5 kGy and then stored at 20°C for 26 weeks and 5 °C for 28 weeks, respectively, was found to be lower in experiments conducted by Mondy & Gosselin (1989) and Todoriki *et al*. (1994). The two investigations demonstrated the impact of storage temperature and radiation level on lipid content, with lower temperatures and higher radiation levels leading to greater lipid content loss. They also reported that the amount of lipids in the tubers decreased as the dosage of irradiation and storage period increased. This is because as the rate of irradiation increases, it generates free radicals which can initiate lipid peroxidation or accelerates oxidative reactions, resulting in the breakdown of fatty acids and other lipid components. Irradiation may also inhibit the enzymes responsible for lipid biosynthesis resulting in reduced synthesis of new lipids (Todoriki *et al*. 1994). Gamma irradiation process has also been noted to potentially lead to a reduction in the levels of certain anti-nutritional factors, such as solanine, which is beneficial for consumer health (Wailare & Madu, 2019; Aycan *et al*., 2021; Haider *et al*., 2022). Furthermore, gamma irradiation treatment can enhance the antioxidant properties of potatoes, contributing to their nutritional value (Bian *et al*., 2019; ; Ara *et al*., 2023; Asmarani, 2024).

The mineral composition of Irish potatoes has previously been found to be affected by gamma irradiation when applied as a post-harvest handling strategy. A study by Sanni *et al*. (2015) noted that the application of gamma irradiation resulted in a reduction of minerals, including sodium, potassium, lead, and copper, which was dose-dependent. The reduction in minerals after irradiation could also be due to a high concentration of antinutritive factors that result from gamma irradiation, which mask the minerals, preventing ease of extractability during spectrophotometric processes (Manupriya *et al*., 2020).

Studies have also shown that lower doses of gamma radiation can increase sugar content, while higher doses can decrease reducing sugars (Lim *et al*., 2005; Liu *et al*., 1990; Rezaee *et al*., 2013). Additionally, the timing of irradiation plays a role, with early irradiation before storage resulting in lower increases in reducing sugars than delayed irradiation (Rezaee *et al*., 2013). According to a study by Liu *et al*. (1990), gamma irradiation can lead to varying effects on reducing sugar content based on factors such as dose, timing of irradiation, and storage conditions. The generation of free radicals during irradiation can promote oxidative reactions that degrade carbohydrates, including reducing sugars hence a reduction in sugar content (Liu *et al*., 1990). Similarly, Maltsev *et al*. (2022) also found that gamma irradiation at 50 Gy reduced the amount of reducing sugar content in Irish potatoes by 2-2.5 times, enhancing fried product quality by improving the colour due to decreased sprouting. This reduction in sugar levels may be beneficial for individuals managing their blood sugar levels, as it can lead to lower glycemic responses when consuming irradiated potatoes.

However, the extent of this effect can vary depending on the specific variety of potato and the irradiation conditions applied (Sarkar & Mahato, 2020). Higher doses of gamma irradiation (≥ 50 Gy) were also found to have minimal impact on dry matter, starch, nitrate, and vitamin C content of the tubers (Maltsev *et al*., 2022). However, gamma irradiation can also result in increased reducing sugar content in Irish potatoes after storage at 10 °C, impacting processing quality (Ogata *et al*., 1959). A study by the IAEA (1997) noted that gamma irradiation doses ranging from 0.04 to 0.16 kGy increased sucrose among some tuber varieties from the U.K. and noted that gamma irradiation reduced Irish potatoes' total reducing sugar content.

