



USE OF SOLAR DRIER PAPAPYA LATHER AS A FAT REPLACER IN CAKES

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ABSTRACT

Fat is a major constituent of food that softens the food product in addition to provide energy. High fat foods are energy dense foods that produce obesity and also some other major disorders. To reduce the risk of disease fat replacers can be used. Weight conscious people are adopting these fat replacers very quickly. There are three different types of fat replacers i.e. carbohydrate based, protein based and fat based. Solar dried papaya lather is an excellent source of fat replacers. This fat replacer can be used in baked especially for cakes products instead of shortening and oil. Papaya lather has the same functions as of fats. It has numerous therapeutical perspectives and can be used in different drugs preparation. Papaya is a rich source of papain that acts as meat tenderizer. Papaya fruit has rich contents of antioxidant activity hence important to be used in diet owing to different health benefits.

Keywords: Fat replacer, Papaya lather, Low energy foods, Baked food products, Heart diseases, Obesity, Antioxidants.

1. INTRODUCTION

Fat replacers are responsible for the low calories products with similar functional properties. Tropical fruits constitute a major nutritional and economic resource for developing countries including banana, papaya, pineapple, mango and avocado are generally the most important in economic and trading terms in developing countries especially Pakistan. Fresh fruits owing to vitamins, essential minerals, phenolic antioxidants, glucosinolates and other bioactive substances/nutrients help to prevent micronutrient deficiencies. Intakes of high fat foods are a reason of certain cancer (Krauss *et al.*, 2001) and linked with other factors such as more energy intake, positive energy balance, and the development of obesity (Wylie-Rosett, 2002). To overcome these problems fat replacers are used. Fat replacers that are used in food products have the same properties as of fat (Claudia *et al.*, 2006). On dry basis carbohydrates supplying 4 Kcal/g but when hydrates they give 1-2 Kcal/g of energy however in some cases it is equal to zero Kcal (Conforti and Archilla, 2001).

Fat is a major food component and plays important role in sensory and physiological benefits. It is important in developing flavor, mouth feel, taste, and aroma (Mistry, 2001; Sampaio *et al.*,

2004). It is also responsible for creaminess, appearance, palatability, texture, and lubricity of foods and during meal enhance the satiety. Due to lipophilic flavor it act as originator of flavor development (*e.g.*, by lipolysis or frying), and stabilize flavor (Romeih *et al.*, 2002). Fat-soluble vitamins and essential fatty acids are derived from fat and it is also a carrier for lipophilic drugs (Cooper *et al.*, 1997). In diet provides more energy as compared to other nutrients and supplying 9 kcal/g of energy as compared to the 4 kcal/g for proteins and carbohydrates. Fat soluble vitamins and other phytochemicals are absorbed by the aid of fat in adipose tissues that helps the body to maintain its temperature and serve as energy reserve (Stretch, 2006).

During cooking fat have different purposes *i.e.* its heat transfer quality enable speedy heating and achievement of very high temperatures. Due to its high temperature during frying many desirable sensory properties develop which produce taste and flavor. Sharpness of acid ingredient can be reduced with the help of fat. In a choice of meat, fat provides the flavor and help in the juiciness and tenderness (Sandrou and Arvanitoyannis, 2000).

Fat have the potential to affect the functional properties like: melting point, viscosity and texture, crystallinity, and spreadability of a foods (Sandrou and Arvanitoyannis, 2000). Fat retards the formation of water and sugar crystals that develop softness and smoothness, ice creams and some candies. Products which are low in fat have watery appearance without the addition of fat extender. Overall palatability of food is depending on aroma and texture of food which further depend on availability of fat. In baked products fat has numerous roles as the enhancement in gluten strength, provide tenderness, softening of the crumb and it also reduce the staling in bread (Penfield and Campbell, 1990). In flour gluten protein is inhibited by the presence of fat which coats the surface of flour particles (Maache-Rezzoug *et al.*, 1998).

Spies (1990) reported that very little amount of water is required in order to achieve the lubricating properties of food if, fat is added in large quantity. Fat causes change in the rheological properties of cookies dough before cooking and add crispiness when added with other ingredients during heating (Jissy and Leelavathi, 2007). Fat replacer should have all the properties as are present in fat as impartment of flavor, taste, texture and also volume to provide a high acceptability.

Fat provides high acceptance but unfortunately it also increases the calories (Drewnowski, 1998) that is a bad characteristic of fat owing to be energy storage for people. Nowadays, food industries are focusing towards the health status of community along with delicious foods having high fat and sugar contents. To reduce the risk of obesity and diabetes, low calories are more often used. To reduces the chances of different disorders different options are available as either use low fat foods or some modified fat replacers can be added in the daily routine diet that reduce the calories intake because the fat replacers are resistant for lipases which partially digest it (Akoh, 1998).

Fat molecules are essentially made up of fatty acids and glycerol. A fatty acid consists of a long carbon skeleton of 16 or 18 carbon atoms or longer in most natural fats and oils Fatty acids are hydrophobic in nature (Stretch, 2006). Fats are combinations of different fatty acids that exert characteristic physiological and metabolic effects on the body (Piper, 1999). In general saturated

fatty acids are more stable and are solid at room temperature. Foods high in unsaturated fatty acids include vegetable oils (e.g. soybean and sunflower) and fish such as salmon, tuna, and herring (Gurr, 2002).

Fat replacers are of three different type *i.e.* carbohydrate based, protein based and fat based fat replacer. The fat in foods can be decreased by simple techniques or by alternating with ingredients or with the help of compounds formulated by food technologist (Schwenk and Guthrie, 1997). There are several classes of fat replacers:

- Fat substitutes are ingredients that look like normal fats and oils and can replace fat on a gram-to-gram basis. At cooking and frying temperature fat substitutes are stable and supply functions of fat and provide 9 kcal/g.
- Similarly, fat analogs are such compounds which have the same characteristics of fat but different pattern of digestion and nutritional value also change.
- Fat extenders optimize the characteristics of fat, and in food the normal amount of fat can be decreased.
- The last one, fat mimetics are ingredients that replicate the one or more of the sensory and physical functions of fat in the food.

Carbohydrates based fat replacer includes hydrocolloids, gums, fiber, and modified starch. In dairy products and other food it is used as thickeners and stabilizers. As fat, dextrin and starches absorb water and form a gel. Pectin can also be used as fat substitutes because of their gelling properties. Yackel and Cox (1992) reported that carbohydrate-based fat replacers form a gel-like matrix, resulting in fat and flow properties similar to those of fats. Functional properties of fat can be copied by polydextrose when hydrated (Swanson *et al.*, 2002). Without changing sensory attributes of cookies, maltodextrins can be replaced with 25 - 35% of fat in cookies, whereas indigestible fiber, can replace 50% of fat in bakery products without altering the taste of product (Conforti and Archilla, 2001).

