EFFECT OF PROCESSING ON NUTRIENT COMPOSITION AND RHEOLOGICAL PROPERTIES OF PAPAYA AND DEVELOPMENT OF VALUE ADDED PRODUCTS

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1. Introduction

1.1 Micronutrient Deficiency

According to WHO, 2003 “micronutrients" is the collective term applied to essential vitamins and trace minerals. Inadequate intake of them is now recognized as an important contributor to the global burden of disease through increased rates of illness and death from infectious diseases, and of disability such as mental impairment. Deficiencies of some micronutrients are highly prevalent in low- and middle-income countries and may affect the risk of illness or death from infectious diseases by reducing immune and non-immune defenses and by compromising normal physiology or development. Micronutrient malnutrition (in particular vitamin A, iron, and iodine) is major public health problem in our country, too.

Iodine deficiency in pregnancy has long been linked to cretinism and possible fetal wastage. More than two billion people live in areas that used to be iodine-deficient, it is estimated that the current burden of disease caused by iodine deficiency is only 0.2 per cent of the global total. Iron deficiency also affects about two billion people. About 800 000 deaths and 2.4 per cent of global death have been attributed to iron deficiency (Sharma, et al., 2006).

The deficiency of Vitamin A, too, has been now recognized, not only to harm the eyes but to increase childhood and maternal mortality. Globally, 21per cent of children have vitamin A deficiency and thereby, suffer increased rates of death from diarrhoea, measles and malaria. About 800 000 deaths in children and women of reproductive age are attributable to vitamin A deficiency which, along with the direct effects on eye disease, account for 1.8per cent of global. It is important to put these disease burden estimates in perspective. In general, micronutrient malnutrition affects growth and mental development in younger children more severely than older children (Sharma, et al., 2006). Vitamin A deficiency is one of the most important causes of preventable childhood blindness and is a major contributor to morbidity and mortality from infections, especially in children and pregnant women, affecting the poorest segments of populations, particularly those in low and middle income countries. The primary cause of vitamin A deficiency is lack of an adequate intake of vitamin A, and may be exacerbated by high rates of infection, especially diarrhea and measles. Its consequence is most apparent during stages of life of high nutritional demand (e.g. early childhood, pregnancy and lactation). A variety of interventions are being used to improve the vitamin A status of populations: dietary diversification, vitamin A supplementation and fortification (WHO, 2009).

Globally, night blindness affects 5.2 million pre school age children and 9.8 million pregnant women, which corresponds to 0.9 per cent and 7.8 per cent of the population at risk of VAD (Vitamin A Deficiency), respectively. WHO, 2006 estimated 0.5 per cent of preschool age children and around 10 per cent of pregnant women to be affected by night blindness in South-East Asia. Further, the estimates show that the South-East Asia region contains the highest proportions of preschool age children (approximately 50 per cent) and pregnant women (17.3 per cent) with biochemical VAD, as indicated by a serum retinol concentration <0.70 µmol/l. In India 18 per cent and 22 per cent of preschool-children suffered from night blindness and Vitamin A Deficiency (Serum retinol level), respectively.

According to the survey carried out by NNMB, 2006 in 10 states of India, analysis of blood samples revealed that the overall median vitamin A level was 16.8 mg/dL, and ranged from a low 9mg/dL in Madhya Pradesh to a high 20.1 mg/dL in Tamil Nadu. The levels were similar between age groups and gender. About 62 per cent of children in general, had vitamin A levels of <20 mg/dL, indicating sub-clinical VAD, and ranged from a low 49 per cent in the State of Tamil Nadu to a high 88 per cent in Madhya Pradesh. The proportion of children with sub-clinical VAD was significantly higher among 3-5 year children (63.1 per cent) compared to 1-3 years (59.6 per cent). No significant gender differentials were observed.

Toteja, et al., 2002, carried out a study in 16 districts of India to find out the prevalence of VAD disorders among children and pregnant women. The findings revealed prevalence of Bitot's spots among more than 0.5 per cent of children (<6 years) in the district of Bikaner, Rajasthan, which according to WHO cut-off values indicate a public health problem. The most common cause of blindness in developing countries is due to vitamin A deficiency (VAD). The World Health Organization (WHO, 2006) estimates 13.8 million children to have some degree of visual loss related to vitamin A deficiency. Vitamin A deficiency can also lead to impaired immune function, cancer, and birth defects.

