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Effectiveness of Gamma Radiations on Properties of Wheat Grains & Chickpeas Starch: A Review

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Abstract- The study was done on impact of gamma irradiation on functional properties of starch that was isolated from irradiated wheat grains and chickpeas. It was undertaken by envisaging that there shall be a substantial demand very soon for modified starches. To meet the demand, the chemical modification of starch, including cross-linking, has been widely used to obtain desirable traits that are suitable for various food applications. Irradiation is employed for a wide range of reasons, like food disinfection, reducing or eliminating food borne diseases and extending the shelf life of the product. It is economically viable, safe, and possesses many benefits over alternative standard strategies utilized for modification and cross-linking. Starch isolated was treated by gamma irradiation at 0, 1, 10, 20 and 30 KiloGray doses. Effect of irradiation on functional properties of native starch was studied. Irradiation of starch results in the attainment of such desired functional attributes as reduction sugar, alpha enzyme activity, solubility, and others. This provides insight into the impact of gamma irradiation on the physicochemical and functional properties of starch. It additionally highlights the importance and also the exciting new opportunities afforded by radiation treatments as a physical means that for the modification of starch.

Keywords – Gamma irradiation, Irradiated wheat grain, irradiated chickpea, physico-chemical and functional evaluation.

I. INTRODUCTION

Food preservation has been a serious anxiety of man over the centuries. Contamination of food with microorganisms and pests causes extensive losses of foods throughout the storage, transportation and marketing (15% for cereals, 20% for fish and dairy farm merchandise and up to 40% for fruits and vegetables). Particularly, the pathogenic bacteria are a major cause of the human sufferings and public health issues all over the globe. The World Health Organization (WHO) stated that, the infectious and parasitic diseases accounted to the most frequent cause of death worldwide (35%), the majority of which happened in developing countries in 1992 [20].

Various processing techniques have been developed to control the spoilage of food and to increase the safety of consumption of food. The traditional methods of food preservation are such as pasteurization (by heat), canning, freezing, refrigeration and chemical preservatives are being used. Another technology that can be added to this list is irradiation. Food irradiation is the process of exposing amount of energy in the form of speed particles or rays for improving food safety, eliminating and reducing pathogens that destroy the food products. This is a very mild treatment, because a radiation dose of 1 kGy represents the absorption of just enough energy to increase the temperature of the product by 0.36°C. It means that, heating, drying and cooking cause higher nutritional losses. Moreover, heterocyclic ring compounds and carcinogenic aromatic produced during thermal processing of food at high temperatures were not identified in irradiated foods [33].

More than one century of research has gone into the understanding of the effective use of irradiation as a safety method. It has been repeatedly considered and judged suitable on available evidence. The projects on food irradiation are being investigated by international bodies including the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), WHO and Codex Alimentarius Commission (CAC) so as to verify the safety and quality of different irradiated products. It has shown that irradiation used on alone or in combination with other methods could improve the microbiological safety and extend shelf life [17]. Furthermore, people are very confused to distinguish irradiated foods from radioactive foods. It is not possible to induce radioactivity in the food by using gamma rays or electron beams up to 10 MeV and at no time during the irradiation process does the food come into contact with the radiation source [13].

The distinctions in sensitivity to radiation are caused due to the differences in chemical and physical structure of organisms, environmental factors, moisture content, temperature during irradiation, presence or absence of oxygen and in their ability to recover from the radiation injury. Radiation-pasteurized or sterilized foods are safe and nutritious even for humans according to long-term animal feeding studies [31]. Irradiation is used for a variety of reasons, such as disinfesting/sterilizing food, reducing or eliminating food borne pathogens, shelf life extending and may serve as a quarantine treatment for many fruits, vegetables, nuts, cut flowers and animal origin products to facilitating international trade of foods [22].

All foods are not appropriate for irradiation. For instance, some fruits (such as cucumbers, grapes, and some tomatoes) are sensitive to radiation. Nowadays, over 60 countries use irradiation for one or more food products. But, the misconceptions and irrational fear of nuclear technologies mostly caused the lack of acceptance of food irradiation. It should be noted that if irradiated products offer clear advantages, and the science-based information on the process is readily available, consumers would be ready to accept more irradiated products.