The plant based carbohydrates give more benefits to product developers and at last consumers: in a reduced fat food they are often more effective to reduce the activity. In nature, they are hydrophilic, creating carbohydrate water network when bind with water which gives the original texture of fat and it is completely digestible in normal metabolic process and due to their all-time availability it is recognized as safe (GRAS). Studied showed an increase trend in the use of malto-dextrin in baked products but it cannot be used in every product (Nonaka, 1997). In a model food system apple pomace is used as the fat replacer that provides water soluble pectin enriched materials (PEM). When these PEM were incorporated into cookies and different types of biscuits instead of shortening then it resulted in reduced spread factor of cookies however, it increased the moisture content. Moreover, this shortening replacer PEM also enhanced the softening in texture and made the cookies surface color more lighter (Bockki *et al.*, 2010).

Protein based fat mimetics give one to the four kcal/g. Microparticulated protein products are the spherical particles and they can provide a creamy mouth feel like fats. These mimetics are mixed with water and use in less amount as compared to the fat for example, 1 g of protein-based fat mimetics can replace 3 g of fat in cream. Protein-based fat mimetics are suitable for low fat

dairy products low-fat baked goods; salad dressing, margarine, mayonnaise, coffee creamers, soup and sauces (Cheung *et al.*, 2002). In frozen and baked products protein blends (another group of protein-based fat mimetics) which combine animal or vegetable protein, gums, food starch and water that are used. For attaining good textural properties mixture of protein, starches and hydrocolloids has been advised (Ordenez *et al.*, 2001). Inulin, act as a fat mimetic without changing the flavor of product. In fat modified food protein based fat mimetics has a great possibility to be used to lower total energy and fat intake (El-Naggar *et al.*, 2002).

These are the chemically altered form of fatty acids to provide low calories or zero calorie. Emulsifiers and fat-based substitutes can provide up to the 9 kcal/g. SALATRIM (short-and long-chain acyltriglyceride molecules) is one of the example of fat based substitutes. Another type of fat-based substitutes is olestra with same characteristics of natural fat and gives zero calories and cannot be absorbed by the body. Although it has the thermal properties of fat but gastric and pancreatic lipase cannot be hydrolyse it and due to its large size it cannot be absorbed in digestive tract and eventually gives no energy. In bakery and dairy products emulsifiers are used with water to replace all or part of the shortening content. From energy point of view they give same calories as fat but fat substitutes are required in less quantity. Some of these ingredients are heat stable and used for different purposes. Use of fat based substitute in fried product leads to decreased energy (Burns *et al.*, 2001).

Food technologist has difficulty in maintaining the functional properties of food while reducing the fat. The utility of fat in any product is the main step in selection of fat substitution. Most important is to understand the function of fat in the particular food system that will be modified. After all of these considerations a fat-substitute that will replace these functions can be selected. Other factors that should be kept in mind while choosing a fat substitute system are cost, availability, safety, and quality (Clark, 1994).

It is observed that more energy dense foods produce obesity because of high energy intakes (Kral *et al.*, 2004). In another case, soft drinks have low density but these drinks have a positive response energy balance owing to their low satiety stimulations and can produce high calories (DiMiguelio and Mattes, 2004). Nuts are also rich source of energy but have less BMI in adults, because of the presence of other dietary ingredients which can increase satiety (Jiang *et al.*, 2002).

These energy dense foods increased body weight about 20-25% due to high energy consumption and it can be reduced by the addition of fat replacers in our diet (De-Castro, 2004).

Cake is emulsion of fat and water having flour, sugar, fat, eggs, and baking powder (Lin and C.C. Lee, 2005). Fat interferes with gluten development by inhibiting contact between water and flour proteins. Fat contributes to tenderness, air retention, flavor and a smooth, moist mouth feel in cakes. Hydrogenated vegetable oil is used in formation of plain cake (Penfield and Campbell, 1990) which takes part in the development of sensory characteristics of flavor, tenderness and color (Swanson and Munsayac, 1999) in finished product. Low fat or low calorie market has gained more popularity due to the public awareness of nutrition and health (Clark, 1994). So, the reduced fat products are the main goal of food companies. In the reduction of fat main problem is to maintain the functional processing benefits of fat. Stauffer (1998) found that low fat, reduced fat

or fat free products are available. Food processors are well known about the consumer needs and according to the International Food Information Council Foundation more than 1000 new low fat or fat free products have been introduced annually since 1990.

Flour is the main ingredient used for cake development. For it the flour should have batter rheological properties. Insect infested wheat can be detected by repeating the rheological measurements of dough through farinograph after it is rested for few hours. Insect enzymes cause hydrolysis of dough proteins and thus reduce the strength of the dough. The data obtained from farinographic evaluation of wheat flours are well correlated with test baking performance and assist millers in obtaining better quality wheat cultivars without any delay. The farinograph is utilized to determine the useful characteristics of flour such as dough development time, water absorption and to distinguish wheat flour of poor and good baking quality. In a similar study, farinograms of different resultant flour showed higher dough stability and dough development time. The excessively high dough development time may be due to the presence of high moisture content of the bran particles in the flour which may cause hindrance in the quicker development of gluten (Ingelin and Lukow, 1999).

In all cereal related researches, farinograph obtained the position to assess the flour properties before and also after baking process (AACC, 2000). The parameters to be observed in farinograph are water absorption, mixing tolerance index and the dough stability time (Walker and Hazelton, 1996). Some decades ago, farinograph was used to determine the rheology of flour during bread making process. It describes the properties regarding to the quality of flour in term of its gluten strength that is an essential parameter in baking process (Faridi and Faubion, 1990).

The main reason of solar drying is to preserve food commodity by removing its moisture content without any microbial contamination or alternation. The other major benefit of drying is that it reduces the weight and the storage or transportation expenditures. Dried foods sometimes have poorer nutritional and eating qualities than the corresponding fresh foods. Due to this, the correct design and operation of dryers is needed to minimize the changes to food (Fellows, 1997).

Sun drying is the oldest food preservation method in Ghana (Gyabaah-Yeboah, 1985). It is traditionally carried out in places where in the average year the climate allows food to be dried and stored without the risk of them becoming moist and spoiled. Dried fruit is becoming more popular these days due to their longer shelf life, taste, and product diversity, but most importantly, it is due to the increased awareness in consumers in avoiding chemical and food preservatives.

The reductions in weight and volume upon drying also reduce transportation and storage costs, and for some types of food, these provide greater variety and convenience for the consumers.

Drying involves heat and mass transfer which will change the nutritive quality of the product and affect the taste. During drying obvious changes like size reduction and crystallization may occur. Some types of attractive and objectionable changes are also a result of drying which effect on color, texture, odor and other properties of food (Bala *et al.*, 2002).

Sun drying is a traditional and the oldest method, where it directly utilizes heat from the sun. Nonetheless, it has several disadvantages; for instance, the slowness of the process, risk of contamination, and total dependency on weather condition (Doymaz, 2004). It is widely used as it is efficient and economical. A solar cabinet dryer can be successfully used for drying mango, apples, figs, and other fruits (Bala *et al.*, 2002).

