REVIEW
OF
LITERATURE
Shelflife is the length of time given to food or other perishable items before they are considered unsuitable for sale or consumption. Shelflife extension of fresh turmeric and ginger rhizomes can be achieved by irradiation technique. The process involves exposing the rhizomes, either packaged or in bulk, to carefully controlled amounts of ionizing radiation for a specific time to achieve certain desirable objective.

Sprouting in fresh ginger rhizomes during storage at 20°C was arrested effectively at a much lower dose of 40 Gy by Srikulvadana and Prompukesara (1980). Mukherjee and Thomas (1995) reported that gamma irradiation at 60 Gy in combination with biocontrol and closed polyethylene bags could enhance the shelflife of fresh ginger rhizomes up to 2 months at ambient temperature of 25-30°C.

A dose of 5 kGy was shown to reduce the total microbial load to below detection level in dry ginger while a dose of 10kGy was found to sterilize the sample without affecting its flavour quality (Andrew et al., 1995).

Lopez Galvez et al. (1997) compared the quality changes in several commercially available packaged salads, including Ceasar salads. They reported that development of off-odor starts at day 10 and are a common problem in commercial salad products.

Lee et al. (1998) and Yook et al. (1996) reported that electron beam irradiation can be useful in reducing the microbial spoilage in red ginseng powder.

Prakash et al. (2000) reported that low dose gamma irradiation increases the microbiological shelflife of modified atmosphere packaged (MAP) fresh cut lettuce. 0.35 kGy irradiation caused softening of the lettuce although the change in texture was
not apparent to a trained sensory panel. Visual quality and off flavour development were not adversely affected.

Kwon et al. (2000) reported that gamma irradiation treatment and fumigation treatment reduced microorganisms in ginseng powder, resulting in improvement of hygienic quality.

Mishra et al. (2004) reported that gamma irradiation reduced microorganisms in ginger, resulting in improvement of hygienic quality. A radiation dose of 5 kGy and storage at 10°C are best suited for the shelflife extension of fresh peeled and packed ginger for a period of more than 2 months, maintaining superior microbiological quality. These studies revealed the efficacy of radiation treatment to address the emerging safety issues associated with minimally processed ready to cook horticultural products.

Radiation processing is a cold process that does not affect the freshness of food. A combination of treatment of low doses of ionizing radiation (0.5 and 1 kGy), edible coating and modified atmosphere packaging has been shown to be effective in reducing total aerobic plate count in ready to eat carrots (Hagnmeir and Baker, 1998; Lafortune et al., 2005).

Dhokane et al. (2006) have shown that low dose radiation of 2 kGy can be used effectively to eliminate *S.typhimurium*, and *L.monocytogenes* from minimally processed carrot, cucumber and various sprouts. It was further shown that no recovery of *S.typhimurium* (10^5 cfu/g) in pineapple treated with 2 and 2.5 kGy doses was observed during storage up to 12 days at 4° and 10°C. Treatment with 2 kGy did not adversely affect the nutritional, organoleptic and textural properties of these products.

Shashidar et al. (2007) reported that radiation processing of minimally processed pineapple at the radiation doses of 2 kGy was effective in eliminating viable spoilage microbial flora. This dose could eliminate 5 log CFU/g of *S.typhimurium* from inoculated pineapple samples.

Jin et al. (2007) reported that electron beam irradiation at the dose of 8 kGy was effective for Korean ginseng and red ginseng in terms of microbial decontamination.
Wani et al. (2007) reported that gamma irradiation dose of 1.0-1.5 kGy significantly helped in extending the shelflife of pears up to 14 days, without adversely affecting the firmness, color and overall acceptability. Irradiation dose below 1 kGy did not showed any significant effect; however doses above 1.5 kGy markedly delayed ripening and reduced the microbial load, but adversely affected the external appearance.