The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources. The importance of wheat is mainly due to the fact that its seed can be ground into flour, semolina, etc., which form the basic ingredients of bread and other bakery products, as well as pastas, and thus it presents the main source of nutrients to the most of the world population. A huge increase in demand for cereals is predicted if the food needs for the estimated world population growth are to be met. But there is another potentially great benefit to these communities and that is the possibility to ensure such staple crops are nutritionally-balanced and help remove the millions of cases of nutritionally-related deficiency disease that afflict them. It should be emphasized that in the past there has not been a single instance where plants have been bred to improve their nutritional content. If this has occurred it is purely by accident not design [19],[37].

Over three billion people are currently malnourished. This global crisis in nutritional health is the result of dysfunctional food systems that do not consistently supply enough of these essential nutrients to meet the nutritional requirements of high-risk groups such as the poor and the underpriviledged groups, pregnant women, infants,etc. [35]. One sustainable agricultural approach to reducing micronutrient malnutrition among people at highest risk (i.e. resource poor women, infants and children) globally is to enrich major staple food crops with micronutrients (such as vitamins and minerals) through plant-breeding strategies. Available research has demonstrated that micronutrient-enrichment traits are available within the genome of wheat (as well as other food crops) that could allow for substantial increases in the levels of minerals, vitamins and other nutrients and health-promoting factors without negatively impacting crop yield. Importantly, micronutrient bio availability issues must be addressed when using a plant breeding approach to eliminate micronutrient malnutrition. Enhancing substances (e.g. ascorbic acid, S-containing amino acids, etc) that promote micronutrient bio availability or decreasing antinutrient substances (e.g. phytate, polyphenolics, etc) that inhibit micronutrient bio availability, are both options that could be pursued in breeding programs [34],[35],[38].

Legumes are plants which belong to the family Leguminosae and are important sources of food due to their high protein (20–50%) and starch content (37–58%) [4]. Over the years the legume consumption has increased globally owing to their high nutritive value as well as low glycemic index. There are reports suggesting decrease in cholesterol and triglyceride level by consuming leguminous fibre (containing more amylose content than amylopectin). Interest in the consumption of legume flours is growing [5], particularly because of their functional properties viz,foaming, emulsification, texture, viscosity, gelation, water and oil absorption capacities [2].

These functional properties of legume flours may be attributed to the proteins, pectins, mucilages and other complex carbohydrates present in the flour. Among the major legumes, chickpea (Cicerarietinum) acts as one of the most important legume, in terms of economic importance and a key source of carbohydrates and proteins in the diet of people particularly in India, Pakistan, Afghanistan and Turkey [27]. The starch from legumes is often over looked by-product after the isolation of proteins from them. It is because of the high amylose (30%) content present, which confer poor functional properties when compared to cereal starches. However, with the advancements in the starch modification techniques, it has become possible to meet the requirements by simply restructuring the starch [14].

Extensive research has been done on the modification of starches from cereal sources. However, there is limited literature available on the modification of legume starch particularly by gamma irradiation. Gamma irradiation modifies the physical and chemical properties of macro-compounds in foods via free radical mechanism. Gamma irradiation reduced the gelatinization viscosity of the starch extracted from red gram. (Rao and Vakil) studied the effects of gamma irradiation on the flatulence causing oligosaccharides (stachyose, verbascose and raffinose) in greengram, they reported that the oligosaccharide content was reduced due to fragmentation in the polymeric chains. Similar results were reported by Rayas-Duarte and Rupnow for northern bean starch with increased maltose content due to the fragmentation and hydrolysis of starch molecules.

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Gamma irradiation on the functional properties of the cowpea and they reported that the swelling and pasting properties decreased while oil absorption capacity increased significantly with dose. Similar findings were reported for bean starch by [14]. Several other studies have revealed a reduction in viscosity, cooking time, increased digestibility and increased amino acid content in various irradiated pulses [12]. However, limited information is available related to the modification of chick-pea starch using gamma irradiation. Therefore, the present work was undertaken to explore the effects of irradiation on the physicochemical, thermal and functional properties of chickpea starch in order to exploit them for diverse food and non-food applications.

II. REVIEW OF LITERATURE

The research done in past by different research workers pertaining to the present investigation is reviewed in following section under suitable headings.