Vitamin A is an essential nutrient needed in small amounts for the normal functioning of the visual system, and maintenance of cell function for growth, epithelial integrity, red blood cell production, immunity and reproduction. Essential nutrients cannot be synthesized by the body and therefore must be provided through diet. When dietary intake is chronically low, there will be insufficient vitamin A to support vision and cellular processes, leading to impaired tissue function. Night blindness is the difficulty for the eyes to adjust to dim light. Vitamin A deficiency affects vision by inhibiting the production of rhodopsin, the eye pigment responsible for sensing low light situations. Rhodopsin is found in the retina and is composed of retinal (an active form of vitamin A) and opsin (a protein). Decreasing night blindness requires the improvement of vitamin A status in at risk populations. Consumption of yellow-orange fruits and vegetables rich in carotenoids, specifically beta carotene, provides pro-vitamin A precursors that will prevent vitamin A deficiency related night blindness. A low dietary intake of carotenoids such as beta-carotene is not known to directly cause any disease or health condition, a dietary deficiency of beta-carotene and/or other provitamin A carotenoids can cause the symptoms associated with vitamin A deficiency. In addition, long-term inadequate intake of carotenoids is associated with chronic disease, including heart diseases and various cancers. One important mechanism for this carotenoid-disease relationship appears to be free radicals. Research indicates that diets low in beta-carotene and carotenoids can increase the body's susceptibility to damage from free radicals. As a result, over the long term, beta-carotene deficient diets may increase tissue damage from free radical activity, and increase risk of chronic diseases like heart diseases and cancer (Young and Lowe, 2001).

Carotenoids are associated with reduced risks in developing certain chronic diseases including cancer, cardiovascular disease, and osteoporosis. (Givannucci, et al., 2002, Keleman, et al., 2006). According to epidemiological studies several carotenoids may be associated with reduced cancer risk. The evidence is much stronger in the case of β- carotene. Numerous studies have reported reduced risk of certain cancers with high dietary intake of β- carotene.

Studies by Zheng, et al., 1995 and Negri, et al., 1996 have reported that dietary antioxidants, especially β- carotene, may be important in the prevention of stomach and breast cancer. Whether, the protective effects are attributable to the antioxidant nutrients themselves or to other substances found in the same foods, however, needs to be verified.

Low vitamin A intake during nutritionally demanding periods in life, such as infancy, childhood, pregnancy and lactation, greatly raises the risk of health consequences, or vitamin A deficiency disorders (VADD). Dietary deficiency can begin early in life, with colostrums being discarded or breastfeeding being inadequate, thereby denying infants of their first, critical source of vitamin A (Haskell and Brown, 1999). The major cause is diet which include few animal sources of pre-formed vitamin A. Breast milk of a lactating mother with vitamin A deficiency contains little vitamin A, which provides a breast-fed child with too little vitamin A. In addition to dietary problems, there are other causes of vitamin A deficiency. Iron deficiency can affect vitamin A uptake. Excess alcohol consumption can deplete vitamin A, and a stressed liver may be more susceptible to vitamin A toxicity. People who consume large amounts of alcohol should seek medical advice before taking vitamin A supplements. In general, people should also seek medical advice before taking vitamin A supplements if they have any condition associated with fat malabsorption such as pancreatitis, cystic fibrosis, tropical sprue and biliary obstruction.

Thereafter, into adulthood, a diet deficient in vitamin A lacks foods containing either preformed vitamin A esters, such as liver, milk, cheese, eggs or food products fortified with vitamin A or lacking its carotenoid precursors (mainly beta-carotene), such as green leaves, carrots, ripe mangos, eggs, and other orange-yellow vegetables and fruits. Where animal source or fortified foods are minimally consumed, dietary adequacy must rely heavily on foods providing beta-carotene. However, while nutritious in many ways, a diet with modest amounts of vegetables and fruits as the sole source of vitamin A may not deliver adequate amounts, based on an intestinal carotenoid-to-retinol conversion ratio of 12:1 (Food and Nutrition Board, US, 2000).

This ratio reflects a conversion efficiency that is about half that previously thought, leading to greater appreciation for why VAD may coexist in cultures that heavily depend on vegetables and fruits as their sole or main dietary source of vitamin A. Usually, VAD develops in an environment of ecological, social and economical deprivation, in which a chronically deficient dietary intake of vitamin A coexists with severe infections, such as measles, and frequent infections causing diarrhoea and respiratory diseases that can lower intake through depressed appetite and absorption, and deplete body stores of vitamin A through excessive metabolism and excretion (Alvarez, et al.,1995; Mitra, et al., 1998). The consequent “synergism” can result in the body’s liver stores becoming depleted and peripheral tissue and serum retinol concentrations decreasing to deficient levels, raising the risks of Xerophthalmia, further infection, other VADD and mortality.