Oven drying is suitable for small-scale drying, gives good protection from insects and dust, and does not depend on weather conditions. The dry oven method is much easier, and its drying time may vary considerably, depending on the temperature variation used (Bouraoui *et al.*, 1993).

Dried products are subject to physical characteristics, such as color, textural properties and nutritional changes (Prachayarawarakorn *et al.*, 2007). The color changes according to sugar content, temperature, and exposure time (Doymaz, 2004).

Drying is extensively used preservation technique for agricultural products. All over the world demand of high quality dried fruit is increasing so drying is becoming alternate of marketing fresh fruits (Espe and Muhlbauer, 1998). Even though sun drying is a cheap drying method but due to its dependency on weather conditions and susceptibility to microorganism, dust, pest and insects it may results in low quality product.

The working of solar drier depends on the principle of the absorption of heat followed by a black body. The inner temperature of this black body is near about maintained at 60 to 70°C, that reduces the nutritional damage of food as it protects vitamins, minerals and also some other essential nutrients. Solar drier can be elaborated as the latest technique of drying by the help of sun radiations. The dryer consists of a tunnel drying unit, small fan that flow the air above the product if required, and a flat plate air heating system. Drying unit as well as the heat collector is located at the roof with the plastic layer between these and the food product. This plastic layer is coated with black paint that acts as an absorber for the moisture eliminated from the food product (Torringa *et al.*, 2001). Glass wool as a best insulating material is used in solar drier to avoid the heat losses from the food product. This completely enclosed system is arranged at some angle horizontal to the elevated plate forms where no fans with direct current supply provide air flow. The low power is required to operate these because of the reality that the air being used in solar drier passes side by side to the product, not from the inner side of the product.

In rainy season the roof of solar dried is kept as sloping to avoid the entry of water into the channel of drier. When the radiation passes through the food, the collector collect radiations and increases the temperature of that chamber that further increase the temperature of food stuff and absorbs the maximum moisture from the product. Temperature in the drier ranges from 34.1-64.0° C by a change in solar radiation form 0- 580 W/m²that increases the drying flow rate (Singh *et al.*, 1999).

Drying is undoubtedly the most extensively used method for assuring the long term storage of food products. By using both microwave and hot air drying method a good dehydrated product can be achieved which has both flavor preservation and acceptable rehydration properties. Numerous researches have depicted that different food stuffs such as vegetables, fruits, oils, herbs, spices, cereal grains and in some cases meat also can be dried in solar drier by covering the food

stuff under the plastic packs (Bala *et al.*, 2002). Therefore, different studies conducted on solar drying have proved that it is a good alternative for sun drying for the production of high quality dried products (Beltagy *et al.*, 2007).

Papaya is one of the major horticultural crops of the tropics and sub-tropics. After harvesting, the quality of papaya deteriorates easily. To stabilize moisture content drying is largely utilized. It is the oldest method of food preservation by removing water from the food. Reduction in water activity prevents the growth of micro-organisms and this consequently reduces the rate of chemical reaction.

Drying and freeze drying are used to reduce the moisture content of papaya chunks and slices. Powdered or dried papaya can be used as a flavoring agent, meat tenderizer or as an ingredient in soup mixes. Lau and Taip (2011) determined the different drying parameters on in papaya halwa drying. They concluded that Factors such as air temperature, sample thickness, drying time, and sugar concentration played a major role during the drying process in all drying methods applied. At high temperature, the samples at any thickness dried faster than those at lower temperature.

Meanwhile, the samples with lower thickness also resulted in faster drying time. The moisture in the thinner samples was removed faster than the thicker samples at any temperature and sugar concentration. An increase in sugar concentration resulted in longer time for the moisture to evaporate at different thicknesses and temperatures.

Similarly, different drying methods resulted in different drying rates and affected the physical attributes of the dried samples such as color and texture. Depending on the temperature, sample thickness and sugar concentration, the time needed to achieve the equilibrium moisture content (0.10 kg H₂O/kg dry solid) for oven drying ranged between 5 to 11 hours. For the solar and sun drying, the drying time was between 14-23 hours; whereas, it only took 6-15 minutes using microwave to achieve particular moisture content. Although microwave drying method could save up to 90% of the drying time, as compared to the sun drying method, the microwave dried samples were the least popular when color appearance and texture were considered. Among the various methods of drying characteristics of papaya halwa, oven drying was preferred with the optimum sample in 5mm thickness and at the air temperature of 70°C, as it saved up to 40% of drying time compared to other methods (except microwave) and produced acceptable physical quality of the product.

Ojike *et al.* (2011), a study was conducted to check the effect of different drying system on vitamin level of papaya. Papaya samples were dried under four different conditions: open-air sun drying and by solar dryers like, green house solar dryer, latitudinal box and sun tracking dryer.

Fresh and dried samples were subjected to analyze for vitamins A, B₁, B₂, C and E. A significant difference was in vitamins concentrations in all drying systems. The concentrations were reduced in all dried samples and vitamins E increased in all types except open air solar dryer.

From all of these four systems, open-air dried samples showed less concentration and solar dryer showed different concentrations with latitudinal box dryers gives best result in terms of

vitamins retention. Prolonged time exposure to air resulted in low level of vitamins in open sun dried samples. Belong to the class of water soluble vitamin, vitamin C leach out (Eze and Chibuzor, 2008). Heat does not show any effect on vitamin E but it is liable to air (Kreutler and Czajka-Narins, 1987) and in solar dried samples its level increased.

Papaya as an excellent source of phytochemicals includes polysaccharides, vitamins, minerals, enzymes, protein, alkaloids, glycosides, fats and oils, flavonoids and sterols. Papaya fruit contain benzyl- β -D glucoside, 2-phenylethyl- β -D-glucoside and four isomeric malonated benzyl- β -D-glucoside. Papaya juice has N-butyric, n-hexanoic, a-octanoic acid, stearic, linolenic and oleic acid (Krishn *et al.*, 2008). Godson and Ojmelulwe (2012) studied the chemical composition of fruit pulp, leaves and seed of some papaya morphotypes and revealed that there was a high significant difference for proximate, chemical and minerals composition of different parts of plant. The leaves have more crude protein, carbohydrate, fiber, Ca, Mg, Fe and K as compared to the fruit pulp and seed. In these morphotypes Beta- carotene was the vitamin which is most abundantly found while papain was only present in leaves.

In papaya seed benzylglucosinolate (with myrosinase inactivation) is present in >1 mmol of 100 g of fresh weight which is equal to quantity found in Karami daikon (the hottest Japanese white radish) and cress (Nakamura *et al.*, 2007). Benzylisothiocynate present in seeds is the chief or sole antihelminthic (Kermanshai *et al.*, 2001). The *C. papaya* seed oil is stable during storage and possesses little or no cellular injury (*i.e.* low toxicity) when consumed. Oil and seed coat can be used as daily energy supply for humans. The oil is a source of antioxidants than the seed coat.