2.1 Physico-chemical properties of wheat grain

In his study, [41] revealed that the wheat grains vary from nearly spherical to long, slender to planar and are typically oval shaped. The grain incorporates a crease down on one facet wherever it absolutely was originally connected to wheat flower and that it is usually between 5 - 9 mm in length, and weighs between 35 - 50mg.

[6] studied that physical properties of agro-food materials are profitable on the grounds that they help in understanding of food processing and are needed as an input to models in predicting the quality and behavior of produce in pre-harvest, harvest, and post-harvest situations.[23]; The physical properties of grains are influences by various factors such as size of the grain, form, superficial characteristics and moisture content of the grain. The physical attributes of the material such as shape, size, volume, density, surface area and coefficient of friction are important and essential engineering data in design of machine, structures, and controls; in analyzing and determining the efficiency of a machine or an operation; and in evaluating and retaining the quality of the final product. Generally, the physical properties of grains are essential for the design of equipment for handling, harvesting, aeration, drying, storing, dehulling and processing.

[9]; studied that most of the part of the grain is protected by bran which are the outer layers of the wheat grain and which contains vitamin B, fibre components (53%) and minerals.The bran is separated from the starchy endosperm during the first stage of milling. In order to protect the grain and endosperm material, the bran comprises water-insoluble fibre. The wheat bran fibre has a complex chemical composition, even though it substantially comprises of cellulose and pentosans which are polymers based on xylose and arabinose, that are tightly bound to proteins. These substances are typical polymers present in the cell walls of wheat and layers of cells such as aleurone layer. Proteins and carbohydrates each represent 16% of total dry matter of bran. The mineral content is rather high (7.2%). The grain has two external layers (pericarp and seed coat) which are made up of dead empty cells. The cells of the inner bran layer- aleurone layer are filled with living protoplasts. This explains the rather high levels of protein and carbohydrate in the bran. There are large differences between the levels of certain amino acids in the aleurone layer and those in flour. Glutamine and proline levels are only about one half, while arginine is treble and alanine, asparagine, glycine, histidine and lysine are double those in wheat flour.

2.2 Physico-chemical properties of chickpea

[5] studied that legumes are plants which belong to the family Leguminosae. These are important sources of food due to their high protein (20–50%) and starch content (37–58%). Over the years the consumption of the legumes has increased globally owing to their high nutritive value as well as low glycemic index. There are reports suggesting decrease in cholesterol and triglyceride level by consuming leguminous fibre (containing more amylose content than amylopectin). Interest in the consumption of legume flours is growing particularly because of their functional properties viz, foaming, emulsification, texture, viscosity, gelation, water and oil absorption capacities. These functional properties of legume flours may be attributed to the proteins, pectins, mucilages and other complex carbohydrates present in the flour.

[14] studies have revealed a reduction in properties of irradiated pulses such as viscosity, cooking time, increased digestibility and increased amino acid content. However, very limited information is available related to the modification of chickpea starch using gamma irradiation. Therefore, the present work was undertaken to explore the impact of irradiation on the physico-chemical and functional properties of chickpea starch in order to exploit them for diverse food and non-food applications such as disinfection, extending of shelf life, etc.

[26] studied that among the major legumes, chick-pea (Cicer arietinum) acts as one of the most important legume, in terms of economic importance and a key source of carbohydrates and proteins in the diet of people particularly in India, Pakistan, Afghanistan and Turkey. The starch from legumes is often overlooked by-product after the isolation of proteins from them. It is because of the high amylase (30%) content present, which confer poor functional properties when compared to cereal starches. However, with the advancements in the starch modification techniques, it has become possible to meet the requirements by simply restructuring the starch.
[1] studied the impact of gamma irradiation on the functional proper-ties of the cowpea and they reported that the swelling and pasting properties decreased while oil absorption capacity increased significantly with dose.

[25] studied the effects of gamma irradiation on the flatulence causing oligosaccharides (stachyose, verbascose and raffinose) in green gram, they reported that the oligosaccharide content was reduced due to fragmentation in the polymeric chains. Similar results were reported by Rayas-Duarte and Rupnow for northern bean starch with increased maltose content due to the fragmentation and hydrolysis of starch molecules.