1.2. Vitamin A/ β- carotene

Vitamin A can be found in two principal forms in foods, those are- (i) ***Retinol***, the form of vitamin A absorbed when eating animal food sources, is a yellow, fat-soluble substance. Since the pure alcohol form is unstable, the vitamin is found in tissues in a form of retinyl ester. It is also commercially produced and administered as esters such as retinyl acetate or palmitate. (ii) ***Carotenes*** alpha-carotene, beta-carotene, gamma-carotene; and the xanthophyll beta-cryptoxanthin (all of which contain beta-ionone rings), but no other carotenoids. There function as vitamin A in herbivores and omnivore animals, which possess the enzyme required to convert these compounds to retinal (www.Wikipedia.com). β- Carotene theoretically possess 100per cent vitamin A activity which α- carotene possesses between 53 and 50per cent. β- Carotene provides 80 per cent of vitamin A value measured as retinol equivalents. Besides, being a remedy for vitamin A deficiency, the carotenoid pigments also serve as effective antioxidants that quench free radicals, provide protection against oxidative damages to cells, multitude of degenera333tive diseases and also stimulate immune function (Bandyopadhyay, et al., 2008). β- carotene is one of approximately 50 carotenoids of the known 600, that are called "provitamin A" compounds because the body can convert them into retinol, an active form of vitamin A. β- carotene have received a tremendous amount of attention as potential anti-cancer and anti-aging compounds. The micronutrient is a powerful antioxidant, protecting the cells of the body from damage caused by free radicals. It is also one of the carotenoids believed to enhance the function of the immune system. In addition to their antioxidant and immune-enhancing activity, carotenoids including beta-carotene have shown the ability to stimulate cell to cell communication. By promoting proper communication between cells, carotenoids may play a role in cancer prevention. It is also believed that β -carotene may participate in female reproduction and plays an important role in reproductive processes (Aggarwal, et al., 2000). In a study on carotenoid and provitamin A activity of carrot in 1990, Heinone stated that carrots contain 6.9 to 15.8mg carotenoids per 100g of carrots, which act as disease preventive agent.

1.3. Natural sources

Vitamin A is an essential human nutrient. It exists not as a single compound, but in several forms. In general, there are two categories of vitamin A, depending on whether the food source is an animal or a plant.

Vitamin A found in foods that come from animals is called preformed vitamin A. It is absorbed in the form of retinol, one of the most usable (active) forms of vitamin A. Sources include liver, whole milk, and some fortified food products. Retinol can be made into retinal and retinoic acid (other active forms of vitamin A) in the body.

Vitamin A that is found in colourful fruits and vegetables is called provitamin A carotenoids found in foods that come from plants are β- carotene, alpha-carotene, and β-cryptoxanthin. Among these, β- carotene is most efficiently made into retinol. Alpha- carotene and β-cryptoxanthin are also converted to vitamin A, but only half as efficiently as β- carotene.

The best sources of β- carotene are listed below in the order of abundance.

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<u>Plant source</u> –

Mango	1,990 µg/100g
Papaya	880 µg/100g
Tomato	590 µg/100g
Orange	190 µg/100g
Cherries	1,160 µg/100g
Pumpkin	1,007 µg/100g
Chilies	140 µg/100g
Drumstick leaves	19,690 µg/100g
Fenugreek leaves	9,100 µg/100g
Curry leaves	7,110 µg/100g
Carrot	6,460 µg/100g
Colocasia leaves	5,920 µg/100g
Coriender leaves	4,800 µg/100g

(Source: ICMR, 1989)

1.3. Fruits:

Fruits provide the necessary nutrition supplements to our body and also improve the body condition. Fruits provide perfect supplement for hormonal imbalance. They have water content that maintain necessary moisture in the body and a substance called fructose whuch is a better supplement than sugar. All the fruits improve the sodium level content in the body and hence regulate the weight in the body by adding necessary supplements and reducing unnecessary fat (Institute of medicine, 2001). Fitzpatrick, et al., 2007 conduct a study on impact of cost on the availability of fruits and according to his study, cost is inversely related to fruit availability. Fruits cost dose impact availability and has the greatest impact for high cost items.

1.3.1. Papaya:

β- Carotene contributes to the orange color to many different fruits. Yellow and orange fruits, such as mangoes and papayas, particularly are rich sources of β- carotene. **Papaya** (*Carica papaya* L.) is grown in every tropical and subtropical country. It is a member of the Caricceae family. It is sweet and juicy, though with some muskiness. Papaya is spherical or pear shaped fruits that can be as long as 20 inches. Their flesh is a rich orange color with either yellow or pink hues. The fruit contain papain an enzyme that helps digest proteins. This enzyme is especially concentrated in the fruit when it is unripe. Papaya ranks highest per serving among fruits for carotenoids, potassium, fiber, and ascorbic acid content (www.Wikipedia.com).