However, both the seed coat and the oil have reasonable antioxidant properties; that gives authority to their nutritional potential and health benefits. This result provided a good quality standard for both the seed and the oil of papaya. The enhanced therapeutical perspective of *C. papaya* seed and its oil increased its commercialization in the world. The oil can also be useful for biofuel purposes while the seed coat may equally be developed into edible coatings accompanied by packaging materials for shelf-extension of agro-crops (Afolabi and Ofobrukmeta, 2011).

The interesterification of ethyl esters of C₂ to C₁₄ in saturated was done by the help of papaya lipase enzyme to produce triglycerols with palmitoyl part in the secondary (*sn*-2), and short-chain or medium-chain acyl moieties in the primary (*sn*-1,3) positions. Medium and long chain ethyl esters prefer for papaya lipase as compare to short chain EE. Because esterification of these medium and long chain acyl fragments has more tendency with primary hydroxyl position (Neena and Mukherjee, 2001).

Many biologically active phytochemicals are present in papaya (*Carcia papaya*) which have been separated and studied for their mode of action. Presently an antifungal chitinase has been cloned genetically that is characterized by papaya fruit. The chitinase is grouped as class IV chitinase based on its amino acid sequence homology with other plant chitinase (Chen *et al.*, 2007).

In literature different parts of papaya is reported to be used in pharmacological as well as for medicinal uses. From different parts of papaya *i.e.* latex, seed, leaf bark, stem and fruit biologically activities of papaya is reported. Although crude extract of different parts of papaya is used as traditional medicine for treatment of diseases. The aqueous extract of fruit showed antimicrobial

activity and profound significant wound healing in diabetic rats. Papaya latex is used as meat tenderizer and wounds and burn healing (Hewitt *et al.*, 2000) such as the latex from the mature papaya fruit may be used in the healing of hepatic jaundice, diphtheria, kidney stones and urinary disorders. Papaya also has medicinal properties for dysentery, tooth decay, whitlow, convulsion, rheumatism and gonococcal infections.

The leaves are used in the treatment of headaches, rheumatism, hernia, orchitis, blennorrhoea and haemorrhoids. Papaya leaves also have the property to tender tough meat when marinated overnight. The fresh green leaves may be used to scrub metal pails and rid them of contamination and other infected organic substances. They may also be used to slow down the development of arthritis, for cleaning the teeth, checking unpleasant breath and also as an antidote against diarrhea (Hewitt *et al.*, 2000).

The best anti-malarial activity of papaya is observed in its petroleum ether extract prepared by using peel. While the aqueous papaya leaves have showed positive prospective against dengue fever treatment. From the patient reports it is cleared that it has a positive potential on hematological (Abdalla *et al.*, 2013). Papaya juice also known as papaya milk has strong therapeutical potential against fungal and bactericidal properties especially towards *Candida albicans* (Giordani and Siepai, 1991), hence, it is strongly useful to the protection from skin eczema caused by this fungus. Antiseptic quality of latex inhibits the growth of undesirable bacteria in human digestive system. Papaya contains essential amino acid from which arginine is important for male fertility and carpain, thought to be good for the heart related disorders.

Globally, there are about 2.6 billion spent hens that are used in the pet food industry and not much for human consumption (Navid *et al.*, 2011). Meat from spent hens tends to be tough, with low juiciness and fat. These spent hens have unacceptable toughness and bitter bones, these hens are a major issue in poultry industry from decades. This toughness in older animals is dependent on the cross linking between the connective tissues (Archile-Contreras *et al.*, 2011). Therefore, the farmers are facing a problem in disposing their old-unproductive layers at a minimum price. Other materials like chlorides, phosphates have been reported to be used for tenderizing aged and tough meat (Sachdev and Verma, 1990).

By cutting the green surface of papaya plant its latex can be obtained. And then exuding latex is collected in porcelain or earthenware containers over a couple of days. The latex is then sun dried or oven dried, and ground into powder. A proteolytic enzyme, papain, is purified from papaya latex and used in the food and feed industries, as well as the pharmaceutical and cosmetic industries (Office of the Gene Technology Regulator Australia, 2008). The latex is a composite mixture of chemical compounds having varied chemical activities (El Moussaoui *et al.*, 2001) and serves as an excellent meat tenderizer (Huet *et al.*, 2006).

The latex is rich in enzyme known as cysteine proteinase and constitutes as much as 80% of the enzyme portion in papaya latex, which is used widely for protein digestion (El Moussaoui *et al.*, 2001).

Papain an enzyme is used in biochemical research for different purposes including analysis of protein, tenderizing action on meat, enzyme activity in food and also in preparation of various

medicines for digestive disorders. In vertebral injuries papain is used to dissolve the disks and also as a digestant of protein. It was suggested that papain with 0.025% concentration at 3% level (w/w) can be used to improve the tenderness and functional properties of spent hen meat cuts for efficient utilization (Khanna and Panda, 2007).

Sensory evaluation of papain treated spent hens revealed significantly higher score for juiciness, tenderness and overall acceptability (Mendiratta *et al.*, 2002). It is also proved that there were no significant differences in percent cooking loss, pH, moisture, protein and fat percentage of product. So, it was concluded that dietary supplementation of 2% papaya leave meal in spent layer hens for a few days before slaughter improved the meat quality in terms of meat tenderness and juiciness (Navid *et al.*, 2011). Recently, Abdalla *et al.* (2013) concluded that adding 10% papaya leaves powder to the feed of the spent layer hens had a significant effect on their meat tenderness.

While for packaging the wrapping of the spent layer hens' meat with fresh papaya leaves for one hour before cooking increased its level of tenderness. Papaya leaves juice or extract in addition to vinegar had lower effect on tenderness compared with papaya leaves. Moist cooking had greater effect on tenderness compared with oven cooking using all marinades. Application of marinades one hour before cooking was enough for meat tenderization.

The bio-molecules present in *C. papaya* such as papain, caricain, chymopapain and glycine endo-peptidase can survive in acidic pH and pepsin degrading environment. Although at low pH these enzymes can alter their molecular structural arrangement. This organization rapidly converts native form of bioactive molecule into globules shape which is very unstable and degraded by pepsin. For the control of gastrointestinal nematodes oral intake of papain enzymes must be confined against both acid denaturation and protein break down (Huet *et al.*, 2006).

Industrially important proteolytic enzymes *i.e.* papain and chymopapain are present in creamy white latex exude of fruit that can be used to promote the potential of papaya plant. The green fruit is normally a superior source of papain than ripen one. Latex of unripe fruit has 15 time higher activity as compared to *C. papaya* (Scheldeman *et al.*, 2002). In papaya benzyl derivatives (Benzyl isothiocyanate, glucosinolate and glucotropaeolin) are found.