2.3 Irradiation properties of gamma rays

As per the studies of [16] Gamma rays with energies of 1.17 and 1.33 MeV are emitted by the Co-60 or energy of 0.66 MeV is emitted by Cs-137. The Co-60 is a radioactive metal that decays with a half-life of around 5.3 years. Although Cs-137 has a longer half-life of around 30.1 years, few commercial gamma facilities use Cs-137 as a gamma ray source. Because, Cs-137 emits gamma rays that are approximately half the energy of those emitted by Co-60 [30]. Gamma irradiation has higher penetration than electron beams. Therefore, it is as suitable for treating large bulk packages of food. Gamma facilities are the majority of food irradiation facilities worldwide. The gamma radiation cannot be switched off and when not being used to treat food, must be stored in a water pool to absorb the radiation energy and protect workers from exposure if they must enter the irradiation room.
[18] defines irradiation as the exposure of a substance to radiation of various frequencies. In this publication, food irradiation is the process in which a product or commodity is exposed to ionizing radiation such as gamma rays to improve its safety and to maintain its quality. During irradiation, energy is transferred from a source of ionizing radiation into the treated product. Among the irradiation process parameters, the most important is the amount of ionizing energy absorbed per unit mass of the target material, which is termed ‘absorbed dose’ or simply ‘dose’.
By the studies of [24], it is little known by the general public, that the irradiation process is used on a wide commercial scale across the world to enhance polymers and to sterilize single-use medical devices. The technology is also used to maintain the quality of food, improve its microbiological safety or reduce waste. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture estimates that the quantity of food irradiated in 2013 was approximately 700000 tonnes.

[32]; stated that gamma ray is a packet (or photon) of electromagnetic radiation emitted from the nucleus during radioactive decay and occasionally accompanying the emission of an alpha or beta particle. Gamma rays are identical in nature to other electromagnetic radiations such as light or microwaves but are of much higher energy. Examples of gamma emitters are Co-60, Zn-65, Cs-137, and Ra-226. Gamma rays do not possess mass or charge like all other forms of electromagnetic radiation and they interact less intensively with matter than the ionizing particles. Gamma rays are able to travel significant distance because gamma radiation loses energy slowly. Depending upon their initial energy, gamma rays can travel tens or hundreds of meters in air.

2.4 Irradiation of grains at different doses

[8] studied that the ionizing radiation produces chemical changes by primary and secondary radiolysis effects. The effect of chemical reactions depends on the absorbed dose, dose rate and facility type, presence or absence of oxygen and temperature. Generally, most food micronutrients (mainly water-soluble and fat-soluble vitamins) and macronutrients (carbohydrates, proteins, and lipids) are not affected by 10 kGy-range ionizing dose with regard to their nutrient contents. But, with radiation doses above 10 kGy, the properties of fibrous carbohydrates can be degraded structurally and lipids can become somewhat rancid. As stated by [17] the physical status of food (frozen or fresh, solid, liquid or powder) and also its composition influence the reactions induced by the radiation.

[7] through his studies concluded that the energy absorption by irradiated food can produce chemical changes via primary and secondary indirect radiolysis effects. The chemical changes that take place are as follows: Irradiation effects water molecule to free an electron producing HO^+. This product reacts with other water molecules to create a quantity of compounds, including hydrogen (H) and hydroxyl radicals (OH•), hydrogen peroxide (H_2O_2), molecular

hydrogen and oxygen. Because the hydroxyl radical is anoxidizing agent, and the hydrated electron is a reducing agent, free radical attack can be expected to cause oxidizing and reducing reactions in food.

2.5 Effect of irradiation on grains

[15] through his studies concluded that the lower radiation doses can reduce/prevent an increase in population of pests by lethal effects on immature stages of adults and it cannot cause immediate death of adults. Mycotoxin producing fungi have been a major safety concern since 1986 for cereals. Some of the recent studies have shown that irradiation up to 10 kGy can reduce the colonization of cereals with mycotoxin producing fungi. For instance, 6 to 8 kGy reduces the risk of mycotoxin accumulation during barley germination for malt production.

[21]; studied that the dry legume seeds, grains and cereals are usually consumed after a wide range of processing. Operations and irradiation (tested at doses between 1 and 10 kGy) can modify the quality and technological properties of cereals and cereal products positively or negatively.