Zingiberaceae plants contain many essential oils, including terpenes, alcohols, ketones, flavanoids, carotenoids and phytoestrogens (Habsah et al., 2000; Mau et al., 2003). The water extract of Zingiber officinale exhibits 6-gingerol, and is mostly found in the rhizome in concentration of 130-7,138ppm in certain species. Less polar constituents including cucuminooids, kava pyrones and gingerols are isolated from Zingiberaceous plants, which have been reported for their biological activities in antifungal, antioxidant, antiinsecticidal and anti-inflammatory activities (Sirat et al., 1994, 1995, 1996).

The essential oil which is one of the products from ginger is commercialized internationally as flavouring agent and or additive for the food and pharmaceutical industry (Kelly et al., 2002; Alexander et al., 1998). The chemical components in the essential oil might affect the characteristic flavouring quality of ginger. The chemical investigations carried out in the past showed that monoterpene hydrocarbonbs, oxygenated monoterpenes, sesquiterpenes hydrocarbons and nonterpenoids compounds were the constituents in ginger oils as reported by Shao et al. (2003).

Ginger oil may be produced from fresh or dried rhizomes. Oil from dried rhizomes will have less of the low boiling point volatile compounds since they tend to evaporate during the drying process (Weiss, 1997). However, these compounds contribute only partially to the flavour impact since fresh ginger is characterized by its aroma, as well as by its pungency.

Yonei and Ohinata (1995) reported ginger volatile oil content of about 50% using supercritical carbon dioxide. They found that, the zingiberene a kind of sesquiterpenes hydrocarbon was higher in Chinese ginger than Guinean ginger, 31.1 and 19.89% respectively.
The major components in essential oils are zingiberene, ar-curcumene, farnesene, bisabolene, sesquiphellandrene (Lawrence, 2000). The amount of monoterpene alcohols and sesquiterpene alcohols in steam distilled oil was higher than those extracted by liquid carbon dioxide. These differences were due to the thermal degradative effect of steam distillation upon the nonvolatile glycosides of monoterpene alcohol and or sesquiterpenes alcohols.

Results by John and Amanda (2000) found zingiberene was about 13.44% using supercritical carbon dioxide in Australian ginger.

Olusegun et al. (2006) determined the chemical composition of the ginger oils obtained by hydrodistillation of fresh and dried rhizomes of Nigerian origin by means of a combination of column chromatography, high resolution gas chromatography and GC-MS. The essential oils contained mainly mono- and sesqui-terpenoids of which geranial, neral, 1,8-cineole, zingiberene, β-bisabolene and β-sesquiphellandrene were the major components. Among the 54 constituents identified, (E)-α.-farnesene, viridiflorol and (E)-farnesal have not been found previously in ginger.

Alhassane Toure and Zhang Xiaoming (2007) isolated the volatile oils from Chinese ginger and Guinean ginger by steam distillation and the yield were highest 0.44% from Guinean ginger and 0.22% from Chinese ginger. The volatile oil content from African ginger were found to be 1-4% on dry weight basis but only 0.4% has been found in fresh African ginger (Connell, 1970). Monoterpenes alcohols sequiterpenes, aldehydes and ester monoterpenes were major categories identified.

The effect of gamma irradiation up to a dose of 15 kGy on the aroma constituents of dry ginger have been reported by Govindarajan (1980). Monoterpene content 17-18% of fresh Indian ginger oil obtained was much higher than the values 5-11% reported for dry ginger. It is known that fresh ginger has much higher monoterpenes content than dry ginger.

Studies carried out by Wu and Yang (1994), on the effect of gamma irradiation at 50 Gy on the flavour compounds of fresh ginger, it was observed that after 3 months of storage the major volatile compounds were significantly lower in irradiated than in non-irradiated samples.
Irradiation at 0.05 kGy of irradiated ginger reduced the production of some major volatile constituents reported by Wu and Yang (1994).