Trypsin inhibitor named as papaya kunitz-type, a glycoprotein of 24-KDa inhibits bovine trypsin in an equal quantity when it is stoichiometrically purified (Azarkan *et al.*, 2006). This reaction provides an idea about the α -amylase inhibition from *C. papaya* seeds which has proved itself effective towards cowpea weevil (*Callosobruchus maculatus*) (Farias *et al.*, 2007).

USDA phytochemical and ethnobotanical databases access the complete list of the compounds found in various parts of the papaya plant. The levels of compound differ in different parts of plant. Male and female plant also produced different compounds like phenolic compounds are higher in male plants as compared to the female plants.

In tropical traditional medicine, the fresh latex is used as vermifuge by smeared on boils, warts and freckle. The latex from the fruit may be used in the treatment of hepatic jaundice, diphtheria, kidney stones and urinary disorders. It is also a coagulant. The leaves are used in the treatment of headaches, rheumatism, hernia, orchitis, blennorrhoea and haemorrhoids. The fresh green leaves may be used to scrub metal pails and rid them of contamination and other infected

organic substances. They may also be used in the treatment of wounds, whitlow amoebiasis, gangrenous ulcers, difficult deliveries and high blood pressure. They also serve as an antidote against poisoning and rabies (Arbonnier, 2004).

Crushed leaves are used for rapid tenderization of tough meat. The leaf is used as laundry soap and for removal of stains in old age. The leaves may also serve as poison for fishing (Arbonnier, 2004). In asthma disease dried leaves have been smoked or used as a tobacco substitute. Dried papaya leaves are used in the manufacturing of tea bags, in the field of medicine it is used to protect against many GIT disorders as well as in urinary system problems. These dried leaves are also helpful to cure stomach problems and can also reduce the occurrence of yellow fever. The fruits are also used as useful medication for the treatment of digestive disorders, wounds, yaws, ergotism, wart and callus (Arbonnier, 2004).

Fruits and fruit purees is one of the most valuable fat mimics. Due to their pectin, fiber and sugar content puree of different fruits are used to perform function of fat. Fiber and pectin are involved particularly in providing texture to any product. Also, fruit sugar gives water binding property to food. Added health benefits may include antioxidant activity. Replacers are mostly used in bakery muffins and other related products. Care must be taken while the addition of these replacers because these are not modified such extent. Pawpaw fruit powdered by the solar drying method could also be used as a fat replacer since it has a high fiber and pectin content. According to Pamplona-Roger (2003), the fruit of pawpaw contains 1.5 g/100 g pectin per raw edible portion of pawpaw fruit.

Duffrin *et al.* (2001) used papaya fruit as fat replacer in muffins and compare with control (100% fat) muffins. They studied that muffins with 91% replacement were equally acceptable than other for all attributes than the appearance. The high pectin content of pawpaw attests to its potential as a fat replacer; thus it can be used for fat replacement purposes in pastries like rock buns and pies. Pawpaw fruit powdered by the freeze drying method could also be used as a fat replacer since it has a high fiber and pectin content. According to Pamplona-Roger (2003), the fruit of pawpaw contains 1.5 g/100 g pectin per raw edible portion of pawpaw fruit.

Tiffany and Duffrin (2003) studied the sensory properties of plain cake with the addition of papaya fruit puree as a partial replacement for the fat in the food formulation. Sensory parameters are affected by this addition and have a great influence on overall acceptability. Participant preferred the control and 25% puree replacement cake more than other high concentration. The increased replacement of fat resulted in decreased preference in cake samples for the color, texture, tenderness and overall acceptability.

Antioxidants are a special group of nutritional supplements that scavenge free radicals. Free radicals impair the proper functioning of the immune system leading to various disease conditions.

Naturally occurring phenolic compounds in plants are flavanoids, which have antioxidant effects. Alkaloids on the other hand, are known for their anti-inflammatory activity (Padma *et al.*, 2006).

Natural antioxidants such as flavonoids, tannins, coumarins, xanthenes, phenolics, terpenoids, ascorbic acid, and proanthocyanins are found in various plant products, including fruits, leaves, seeds, oils, and juices. *Carica papaya* L. (Caricaceae) is cultivated in most subtropical and tropical countries for its fruits and its proteolytic enzymes. These constituents are vitamin E as α tocopherol, Vitamin C as ascorbic acid, beta carotene, flavonoids, vitamin B₁, and niacin (Bhattacharjee, 2001). The flesh color of papaya fruits is due to the presence of carotenoids. Red-fleshed papaya fruits also comprised of five sub classes of carotenoids: beta-carotene, beta-cryptoxanthin, beta-carotene-5-6-epoxide, lycopene and zeta-carotene whilst, yellow-fleshed papaya contains only three subclasses of carotenoids: beta-carotene, beta-cryptoxanthin and zeta-carotene (Chandrika *et al.*, 2003). The concentration of b-carotene ranges from 866 to 7,807 $\mu\text{g}/100\text{g}$ dry matter in ripe fruits (Puwastien *et al.*, 2000; Saxholt *et al.*, 2008). Differences in the methods of analysis have been shown to contribute to the variations in reported beta-carotene content (Rodriguez-Amaya *et al.*, 2008).

(Ayoola and Adeyeye, 2010) evaluated the phytochemicals and nutrient of papaya leaves. The randomly chosen leaves were subjected to phytochemical composition, vitamins and mineral constituents. Bioactive components were present in these samples. Results showed that the plant leaves contained the vitamins, (mg/100g), thiamine (B1), riboflavin (B2), ascorbic acid (C). In green leaves minerals were present in high concentration and in yellow leaves iron is present in more concentration. Also the green and yellow leaves differ from each other from nutrient point of view like: green papaya leaf is a better source of essential nutrients and yellow leaves are good for iron. Hence, papaya is a powerful tool used in the manufacturing of different drugs and its laved can be used in numerous herbal treatments.

The phytochemical and the antioxidant nutritional potential of papaya was observed by Ngozi *et al.* (2010), they suggested that the skin cell anemia can be controlled by the induction of papaya owing to its medicinal perspectives. Modern techniques as the chromatography techniques are helpful to detect the medicinal properties present due to the presence of the antioxidant potential, proximate, amino acids and the mineral contents present in it. The rich phytochemical potential is also due to the presence of the antioxidants and the vitamins present in its juice. Different studies showed that this papaya can be used as medicine (Oduola *et al.*, 2006). Another study leaves of papaya tree has anti-sickling property in different concentrations (Imaga *et al.*, 2009).

Papaya is a carbohydrate based fat replacer and has a great potential to be used in bakery and its fat replacing property make it an excellent choice among health conscious people. Sensory characteristics of papaya substituted baked product showed that it is acceptable by consumer and it showed almost same properties as of controlled or full fat bakery product. Drying is a best preservative technique to store a food commodity for a longer period of time. Laura *et al.* (2010) concluded that the ripening stage effects on the physiological and the biochemical parameters of the papaya. Ripened fruit is further divided into four classes as R1, R2, R3 and R4 depending upon these parameters. Physiological and physico-chemical analysis such as pH, acidity, color,

total soluble solids, respiration & production of ethylene, total phenolic contents and also the antioxidant activity.