Other Study findings by Lu *et al*. (2012) and Soares *et al*. (2016) also reported that gamma irradiation of tubers increased total glucose levels in two potato varieties. However, a study by Gökmen *et al*. (2007), who studied the effects of irradiation on tubers done at 50 and 200 Gy, reported that total reducing sugars in the tubers reduced as the irradiation levels increased. Another study by Maltsev *et al*. (2022), who studied tubers exposed to irradiation doses of between 15 to 50 Gy, noted a significant decrease in reducing sugars by about 2 to 2.5 times and also noted that irradiation doses of 25 and 50 Gy were optimal in producing tubers suitable for processing into fried products since it helped reduce the sugar content to recommended levels to deter browning of the fries. The decrease in reducing sugars was caused by alteration of metabolic pathways in tubers since radiation disrupts enzyme activities involved in sugar synthesis and degradation, resulting in lower levels of reducing sugars (Maltsev *et al*.,2022). Generally, different potato cultivars may respond differently to irradiation in terms of their physicochemical changes and the irradiation doses used.

Irish Potatoes Functional Properties

The functional attributes of potato starch, such as its capacity to thicken and form a gel, are essential for its utilisation in food processing and other industries (Nwokocha *et al*., 2014). Potato starch, being the predominant component, directly influences the functional properties of the tubers. Irish potatoes' most critical functional properties that determine their applicability include Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), and pasting properties.

Water absorption capacity (WAC) refers to the maximum amount of water flour can absorb and retain before becoming saturated, and it is normally expressed as a proportion of the flours weight. A study by Singh *et al*. (2018) revealed that the WAC of Irish potato flour varied between 2.5 to 3.5 g/g, suggesting that Irish potato flour could be used as an effective thickening and binding agent in food formulations. In another study conducted by Klang *et al*. (2019), the water WAC of various types of Irish potato flours was examined, and they revealed that it was affected by factors such as temperature, processing techniques (such as bleaching), and the variety of potatoes. Oil absorption capacity (OAC) is the amount of oil that flour can absorb and retain, typically expressed as the weight of oil absorbed per unit weight of the flour. OAC is a significant functional property, especially in frying and baking applications. In their study, Yussuf *et al*. (2024) found that chemical alterations, such as oxidation and acetylation of starch, enhanced the OAC of Irish potato starch. More precisely, oxidation caused a 26.7% rise in OAC, but acetylation resulted in a significant 138% increase. The increase in OAC was ascribed to incorporating functional groups onto the starch molecules, perhaps augmenting their attraction to oil. In another study, Kaur *et al*. (2013) found that Irish potato flour had an OAC of 1.5 to 2.0 g/g, which suggests that the flour has the ability to improve the consistency if used in soups.

Pasting properties refer to the characteristics of starch when it is subjected to heat in the presence of water (Olatunde *et al*., 2017). These properties also play an essential role in determining the texture and consistency of the final product. Adedokun & Itiola (2010) documented that the key pasting parameters characterize the gelatinization behaviour of starch when exposed to heat. The pasting temperature signifies the onset of starch gelatinization, where the granules begin to swell and lose crystallinity. Peak viscosity indicates the starch's maximum swelling and water-binding capacity, reflecting its thickening potential. Breakdown viscosity measures the stability of swollen granules under shear and heat, providing information on their resistance to mechanical stress. Final viscosity, measured after cooling, reveals the extent of starch retrogradation or reassociation, influencing the texture and stability of the final product. Setback viscosity refers to the increase in viscosity upon cooling, further quantifying the starch's tendency to retrograde. The pasting properties of Irish potato flour and starch might vary depending on various factors, such as the potato cultivar, cultivation conditions, and processing techniques (Buzera *et al*., 2023). The pasting characteristics of Irish potato flour and starch render them well-suited for various uses within the food sector.