Farag et al. (1995) worked on spices from Egyptian local markets irradiated with different recommended doses (0, 5, 10, 20 and 30 kGy). The spices tested included dried leaves of marjoram (*Majorana hortensis* Moench), rhizomes of ginger (*Zingiber officinale* Roscoe) and powdered hot pepper (*Capsicum annum* L.). The study included the isolation and identification of micro-organisms in spices following their irradiation, as well as gas chromatographic (GLC) chemical analysis for the presence and structure of volatile oils, pungent and pigment materials. The results showed that ginger was contaminated with $14.3 \times 10^3$ g of total aerobic bacterial count. The total contents of moulds were $5.7 \times 10^3$ g in the same spice, but the pathogenic moulds and bacterial strains differed according to the type of spice. Irradiation at 10, 20 and 30 kGy caused complete elimination of micro-organisms, whereas 5 kGy was less effective. With the GLC method chosen 18 and 50 compounds could be detected in the extracts of ginger: terpinene and zingiberene being the major compounds in ginger. Ginger was more sensitive to irradiation, especially at high doses, but moderate changes were detected at low doses (5 and 10 kGy). These results prove that 10 kGy is a sufficiently high dose to eliminate the microorganisms in spices, causing only slight changes in the flavouring matter.

Onyenekwe (2000) reported the oleoresin and gingerol contents in gamma irradiated dried ginger rhizomes were evaluated to determine the effect of radiation and storage on these constituents of ginger. Dried ginger rhizomes were subjected to 0, 5 and 10 kilogray (kGy) doses of gamma rays from $^{60}$Co source. The oleoresin and gingerol contents were monitored for 9 months. Radiation treatment (10 kGy) reduced the decrease of the oleoresin content of ginger during the storage period by 14% in unground samples and 11% in ground samples. There was a dose-dependent decrease in the 6-gingerol content of the ground ginger decreased by 65.6, 67.4 and 70.4% for the 0, 5, and 10 kGy samples, respectively, while the corresponding values for the ungrounded ginger samples were 37.8, 40.0 and 44.3% at the end of the storage period.
Variyar et al. (2007) reported that fresh ginger rhizomes gamma irradiated at sprout inhibiting doses of 60 Gy and stored for two months at ambient temperatures (28-30°C) in perforated low-density polyethylene bags were analyzed for changes in volatile aroma constituents and pungent principles (gingerols) during the storage period at intervals of one month. No significant qualitative and quantitative differences could be noted in the volatile aroma constituents of the control (non-irradiated) and irradiated samples any time during storage. The major constituents identified in the oil by GC/MS analysis were zingiberene, β-sesquiphellandrene and ar-curcumene. A decrease in gingerol content was observed in the irradiated samples on storage. This decrease was approximately 21%, 22% and 10% in irradiated ginger stored at 0, 1 and 2 months, respectively, compared with their corresponding non-irradiated controls. Gamma irradiation at a dose of 60 Gy was found to prevent sprouting and extend the shelflife.

The aroma of turmeric is due to its volatile oil, while the phenolic compounds and its analogues account for its bright yellow colour.

Gopalan and Ratnambal (1987) compared the main constituents of turmeric oils produced from different cultivars. There was considerable quantitative variation in the main components depending upon the cultivars from which the oil was produced.

Hiserodt et al. (1996) examined the volatiles of a number of samples of turmeric powder. Volatile oil was obtained by mixing 20 mg turmeric powder with preconditioned 200 mg of Chromosorb W (80–100 mesh). Ar-turmerone, turmerone and curlone were identified as major compounds by Direct Thermal Desorption Gas Chromatography–Mass spectroscopy.

Martins et al. (2001) reported the essential oils from the rhizomes of C. longa contained a lower content of ar-turmerone (4.0–12.8%) than those reported in the literature for C. longa from other geographical origins (24.7–31.4%), whereas results for Z. officinale essential oils were in accordance with literature data.