2. CONCLUSION

Dietary factors are involved in a number of chronic degenerative diseases. People continue to look for ways to improve their nutritional habits without changing psychological satisfaction. High fat intake result in increased risk for some types of cancer and high blood cholesterol and heart problems are associated with saturated fat intake. Also, high fat intake results in excess energy intake, positive energy balance, and the development of obesity. As the result, almost all the healthy conscious individuals are changing their dietary habits and eating less fat. Taste is the most important sensory parameters on which is responsible for the acceptance of any product. Consumers want foods with less or no fat, they also want the foods to taste good. It gives a new challenge to food manufacturers to develop reduced fat food with same attributes. For this purpose different fat replacers are used. Fruits have the capacity to be used as fat replacer. The purpose of this study is to use papaya due to its pectin content and it can be used as fat replacer. The whole research was categorized into four parts: Development of papaya powder, use of powder as fat replacer, evaluate the acceptability of papaya cake and evaluate the storage effect on sensory properties of cake.

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REFERENCES

- AACC, 2000. Approved methods of the American association of cereal chemists. 10th Edn., St. Paul, MN: American Association Cereal Chemistry.
- Abdalla, H.O., N.N.A. Ali, F.S. Siddig and S.A.M. Ali, 2013. Improving tenderness of spent layer hen's meat using papaya leaves (*Carica Papaya*). *Pakistan Veterinary Journal*, 33(1): 73-76.
- Afolabi, I.S. and K. Ofobrukmeta, 2011. Physicochemical and nutritional qualities of carica papaya seed products. *Journal of Medicinal Plants Research*, 5(14): 3113-3117.
- Akoh, C.C., 1998. Fat replacers. *Food Technology*, 52(3): 47-52.
- Arbonnier, M., 2004. Trees, shrubs and lianas of West African dry zones. Netherlands: CIRAD, MARGAF Publishers GMBH, MNHN. pp: 149-248.
- Archile-Contreras, A.C., M.C. Cha, I.B. Mandell, S.P. Miller and P.P. Purslow, 2011. Vitamins E and C may increase collagen turnover by intramuscular fibroblasts, potential for improved meat quality. *Journal of Agriculture and Food Chemistry*, 59(2): 608-614.
- Ayoola, P.B. and A. Adeyeye, 2010. Phytochemical and nutrient evaluation of carica papaya (Pawpaw) leaves. *International Journal of Research and Applied Science*, 5(3): 325-328.

- Azarkan, M., R. Dibiani, E. Goormaghtigh, V. Raussens and D. Baeyens-Volant, 2006. The papaya kunitz-type trypsin inhibitor is a highly stable β -sheet glycoprotein. *Biochimica et Biophysica Acta (BBA) - Proteins and Proteomics*, 1764(6): 1063-1072.
- Bala, B.K., M.R.A. Mondol, B.K. Biswas, B.L. Das Chowdury and S. Janjai, 2002. Solar drying of pineapple using solar tunnel drier. *Journal of Food Engineering*, 28(2): 183-190.
- Beltagy, A.E., G.R. Gamea and A.H. Amer Essa, 2007. Solar drying characteristics of strawberry. *Journal of Food Engineering*, 78(2): 456-464.
- Bhattacharjee, S.K., 2001. Carica papaya, In: Hand book of medicinal plants. 3rd Revised ed, by Shashi Jain (Ed). Jaipur: Pointer Publisher. pp: 1-7.
- Bockki, M., I.Y. Bae, H.G. Lee, S.H. Yoo and S. Lee, 2010. Utilization of pectin-enriched materials from apple pomace as a fat replacer in a model food system. *Journal of Bioresources and Technology* 101(14): 5414-5418.
- Bouraoui, M., P. Richard and J. Fichtali, 1993. A review of moisture content determination in foods using microwave oven drying. *Journal of Food Engineering*, 26: 49-51.
- Burns, A.A., M.B.E. Livingstone, R.W. Welch, A. Dunne, A. Reid and I.R. Rowland, 2001. The effects of yoghurt containing a novel fat emulsion on energy and macro-nutrient intake in lean, over-weight and obese subjects. *International Journal of Obesity Related to Metabolic Disorders*, 25: 1487-1496.
- Chandrika, U.G., E.R. Jansz, S.N. Wickramasinghe and N.D. Warnasuriya, 2003. Carotenoids in yellow- and red-fleshed papaya (*Carica Papaya* L). *Journal of Science and Food Agriculture*, 83: 1279-1282.
- Chen, Y.T., I.P. Huang, T.C. Tsai, G.G. Lee and J.F. Shaw, 2007. Gene cloning and characterization of a novel recombinant antifungal chitinase from papaya (*Carica Papaya*). *Journal of Agriculture and Food Chemistry*, 55(3): 714-722.
- Cheung, I., F. Gomes, R. Ramsden and D.G. Roberts, 2002. Evaluation of fat replacers avicel, N Lite S, and simplese in mayonnaise. *International Journal of Consumer Study*, 26: 27-33.
- Clark, D., 1994. Fat replacers and fat substitutes. *Food Technology*, 48(12): 86-88.
- Claudia, F.O., D. Neli and M. Ognean, 2006. Fat replacers-review. *Journal of Agroalimentary Product Technology*, 12(2): 433-442.
- Conforti, F.D. and L. Archilla, 2001. Evaluation of amylo-dextrin gel as a partial replacement for fat in a high ratio white-layer cake. *International Journal of Consumer Science*, 25: 238-245.
- Cooper, D.A., D.A. Berry, M.B. Jones and A.L. Kiorpes, 1997. Olestra's effect on the status of vitamins A, D and E in the pig can be offset by increasing dietary levels of these vitamins. *Journal of Nutrition*, 127: 1589-1608.
- De-Castro, J.M., 2004. Dietary energy density is associated with increased intake in free living humans. *Journal of Nutrition*, 134: 335-341.
- DiMigelio, D.P. and R.D. Mattes, 2004. Liquid versus solid carbohydrate: Effects on food intake and body weight. *International Journal of Obesity*, 24: 794-800.
- Doymaz, I., 2004. Pretreatment effect on sun drying kinetics of mulberry fruits (*Morus Alba* L.). *Journal of Food Engineering*, 65: 205-209.