Effects of Gamma Irradiation on the Functional Properties of Irish Potatoes

Gamma irradiation is documented to affect the functional and rheological properties of different flours, including those of Irish potatoes. Gamma irradiation can significantly alter the water absorption capacity (WAC), oil absorption capacity (OAC), and pasting properties. Several study findings have noted that Irish potatoes' WAC, amylose leaching, and transmittance increased, whereas swelling power, syneresis, and pasting properties decreased with increasing doses of gamma irradiation (Lim *et al*., 2005; Liu *et al*., 1990; Rezaee *et al*., 2013; Maltsev *et al*., 2022). Moreover, the water absorption index (WAI) is another critical parameter that reflects the extent of water uptake by potato starch. Studies have demonstrated that gamma irradiation can lead to a significant increase in the WAI of Irish potatoes, particularly at doses ranging from 10 to 30 Gy (Dettori *et al*., 2018; Widaningsih, 2023; Mohamed *et al*., 2023). This increase is attributed to the breakdown of crystalline structures within the starch granules, facilitating greater interaction with water (Widaningsih, 2023). The implications of this enhancement are profound, as a higher WAI can improve the texture and mouthfeel of potato-based products, making them more appealing to consumers. Gamma irradiation reduced starch viscosity but increased solubility, water absorption, and susceptibility to α-amylolysis (Verma *et al*., 2019). Irradiation also decreased gelatinization enthalpy and transition temperature but enhanced the antioxidant capabilities of Irish potatoes (Verma *et al*., 2019).

Application of gamma rays at doses <20 kGy induces active particles, including ions, free radicals, and electrons, which interact with starch molecules, resulting in oxidation and degradation of the starch components (amylose and amylopectin), which appear depolymerized and have reduced crystallinity (Gani *et al*., 2014; Lei *et al*., 2024). The changes in the structure of the starch makeup result in decreased potato starch viscosity but increased stability and anti-digestibility of the paste (Lu *et al*., 2012; Lei *et al*., 2024). Pasting properties, which include parameters such as peak viscosity, breakdown viscosity, and final viscosity, are also significantly influenced by gamma irradiation. Research has shown that irradiation can modify the pasting behavior of potato starch, leading to changes in viscosity profiles during cooking.

Different studies have reported that gamma irradiations at doses of 10 to 20 Gy can enhance peak viscosity, indicating a greater ability of the starch to swell and thicken when heated (Mansour *et al*., 2018; Chepkoech, 2018; Kara & Arıcı, 2019). This is particularly relevant for applications in food processing, where the thickening ability of starch is crucial for the production of sauces, soups, and other culinary products. It has also been noted that the starch’s fine structures, including helical, lamellar, pore, and channels, can also be altered through gamma irradiation, which results in changes in the pasting properties (Lei *et al*., 2024). Verma *et al*. (2019) also noted that gamma irradiation reduces pasting properties such as peak viscosity, trough viscosity, setback viscosity, final viscosity, and pasting temperature as the dosage of gamma rays increases.

The relationship between irradiation dose and the functional properties of Irish potatoes is complex and dose-dependent. While low doses of gamma irradiation can enhance water absorption and pasting properties, excessively high doses may lead to detrimental effects, such as the degradation of starch and loss of desirable texture (Wailare & Madu, 2019; Li & Huang, 2022). Therefore, it is crucial to optimize irradiation conditions to achieve the desired improvements without compromising the quality of the potatoes.

Conclusion

Gamma irradiation has emerged as a promising technology for preserving Irish potatoes and potentially enhancing their quality and processing suitability. The technique effectively controls sprouting, greening, and microbial contamination, extending the shelf life of tubers and reducing postharvest losses. However, irradiation can also induce changes in the physical, chemical, and functional properties of potatoes, which need to be carefully considered to ensure the safety and acceptability of irradiated products. The potential of gamma irradiation in potato breeding is an exciting area for future research, offering opportunities to develop new varieties with improved traits. Further investigations are necessary to optimize irradiation doses, understand the underlying mechanisms of irradiation-induced changes, and assess the long-term effects on potato quality and consumer acceptance.

Recommendations

- Further research is needed to optimize irradiation doses for different potato varieties and storage conditions to minimize any adverse effects on quality.

- The long-term impact of gamma irradiation on the nutritional value and safety of potatoes should be thoroughly investigated.
- Studies should explore the potential of gamma irradiation in potato breeding to develop new varieties with desirable traits.
- Consumer acceptance studies are crucial to understand public perception and address any concerns regarding irradiated potatoes.
- The development of clear labeling and regulatory guidelines for irradiated potatoes is essential to ensure transparency and consumer confidence.

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