Leela et al. (2002) isolated volatile oil from various parts of Curcuma longa and found that the roots contained the highest yield 4.3% followed by rhizomes 3.8%. The main constituents of flower oil was p-cymene followed by terpinolene and 1, 8-
cineole. Flower oil and leaf oil were dominated by monoterpenes while root and rhizomes contained sesquiterpenes.

Chosdu et al. (1985) were unable to detect any changes in aroma constituents of turmeric subjected to gamma irradiation up to a dose of 10 kGy.

Tajima and Hossain (1989) have reported that gamma irradiation even at doses of 5 kGy affected the recoveries of essential oil of several spices including turmeric.

The colouring principle of turmeric was isolated in the 19th century and was named curcumin. Curcuminoinds refer to a group of phenolic compounds present in turmeric, which are chemically related to its principal ingredient curcumin. Three curcuminoinds were isolated from turmeric viz., curcumin, demethoxycurcumin and bisdemethoxycurcumin. All three impart the hallmark yellow pigmentation to the *C. longa* plant and particularly to its rhizomes. Although the chemical structure of curcumin was determined in the 1970's and 1980's, recently the potential uses of curcuminoinds in medicine have been studied extensively. The structure of curcumin as diferuloylmethane was confirmed by the degradative work carried out by Majeed et al. (1995). On boiling with alkali, curcumin gave vanillic acid and ferulic acids whose structures were established. Fusion with alkali yielded protocatechuic acid and oxidation with potassium permanganate yielded vanillin. On hydrogenation, mixtures of hexahydro- and tetrahydro-derivative were obtained. Based on these, the structure of curcumin was established as diferuloylmethane.

Considering the various biological activities of curcuminoinds, attempts were made by several researchers in the past to isolate curcuminoinds from turmeric rhizomes by solvent extraction using organic solvents by Verghese and Joy (1989); Xianchung et al. (1993) and Zhang and Yang (1988). Recently, Baumann et al. (2000) have claimed efficient extraction of curcuminoinds using supercritical CO2 modified by 10% ethanol. Dandekar and Gaikar (2002) reported microwave assisted extraction (MAE) technique for selective and rapid extraction of curcuminoinds. Turmeric powder was irradiated for 2 and 4 min with microwave showed marginally higher extraction of curcuminoinds in 60 min by acetone.

Numerous methods are available for isolating curcuminoinds from *C. longa*. Isolation of pure curcumin from plant material is time consuming and pure curcumin
sold on the market is therefore, a purified extract containing a mixture of the three curcuminoids i.e. curcumin (75–81%), demethoxycurcumin (15–19%) and bisdemethoxycurcumin (2.2–6.6%). Except by the chromatographic routes, all other methods generally provide several curcuminoids, with curcumin as the dominant constituent.

Munnasiri et al. (1987) reported a slight increase in colour power of turmeric powder stored up to 8 months, which was attributed to increased extractability of the pigments irradiated up to 10 kGy.

Chatterjee et al. (1998) reported the colour power value of turmeric powder expressed as curcumin content was found to be highly stable during storage at the high ambient temperatures (25±32°C) for up to 12 months. These results are in agreement with the observation that the colour of turmeric powder was little affected by packaging or storage for up to 6 months, even under the drastic conditions of exposure to sun light (Govindarajan, 1980). Gamma irradiation at 10 kGy, the dose recommended for microbial decontamination of spices, had no effect on the content or stability of the natural pigments present in turmeric powders. Irradiation decontaminated turmeric can be used as a source of natural pigments and would have the added advantage in view of their improved microbial quality.

Zingiberaceous plants have received much attention, since they produce many complex compounds that are useful in food as herbs and spices, flavouring and seasoning and in the cosmetics and medicinal industries, as antioxidant and antimicrobial agents. The theory of oxygen stress on ageing and age degenerated diseases places an importance in daily use of natural phytochemicals and compounds (Harman, 1986).