[39] experimented two milled Indica rice varieties which were exposed to gamma radiation with doses ranging from 0 to 1.0 KiloGray. The effects of gamma irradiation on rice flour pasting properties and the qualities of its food product, rice curd, were compared to the effects of storage. A dose of 1 kGy can decrease the flour paste viscosity and tenderize the texture of the rice curd to similar levels as those obtained after 12 months of storage. The results thus revealed that gamma irradiation could shorten the Indica rice aging time and improve the processing stability and quality of rice products.

2.5.1 Effect on Carbohydrates

[28] studied that the use of gamma-irradiation (up to 6.2 kGy/h) to starches from maize, wheat, rice or potato, induced the aldehydes (-CHO) such as malonaldehyde(CH3H4O2), formaldehyde (CH2O), and acetaldehyde, formic acid and hydrogen peroxide as main radiolytic products. Recent studies have revealed that, gamma irradiated solutions of monosaccharides(dextrose, levulose) and disaccharides (sucrose) starch (at 3 kGy at 5ºC) produced malonaldehyde.

2.5.2 Effect on Proteins

In his study [11] showed that, the protein irradiation could produce chemical reactions that were dependent on the structure of protein, state (native or denatured), physical status, amino acid composition and the presence of other substances. The most important changes that occurred due to irradiation include dissociation of the protein structure, aggregation, cross-linking and oxidation of the protein molecule. For example gamma irradiation of hazelnuts at 10 kGy induced protein aggregation and de-naturation.

2.5.3 Effect on Lipids

[29] by his experiments showed that there was significant increase in lipid oxidation due to the formation of free radicals during the process of irradiation. The chemical effects of irradiation are more relevant in foods with large content of fat, physical form (liquid or solid), the presence of antioxidants, environmental conditions such as light, heat, oxygen, moisture and pH, the irradiation treatment, type of storage (vacuum, modified atmosphere, etc.), storage conditions (time, temperature, light, etc.) and high unsaturated fatty acids content. The use of low temperatures, the presence of oxygen, antioxidants and suitable packaging type showed a great capacity to minimize lipid oxidation [28]. Phytosterols (include sterols and stanols), which are naturally present in cereals, nuts, seeds, fruits and vegetables have a structure similar to cholesterol.

2.5.4 Effect on Vitamins

[28] revealed that the primary effects of radiation on vitamins at low and medium doses are not considerable. But, the combination of free radicals made through irradiation with antioxidant vitamins can lose some of their influence. While considering the case of water soluble vitamins, Vitamin B1 is the most sensitive and can cause significant losses of irradiated meats.

2.6 Effect of Irradiation on Starch

In his study on evaluation of the effect of gamma irradiation (0, 0.5, 1, 2.5, 5 and 10 kGy) on physicochemical, functional and thermal properties of chickpea starch [3], the results revealed that the pasting properties showed a significant ($p \leq 0.05$) decrease in peak viscosity, final viscosity, setback viscosity, trough viscosity and pasting temperature in dose dependent manner (p.614-622). He found that the physicochemical properties had a significant increase in their values with dose, except syneresis which decreased with dose. Gelatinization temperatures To, Tp and Tc decreased significantly with dose. X-ray diffraction showed a characteristic C type pattern of the starches and the crystallinity decreased with dose. Scanning electron microscopy revealed small oval shaped starch granules and slight surface fissures were seen in the irradiated starch treated with 5 and 10 kGy.

[3] describes the studies carried out for effects of gamma irradiation on physico-chemical, thermal and functional properties of the whole wheat flour and the starch extracted post irradiation. The results showed that the proximate composition did not change with dosage. However, pasting properties for both flour and starch showed a significant (p 0.05) decrease in peak viscosity, final viscosity, setback with increase in dosage. Amylose content increased significantly with dosage from 25.33 to 36.03%, bulk density of the flour did not change significantly. The physical parameters such as solubility, swelling power, syneresis and freeze thaw stability increased with increasing dosage. Water and oil absorption capacity of the flour increased significantly with dosage and was found in the range of 0.85e 0.91 and 1.10e1.91 g/g of flour respectively. Due to irradiation there was no significant change in the FTIR spectra pattern.