- Drewnowski, A., 1998. Energy density, palatability and satiety: Implications for weight control. *Nutrition Review*, 56: 347-353.
- Duffrin, M.W., D.H. Holben and M.J. Bremner, 2001. Consumer acceptance of pawpaw (*Asimina Triloba*) fruit puree as a fat-reducing agent in muffins, compared to muffins made with applesauce and fat. *Consumer Science and Research Journal*, 29: 281-287.
- El-Naggar, A.K., H.W. Kim, G.L. Clayman, M.M. Coombes, B. Le, S. Lai, F. Zhan, M.A. Luna, W.K. Hong and J.J. Lee, 2002. Differential expression profiling of head and neck squamous carcinoma: Significance in their phenotypic and biological classification. *Oncogene*, 21(53): 8206-8219.
- El Moussaoui, A., M. Nijs, C. Paul, R. Winljens, J. Vincentelli, M. Azarkan and Y. Looze, 2001. Revisiting the enzymes stored in the laticifers of carica papaya in the context of their possible participation in the plant defense mechanism. *Cell Molecule Life Science*, 85: 556-570.
- Espe, A. and W. Muhlbauer, 1998. Solar drying an effective means of food preservation. *Renew. Energy*, 15: 95-100.
- Eze, J.I. and E.E. Chibuzor, 2008. Evaluation of drying efficiency of solar cabinet dryer using okra and tomato. *Nigerian Journal Solar Energy*, 19(1): 25-33.
- Farias, L.R., F.T. Costa, L.A. Souza, P.B. Pelegrini, M.F. Grossi-de-Sa, S.M. Neto Jr, C. Bloch, R.A. Laumann, E.F. Noronha and O.L. Franco, 2007. Isolation of a novel carica papaya α -amylase inhibitor with deleterious activity toward *callosobruchus maculatus*. *Pesticide Biochemistry and Physiology*, 87: 255-260.
- Faridi, H. and J.M. Faubion, 1990. Dough rheology and baked product texture .AVI. Van Nostrand Reinhold New York.
- Fellows, P., 1997. Traditional foods. Processing for profit. UK: Intermediate Technology Publications Ltd. pp: 1-120.
- Giordani, R.O. and M. Siepai, 1991. Antifungal action of carica papaya latex isolation of fungal cell wall hydrolyzing enzymes. *Mycoses*, 34: 469-477.
- Godson, E.N. and P. Ojimeulwe, 2012. Chemical composition of leaves, fruit pulp and seed in some carica papaya (*L*) morphotypes. *Int. J. Med. Arom. Plants*, 2(1): 200-206.
- Gurr, I., 2002. Fats. In: S. Garrow, W.P.T. James and A. Ralph (Eds.). 10th Edn., U.K.: Churchill Livingstone. pp: 97-102.
- Gyabaah-Yeboah, E., 1985. African workshop for improvement and development of drying fruits in Ghana. Proceedings of the Expert Consultation on Planning the Development of Sun Drying Techniques in Africa, Food and Agriculture Organisation of the United Nations, Rome. pp: 1-3.
- Hewitt, H.H., S. Whittle, S.A. Lopez, E.Y. Bailey and S.R. Weaver, 2000. Topical uses of papaya in chronic skin ulcer therapy in Jamaica. *Indian Medicine Journal*, 49(1): 32-33.
- Huet, J., Y. Looze, K. Bartik, V. Raussens, R. Wintjens and P. Boussard, 2006. Structural characterization of the papaya cysteine proteinases at low pH. *Biochemistry Biophysics Research Community*, 341: 620-626.
- Imaga, N.O.A., G.O. Gbenle, V.I. Okochi, S.O. Akanbi, S.O. Edeoghon, V. Oigbochie, M.O. Kehinde and S.B. Bamiro, 2009. Antisickling property of carica papaya leaf extract. *African Journal of Biochemistry and Research*, 3(4): 102-106.

- Ingelin, M.E. and O.M. Lukow, 1999. Mixograph absorption determined by response surface methodology. *Cereal Chemistry*, 76: 9-15.
- Jiang, R., J.E. Manson, M.J. Stampfer, S. Liu, W.C. Willet and F.B. Hu, 2002. Nut and peanut butter consumption and risk of type 2 diabetes in women. *Journal of American Medicinal Association*, 288: 2554-2560.
- Jissy, J. and K. Leelavathi, 2007. Effect of fat type on cookie dough and cookie quality. *Journal of Food Engineering*, 79: 299-305.
- Kermanshai, R., B.E. McCarry, J. Rosenfeld, P.S. Summers, E.A. Weretilny and G.J. Sorger, 2001. Benzyl isothiocyanate is the sole or chief anthelmintic in papaya seed extracts. *Phytochemistry*, 57(3): 427-435.
- Khanna, N. and P.C. Panda, 2007. Effect of papain on tenderization and functional properties of spent hen meat cuts. *Indian Journal of Animal Research*, 41: 55-58.
- Kral, T.V., L.S. Roe and B.J. Rolls, 2004. Combined effects on energy density and portion size on energy intake in women. *American Journal of Clinical Nutrition*, 79: 962-968.
- Krauss, R.M., R.H. Eckel and B. Howard, 2001. American heart association's (AHA): AHA dietary guidelines – Revision 2000: A statement for healthcare professionals from the nutrition committee of the American heart association. *Journal of Nutrition*, 131: 132-146.
- Kreutler, P.A. and D.M. Czajka-Narins, 1987. *Nutrition in perspective*. 2nd Edn., Englewood Cliffs, New Jersey: Prentice Hall.
- Krishn, K.L., M. Paridhavi and A.P. Jagruti, 2008. Review on nutritional, medicinal and pharmacological properties of papaya (*Carica Papaya* Linn.). *National Product Report*, 7: 364-373.
- Lau, F. and F.S. Taip, 2011. Effects of different operating parameters in papaya halwa. *Pertanika Journal of Food Science and Technology*, 19(2): 389-396.
- Laura, E., G.G. Sancho and E.M. Yahia, 2010. Effect of maturity stage of papaya maradol on physiological and biochemical parameters. *American Journal of Agriculture and Biology Science*, 5(2): 194-203.
- Lin, S.D. and C.C. Lee, 2005. Qualities of chiffon cake prepared with indigestible dextrin and sucralose as replacement for sucrose. *Cereal Chemistry*, 82: 405-413.
- Maache-Rezzoug, Z., J.M. Bouvier, K. Allaf and C. Patras, 1998. Study of mixing in connection with the rheological properties of biscuit dough and dimensional characteristics of biscuits. *Journal of Food Engineering*, 35(1): 43-56.
- Mendiratta, S.K., G. Chauhan, P.K. Nanda, A.S.R. Anjaneyulu, N. Kondaiah and S. Devatkal, 2002. Preparation of enrobed chunks from spent hen meat tenderized with papain. *Indian Journal of Poultry Science*, 37: 295-298.
- Mistry, V.V., 2001. Low fat cheese technology. *International Dairy Journal*, 11: 413-422.
- Nakamura, Y., M. Yoshimoto, Y. Murata, Y. Shimoishi, Y. Asai, E.Y. Park and K. Sato, 2007. Papaya seed represents a rich source of biologically active isothiocyanate. *Journal of Agriculture and Food Chemistry*, 55: 4407-4413.
- Navid, S., A. Sheikhlar and K. Kaveh, 2011. Influence of the combination of vitamin D3 and papaya leaf on meat quality of spent layer hen. *Agriculture Journal*, 6: 197-200.