Snyder (1997) reported that clove, cinnamon and mustard were recognized as strong antimicrobial agents while ginger and mint as weak ones. Arora and kaur in 1999 confirm these results, where ginger showed little or no inhibition on different test bacteria.

Bhandari et al. (2005) administered an ethanolic extract of Z. officinale abstract for diabetic rats. A dosage of 200 mg/kg produced effects such as lowered serum total cholesterol and triglycerides, and increased high density lipoproteins cholesterol.
levels. The Zingiber extract also significantly reduced lipid peroxidation in tissues (Berends et al., 1997). Most of the Zingiberaceae plants were consumed fresh and some were concentrated for external use.

Hiral Chandarana et al. (2005), carried out their work on ginger (G), mangoginger (M), turmeric (T), mixtures of ginger and mangoginger (GM), ginger and turmeric (GT), and turmeric and mangoginger (TM) and a mixture of peels (P). The results showed that different bacterial species exhibited different sensitivities towards these compounds. The sensitivities of bacterial species against phenolic compounds of the family Zingiberaceae also varied in the 2 different species of the same genus. Extracts of the 3 individual spices, as well as mixtures showed more activity against Gram positive bacteria compared to Gram negative bacteria. The decreasing order of sensitivity of selected species of Gram positive and Gram negative bacteria against extracts of spices (under study) was B. subtilis > S. aureus > E. coli.

Sofia et al. (2006) reported the antimicrobial activity of ginger along with other spices such as mint, garlic, mustard, cinnamon and clove. Ginger showed its activity against S. aureus however as against most of the studies.

Turmeric extract is used as a remedy for hypercholesterolemia, arthritis, indigestion and liver problem has been known since long (Srimal, 1997). Aromatic turmerone 20-30% was reported to be the major compound present in turmeric volatile oil (Govindarajan, 1980) which is a mosquito repellent (Tawastin et al., 2001). It is an effective drug for the treatment of respiratory diseases (Lie et al., 1998). And dermatophytosis (Apisaryakul et al., 1995) synthetic turmerone appears as anticarcinogenic (Baik et al., 1993) antivenom activity of turmerone isolated from turmeric has also been reported (Ferreira et al., 1992).

The antibacterial activity of turmeric was reported as early as 1956. Negi et al. (1999) reported the antibacterial activity of turmeric oil. The oil was extracted from the spent turmeric oleoresin and it was separated into three fractions using column chromatography. These fractions were tested for antibacterial activity by pour plate method against Bacillus cereus, Bacillus coagulans, Bacillus subtilis, Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa. Fraction eluted with 5% ethyl acetate in hexane was found to be most active fraction. The turmeric oil, fractions
were analyzed by GC and GC-MS. *ar*-turmerone, turmerone, and curlone were found to be the major compounds present in these fractions along with other oxygenated compounds.

Alzoreky and Nakahara (2001) reported that gram negative bacteria were not susceptible to turmeric extracts when compared to gram positive bacteria. The resistance of gram negative bacteria towards antibacterial substance is due to the lipopolysaccharides in their outer membrane. It should be noted that the solubility and diffusion of active compounds in agar media could play a major role in evaluating the antimicrobial capability of plants (Berghie and Vlietinck, 1991; Brantner et al., 1996).

Gram negative bacteria were also more resistant than Gram positive bacteria, as also shown by Zaika (1988). These variations in inhibition may be because of differences in the composition and structure of the cell surface between Gram positive and Gram negative bacteria. In addition to the cell wall and cell membrane, Gram negative bacteria have an outer membrane composed of a phospholipid bilayer, which may be a protective barrier against these phenolic compounds. Moreover, the cell walls of Gram positive bacteria have a large amount of peptidoglycan and a small amount of lipid, while in the case of Gram negative bacteria, due to the presence of an outer membrane, a large amount of lipid and a small amount of peptidoglycan is found.