[40] studied the irradiation, an effective method to change starch structure and its functionalities, was carried out before traditional air-drying. Effect of irradiation on the structural and physicochemical properties of rice starch and contrast with that of non-irradiated and traditional air dried rice was studied in this research. Micrbiological observation of micro structure of starch, at outer and inner layer rice endosperm, showed that the starch granules would be destroyed by gamma irradiation, and the breakage was increased with increasing dose. Effect of gamma irradiation on micro structures of inner endosperm was greater than that of outer endosperm. Chemistry examination and RVA rice viscosity analysis were carried out on the air-dried rice.The properties such as the Apparent amylose content, gel consistency and gelatinisation temperature were all affected by irradiation pre-treatment. The results obtained were such that: the apparent amylose content being decreased, and gel consistency and gelatinisation temperature being increased with increasing dose. These effects were generally related to the changes of starch structure. With the analysis of RVA, six major parameters of starch such as pasting properties, peak viscosity (PKV), hot pasting viscosity (HPV), cool pasting viscosity (CPV), setback(CPV minus PKV), breakdown (PKV minus HPV), and peak time (PKT), were significantly decreased with the increasing dose by different velocity. There were high correlation coefficient between dose and individual major parameters of starch pasting properties (range from 0.961 to 0.998). These changes of pasting properties were also due to the breakage of starch granules caused by gamma irradiation.

[10] studied three types of rice cultivars (indica, japonica and hybrid rice) with similar intermediate apparent amylose content(AAC) as well as early indica rice cultivars with different amounts of AAC were selected for studying the effects of gamma irradiation on starch viscosity, physicochemical properties and starch granule structure. Four major parameters of RVA profile that was determined by a rapid visco analyser (RVA, Model-3D), peak viscosity, hot pasting viscosity, cool pasting viscosity, and setback viscosity were considerably decreased with increasing dose levels. Gamma irradiation reduced the amylose contents in the cultivars with low AAC, intermediate AAC, and glutinous rice, but had no effects on the high AAC cultivar. No visible changes in gelatinization temperature were detected after irradiation, but the peak time was reduced with the dose levels. Gel consistency was significantly increased in the tested cultivars, especially in the high AAC indica rice. The starch granules were somewhat deformed by gamma irradiation. These results suggested that it is promising to use gamma irradiation to improve rice eating or cooking quality.

III. CONCLUSION

Water absorption capacity of starch obtained from irradiated wheat and chickpea was found to increase due to irradiation treatment in dose dependent manner. The increase was 8.8, 12.8, 32.7 and 38.7 % at 1.0, 10.0, 20.0 and 30.0 kGy doses respectively. The increase in WAC with irradiation may in part be due to irradiation-induced damage or degradation of starch to simpler molecules such as dextrins and sugars that have higher affinity for water than starch.

Irradiation, at all the doses caused significant reduction ($p \leq 0.01$) in swelling index of wheat and chickpea starch. Swelling index decreased as the irradiation dose increased in both starch samples. The decrease in swelling power could be beneficial to improve textural quality upon cooking as the bursting of the starch could be prevented.

Solubility increased with increase in irradiation dose (Table 4.3). Though the increase was significant ($p \leq 0.01$), it was observed to be dose dependent. Solubility index increasedfrom28.28 ± 0.34 to 32.06 ± 0.58 and 25.59 ± 0.1 to 29.72 ± 1.08g/g for wheat and chickpea starches, respectively for 0 (un-irradiated) to 30 KiloGray doses. The increase in solubility with irradiation may be due to radiation induced de-polymerization of starch molecules and increased proportion of short chains upon irradiation that have greater tendency for hydration than the native starch molecules.

Steady decrease in syneresis (g/100 g) was observed with increasing irradiation dose in both wheat and chickpea starches and increase in syneresis was found. The reduction in syneresis may in part be attributed to decreased apparent amylose content at higher irradiation dose.

The light transmittance of gelatinized starch pastes (1 g/100 g) decreased sharply up to 5 days of storage. Native wheat and chickpea starch pastes had a low clarity up to storage of 5 days which increased spectacularly after irradiation (30 KiloGray). The sample clarity changed significantly ($p \leq 0.01$) during further storage time.

The peak viscosity of chick pea and wheat starch isolate was found to be 3780 cp and 2741 cp respectively. The reduction in the viscosity was observed even at the dose of 1 KiloGray, at which nearly 70 & 28% reduction in the peak viscosity observed for starch isolate of chickpea and wheat respectively.