- Neena, N.G. and K.D. Mukherjee, 2001. Synthesis of designer lipids using papaya (*Carica Papaya*) latex lipase. *Journal of Molecular Catalase B: Enzyme*, 11: 271-277.
- Ngozi, A.I., G.O. Gbenle, V.I. Okochi, S. Adenekan, T. Duro-Emmanuel, B. Oyeniyi, P.N. Dokai, M. Oyenuga, A. Otumara and F.C. Ekeh, 2010. Phytochemical and antioxidant nutrient constituents of carica papaya and parquetina nigrescens extracts. *Science Research and Essays*, 5(16): 2201-2205.
- Nonaka, H.H., 1997. Plant carbohydrate derived products as fat replacers and calorie reducers. *Cereal Foods World*, 42(5): 377-378.
- Oduola, T., F.A.A. Adeniyi, E.O. Ogunyemi, I.S. Bello and T.O. Idowu, 2006. Antisickling agent in an extract of unripe pawpaw (*Carica Papaya*): Is it real? *African Journal of Biotechnology*, 5(20): 1947-1949.
- Office of the Gene Technology Regulator Australia, 2008. The biology of carica papaya L. (*Papaya*, *Papaw*, *Paw Paw*): February 2008, Aus. Gov. Deptt. Health and Ageing.
- Ojike, O., O.O. Nwoke and W.I. Okonkwo, 2011. The influence of different solar drying systems on the vitamin content of pawpaw (*Carica Papaya*). *Australian Journal of Agriculture and Engineering*, 2(1): 8-11.
- Ordenez, M., J. Rovira and I. Jaime, 2001. The relationship between the composition and texture of conventional and low-fat frank furthers. *International Journal of Food Science and Techology*, 36: 749-758.
- Padma, S.V., T.L. Vandna, S. Warjeet and S. Ningomban, 2006. Antioxidant properties of some exclusive species of zingiberacea family of manipur electronic. *Journal of Agriculture and Food Chemistry*, 5(2): 1318-1324.
- Pamplona-Roger, G.D., 2003. *Healthy foods*. 1st Edn., Euorpean Union: Marpa Artes Publications, 32: 264-267.
- Penfield, M.P. and A.M. Campbell, 1990. *Fats and their lipid constituents*. In: *Experimental food science*. 3rd Edn., San Diego, CA: Academic Press Inc. pp: 351-357.
- Piper, B., 1999. *Diet and nutrition. A guide for students and Practitioners*. Ltd., UK. pp: 66-85.
- Prachayarawarakorn, S., W. Tia, N. Plyto and S. Soponronnarit, 2007. Drying kinetics and quality attributes of low-fat banana slices dried at high temperature. *Journal of Food Engineering*, 85: 509-517.
- Puwastien, P., B. Burlingame, M. Raroengwichit and P. Sungpuag, 2000. *ASEAN food comp. Tables Nutr.* Mahidol Univ. Thailand.
- Rodriguez-Amaya, D.B., M. Kimura, H.T. Godoy and J. Amaya-Farfan, 2008. Updated brazilian database on food carotenoids: Factors affecting carotenoid composition. *Journal of Food Components Analysis*. 21: 445-463.
- Romeih, E.A., A. Michaelidou, C.G. Biliaderis and G.K. Zerfiridis, 2002. Low-fat white-brined cheese made from bovine milk and two commercial fat mimetics: Chemical, physical and sensory attributes. *International Dairy Journal*, 12: 525-540.
- Sachdev, A.K. and S.S. Verma, 1990. Tenderization of spent hen meat. *Indian Poultry Review*, 21: 21-25.
- Sampaio, G.R., M.N. Claudia and E.A.F.S. Torrcs, 2004. Effect of fat replacers on the nutritive value and acceptability of beef frankfurters. *Journal of Food Component Analysis*, 18: 469-474.

- Sandrou, D.K. and I.S. Arvanitoyannis, 2000. Low-fat/calorie foods: Current state and perspective. *Critical Review of Food Science and Nutrition*, 40: 427-447.
- Saxholt, E., A.T. Christensen, A. Moller, H.B. Hartkopp, K. Hess Ygil and O.H. Hels, 2008. Danish food composition databank, deperatment of nutritional national food institute. Technological University. Denmark.
- Scheldeman, X., P.S.V. Damme and J.P.R. Motoche, 2002. Highland papayas in Southern ecuador: Need for conservation actions. *Acta Horticulture*, 575: 199-205.
- Schwenk, N.E. and J.F. Guthrie, 1997. Trends in marketing and usage of fat-modified foods: Implications for dietary status and nutrition promotion. *Economic Nutrition and Review*, 10: 16-32.
- Singh, A.K., H.K. Sharma, P. Kumar and B. Singh, 1999. Physico-chemical changes in white button mushroom (*Agaricus Bisporus*) at different drying temperatures. *Mushroom Research*, 8: 27-30.
- Spies, R., 1990. Application of rheology in the bread industry. In: H. Faridi and J.M. Faubion (Eds.), *Dough rheology and baked product texture*, New York: AVI Van Nostrand Reinhold. pp: 343-361.
- Stauffer, C.E., 1998. Fats and oils in bakery products. *Cereal Foods World*, 43(3): 120-126.
- Stretch, B., 2006. *Health studies*. Oxford, UK: Heinemann Educational Publishers. pp: 472-517.
- Swanson, L.B. and L.B. Munsayac, 1999. Acceptability of fruit puree in peanut butter, oatmeal and chocolate chip reduced fat cookies. *Journal of American Diet Association*, 99: 343-345.
- Swanson, R.B., J.M. Perry and L.A. Carden, 2002. Acceptability of reduced fat brownies by school-aged children. *Journal of American Diet Association*, 102: 856-859.
- Tiffany, D.W. and W. Duffrin, 2003. Effects of substituting pawpaw fruit puree for fat on sensory properties of a plain shortened cake. *Consumer Science Research Journal*, 13(3): 442-444.
- Torringa, E., E. Esveld, I. Scheewe, V. Den-Berg and P. Bartels, 2001. Osmotic dehydration as a pretreatment before combined microwave hot air drying of mushrooms. *Journal of Food Engineering*, 49: 185-191.
- Walker, C.E. and J.L. Hazelton, 1996. Dough rheological test. *Cereal Foods World*, 41: 161-168.
- Wylie-Rosett, J., 2002. Fat substitutes and health – An advisory from nutrition committee of the American heart association circulation, 105: 2800-2804.
- Yackel, W.C. and C.L. Cox, 1992. Application of starch-based fat replacers. *Food Technology*, 46: 146-148.

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