Jayaprakasha et al. (2001) reported the antifungal activity of turmeric oil, which was also isolated from mother liquor after isolation of curcumin. The turmeric oil was fractionated using fractional distillation under vacuum to get two fractions. These fractions were tested for antifungal activity against *Aspergillus flavus*, *A. parasiticus*, *Fusarium moniliforme* and *Penicillium digitatum* by spore germination method. Fraction obtained at 110–120 °C under vacuum was found to be more active. The chemical constituents of turmeric oil, fractions were determined by GC and identified by GC-MS. Aromatic turmerone, turmerone and curlone were major compounds present in the active fraction along with other oxygenated compounds. Rambir et al. (2002) reported that essential oil fractions is more effective against gram positive compared to gram negative strains of *S. aureus* and *S. epidermidis* have shown 246 and 83% inhibition respectively, compared to gram negative strains of
*E. coli*, *Pseudomonas aeruginosa*, *S typhimurium* showing inhibition of 38, 17, 35% respectively. Thus a very low concentration 20μg/disc showed significant antibacterial activity.

Saptha Jyoti Gerege *et al.* (2007) reported that the volatile oil of *Curcuma longa* has a broad spectrum of antimicrobial activity due to the presence of certain constituents namely linalool, a pinene, myrcene, alpha phellandrene, gamma terpinene, terpinolene, curcumene turmerone, carvacrol, cineole, para-cymene, thymol and nerolidol thus controlling agents against bacteria and fungus. The results showed that the leaf volatile oils inhibited 96% growth of skin pathogens at the concentration 250μicrol/ml. The compound linalool inhibited 74% growth of skin pathogens whereas compound 1,8 cineole inhibited 60% of skin pathogens.

Shruti Goel (2008) reported that turmeric extract showed considerable antimicrobial activity as measured by a standard MIC assay. Gram-positive and gram-negative bacteria, some pathogenic, were inhibited at relatively low concentrations of 20micrograms/ml to 100micrograms/ml. Only one pathogenic bacterium, *Campylobacter jejuni*, proved resistant.

In recent years, interest in plant derived food additives has grown. Plant extracts might substitute synthetic antioxidants and may influence human health when one consumed chemically (Martinez *et al.*, 2001). Phenolic substances have been shown to be responsible for the antioxidant properties of plants extracts (Rice-Evans *et al.*, 1997). Turmeric and ginger rhizomes are rich sources of phenols. In turmeric, the curcuminoids possess antioxidant activity. Spice principles like curcumin prevent oxidation of oils and fats (Kakar and Iwao, 1974). Active principles of spices such as curcumin (turmeric), zingerone (ginger) are reported to inhibit lipid peroxidation (Reddy and Lokesh, 1992). Increasing restrictions in the use of synthetic antioxidants such as butylated hydroxytoluene and butylated hydroxyl anisole in foods has increased the interest in natural antioxidants.

Effect of gamma irradiation (10kGy) on the antioxidant property of turmeric extracts was investigated by Chatterjee *et al.* (1999). Gamma irradiated as well as non-irradiated turmeric samples were subjected to successive solvent extraction using hexane, benzene, and 80% aq. methanol. Benzene extract, containing
mainly curcuminoids were subjected to column fractionation in order to isolate the individual curcuminoids. The curcuminoid analogues as well as the above fractions were then tested for their antioxidant activity by measuring thiobarbituric acid value (TBAV) and peroxide value (PV) based on the air oxidation of linoleic acid. Gamma irradiation at a dose of 10Kgy did not affect the antioxidant activity of turmeric extracts studied.

The antioxidative properties of turmeric oil and its fractions in which the compounds like turnerone and aromatic turmerone or in synergy with curlone are responsible for the antioxidative properties in turmeric oil isolated (Jayaprakash et al., 2002).

The antioxidant activity of ginger along with other spices has been reported by Hinneburg et al. (2005). Extracts of parsley, basil and barley showed more antioxidant activity compared to ginger extract.