V. REFERENCE

[1] Abu, J.O., Duodu, K.G. Minnaar, A. (2006), Effect of gamma irradiation on some physicochemical and thermal properties of cow pea starch, Food Chem. 95, 386–393.

[2] Adebowale, K.O.,Lawal,O.S. (2004), Comparative study of the functional properties of Bambara groundnut (Voandzeia subterranean), jack bean (Cavanaliaensiformis) and mucuna bean (Mucunapruriens), Food Res. Int. 37, 355–365.

[3] Bashir, K. and Aggarwal, M. (2017), Effects of gamma irradiation on the physicochemical, thermal and functional properties of chickpea flour, LWT—Food Sci. Technol.69, 614–622.

[4] Bashir, K.,Aeri, V. Masoodi,L. (2012). Physicochemical and sensory characteristics of pasta fortified with chickpea flour and defatted soy flour, J. Environ. Sci.Toxicol. Food Technol. 1 (5), 34–39.

[5] Bashir, K.,Aggarwal, M.(2016).Effects of gamma irradiation on the physicochemical, thermal and functional properties of chickpea flour, LWT—Food Sci. Technol.69, 614–622.

[6] Baumler E., Cuniberti A., Nolasco S.M. and Riceobene I.C. (2005), Moisture dependent physical and compression properties of Safflower seeds. Journal of Food Engineering, Vol.4(2), pp, 1-7.

[7] Black, J.,L. and Jaczynski, J. (2008), Effect of water activity on the inactivation kinetics of Escherichia coli O157: H7 by electron beam in ground beef, chicken breast meat, and trout fillets. Inter. J. Food Sc. & Tech., Vol. 43, no. 4, pp. 579-586.

[8] Brewer, M.S. (2009), Irradiation effects on meat flavor: a review, Meat Science, 1-14. Radiation Physics and Chemistry 73, 224–228.

[9] Cornell, H. (2003), In: Cauvain SP (ed) Bread Making: Improving Quality. Wood head Publishing, Cambridge.

[10] Dianxing, Wu, Qingyao, Shu, Zhonghua, Wang, Yingwu, Xia (2002), Effect of gamma irradiation on starch viscosity and physicochemical properties of different rice. Radiation Physics and Chemistry 65, 79–86.

[11] Dogan, A., Siyakus, G. and Severcan, F. (2007), FTIR spectroscopic characterization of irradiated hazelnut (Corylusavellana L.), Food Chem., Vol. 100, pp. 1106-1114.

[12] Falade, K.O.,Kolawole, T.A.(2013),Effect of irradiation dose on physical, functional and pasting properties of cowpea (Vignaunguiculata) cultivars, J. Food Process Eng. 36,147–159.

[13] Farkas, J. (2004), Charged particle and photon interactions with matter, In: Mozumder, A. & Hatano, Y. (eds): Food Irradiation, Marcel Dekker, New York, pp. 785–812.

[14] Gani, A., Bashir, M., Wani, S.M., Masoodi, F.A. (2012),Modification of bean starch by gamma irradiation: effect on functional and morphological properties, LWT—Food Sci. Technol. 49, 162–169.

[15] Hosseinzadeh, A. and Shayesteh, N. (2011), Application of gamma radiation for controlling the red flour beetle Triboliumcastaneum Herbst (Coleoptera: Tenebrionidae). African J. Agri. Res., Vol. 6, no. 16, pp. 3877-3882.

[16] Hvizdzak, A. L., Beamer, S., Jaczyn ski, J. and Matak, K. E. (2010), Use of Electron Beam Radiation for the Reduction of Salmonella enterica Serovars Typhimurium and Tennessee in Peanut Butter . J. Food Protec., Vol. 73, no. 2, pp. 353-357.

[17] IAEA (International Atomic Energy Agency), (2009), Irradiation to ensure the safety and quality of prepared meals, Vienna, Austria, p. 375.

[18] International Organization for Standardization (2004), American Society For Testing And Materials, Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing, ISO/ASTM 51204:2004, ISO, Geneva.

[19] Lindsay DG (2002) Phytochem. Rev. 1: 101–111

[20] Loaharanu, P. (1994), Food irradiation in developing countries: a practical alternative, IAEA Bull.,Vol. 1, pp. 30-35.

[21] Lynch, M. F., Tauxe, R.V. and Hedberg, C.W. (2009), The growing burden of food borne outbreaks due to contaminated fresh produce: risks and opportunities , Epidemiology & Infection, Vol. 137, no. 3, pp. 307-315.

[22] Marcotte, M. (2005), Effect of irradiation on spices, herbs and seasonings-comparison with ethyleneoxide fumigation,www.foodirradiation.com.

[23] Nesvadba, P., Houska, M., Wolf, W., Gekas, V., Jarvis, D., Saaad, P.A. and Johns, A. I. (2004), Database of physical properties of agro-Food materials Journal of Food Engineering.61:497-503.

[24] Osterholm, M.T. and Potter M.E. (1997), Commentary: Irradiation pasteurization of solid foods: taking food safety to the next level. J. Emerg. Inf. Dis. 3(4): 575-577.

[25] Rao,V.S.,Vakil, U.K.(1983),Effects of gamma-irradiation on flatulence-causing oligosaccharides in green gram (Phaseolusareus), J. Food Sci. 48, 1791–1795.

[26] Siddiq, M.R, Ravi, R., Harte, J.B. and Dolan, K.D. (2010), Physical and functional characterisation of selected dry bean (Phaseolus vulgaris L.) flours, LWT—Food Sci. Technol. 43 (2), 232–237.
[27] Singh, U.,Jambunathan, R. (1981),Studies on desi and kabull chickpea (CicerarietinumL.) cultivars: levels of protease inhibitors, levels of polyphenolic compounds and in vitro protein digestibility, J. Food Sci. 46, 1364–1367.
[28] Stefanova, R.,Vasilev, N.V. and Spassov, S. L. (2010), Irradiation of food, current legislation framework, and detection of irradiated foods, Food Analytical Methods, Vol. 3, pp. 225- 252.
[29] Stewart, E. M. (2009), Effect of gamma irradiation on the quality of ready meals and their meat components. In: Irradiation to Ensure the Safety and Quality of Prepared Meals, Results of the coordinated research project organized by the joint FAO/IAEA division of nuclear techniques in food and agriculture (2002-2006). IAEA, Vienna, pp. 313-342.
[30] Suresh, P., Leslie, A. and Braby, L. (2005), Electron beam technology for food irradiation, The International Review of Food Science and Technology (Winter 2004/2005). An Official Publication of the International Union of Food Science and Technology (IUFoST).
[31] Thayer, D.W. & Boyd G. (1999), Irradiation and modified atmosphere packaging for the control of Listeria monosytogenes on turkey meat, J. Food Prot., Vol. 62, no. 10, pp. 1136-1142.
[32] Thomas, M.H., Atwood, B.M., Wierbicki, E. and Taub I.A. (1981), Effect of radiation and conventional processing on the thiamin content of pork. J. Food Sci. 46(3): 824-828.
[33] Tomlins, K. (2008), Food safety and quality management, Food Africa.: foodafrica.nri.org/safety/safetydiscussions.html.
[34] Welch RM (2002), J. Nutr. 132: 495S-499S
[35] Welch RM (2005). Food Nutr. Bull. 26: 419-21
[36] Welch RM, Graham RD (1999), Field Crops Res. 60: 1–10
[37] Welch RM, Graham RD (2002), Plant Soil 245: 205–214
[38] Welch RM, Graham RD (2004), J. Exp. Bot. 55: 353–364
[39] Wen, Chieh (2004), Sung Effect of gamma irradiation on rice and its food products Department of Hotel and Restaurant Management, Chia Nan University of Pharmacy and Science, 60 Erh-Jen Road, Sec. 1, Pao-An, Jen-Te Hsiang, Tainan 717, Taiwan.
[40] Yu, Y., and Wang, J. (2007), Effect of c-ray irradiation on starch granule structure and physicochemical properties of rice. Food Research International 40 (2007) 297–30.
[41] Zuzana, Sramkova, Edita, Gregovab, Ernest, Sturdik (2009), Chemical composition and nutritional quality of wheat grain. Acta Chimica Slovaca, Vol.2, No.1, 2009, 115 – 138.