Papaya offer not only the luscious taste and sunlight color of the tropics, but are rich sources of antioxidant nutrients such as carotene, vitamin C and flavonoids, the B vitamins, folate and pantathonic acid, and the minerals, potassium and magnesium and fiber. Together, these nutrients promote the health of the cardiovascular system and also provide protection against colon cancer (http://www.online-family-doctor.com/fruits/papaya.html). It contains a high amount of potassium and the flash of papaya is very high vitamin A. It helps in preventing constipation and also aids in digestion. It contains protein called papain which is a digestion enzyme. Papaya juice helps in alleviating infections of colon by clearing away the infection, pus and mucus. It is low in calories and high in nutritive value, hence it is an excellent food for those on a diet. Papaya has anti inflammatory and anti cancerous properties. Its consumption strengthens immune system as it has high concentration of vitamin C and A (www. Technopreneur.net, 2010).

1.4. Interventions to combat vitamin A deficiency:

There is global agreement on the need to combat vitamin A deficiency. More than 70 countries have formal intervention programs. Three basic strategies exist for increasing vitamin A intake: increasing the consumption of foods rich in vitamin A and provitamin A; fortifying commonly consumed dietary items with vitamin A (or beta-carotene); and providing large, periodic, vitamin A supplements to high-risk populations.

The Nutrition Education and Consumer Awareness Group gives technical assistance to FAO member countries to develop policies and programmes that foster public understanding of diets that promote health and raise levels of nutrition.

Nutrition education activities at country level aim to influence public policies and promote access to a variety of nutritious foods, increase knowledge of the nutritional value of foods, influence behaviors, attitudes and beliefs and develop personal skills and motivation to adopt healthy eating practices (www. Fns.usda.gov/fns/nutrition.htm).

Dietary diversification should be viewed as an activity for all communities in order to enhance the overall nutritional status of the population. This requires nutrition education to change dietary habits, as well as providing better access to Vitamin A or Provitamin A-rich foods, such as mangoes, papaya, or dark green leafy vegetables and development of products by incorporating vitamin rich foods.

Fortifying dietary items with preformed vitamin A or beta-carotene is a proven strategy for preventing deficiency. Dietary items that are fortified with vitamin A are milk, margarine and cereal products. Developing countries have experimented with fortifying a range of products with vitamin A like monosodium glutamate, wheat, noodles and sugar. Traditional fortification techniques require a dietary item that is consumed in suitable quantities by the groups at highest risk; is processed at a limited number of sites where the fortificant can be conveniently added; stabilizes vitamin A during its normal shelf life in the marketplace (www.who.int/nutrition/publications).

This has been the primary strategy for reducing VAD in Central and South America. Although many food items such as fats, oils and margarine and cereal products have long been fortified with Vitamin A in high income countries, few other Vitamin A fortification programmes with national reach currently exist in lower income countries. It can be expected that this approach will gain momentum as increasing numbers of potentially fortifiable foods become centrally produced or processed under controlled conditions and penetrate markets of the poor in many countries (Dary and Mora, 2002).

Periodic delivery of high-potency supplements, containing 200 000 IU of Vitamin A, to preschool-age children (<5 years), with half this dose given to infants 6–11 months of age (WHO, 1997). In the past decade, vitamin A supplementation gained momentum as it was added to the annual Expanded Programme for Immunization (EPI) visits, during which high-potency vitamin A is distributed twice yearly in many countries (Report of the XXII International Vitamin A Consultative Group Meeting, Peru, 2004). Many high-risk countries have also adopted the WHO policy of supplementing mothers with a 200 000 IU oral dose of vitamin A within six weeks after delivery (WHO, 1997) to enrich their breast milk content of vitamin A, although in practice coverage remains quite low.

1.5. Product formulation

1.5.1. Processing of fruits:

Fruits and vegetables are the reservoir of vital nutrients. Being highly perishable, 20-40per cent of the total production of fruits and vegetables goes waste from the time of harvesting till they reach the consumers. It is, therefore, necessary to make them available for consumption throughout the year in processed or preserved form and to save the sizeable amount of losses. Fruits and vegetables have great potential for value addition and diversification to give a boost to food industry.

1.5.1 (i) Blanching

Blanching is a unit operation prior to freezing, canning or drying in which fruits are heated for the purpose of inactivating enzymes, modifying texture, preserving color, flavor, and nutritional value, and removing trapped air. Blanching of vegetables and fruits, using microwave oven helps in retaining ascorbic acid and carotene, and has very short processing time compared to conventional water or steam blanching. Microwave blanching should be used to improve product quality and minimize waste production (Corcuera, 2004).

Ramesh et al., 2001 revealed in their study that pre treatments such as blanching and dipping in sulphite solutions reduce the loss of vitamins during drying. As much as 80 per cent decrease in the carotene content of some vegetables may occur if they are dried without enzyme inactivation. However, if the product is adequately blanched then carotene loss can be reduced to 5 per cent. According to Mohammad and Hussein, 1994 **Na**- meta bisulphate treatment was able to reduce oxidation of carotenoid in carrots.

Dutta et al., 2004 carried out a study on retention of β-carotene in frozen carrots under varying blanching time. As the heat treatment such as blanching, cooking and steaming help to release bound carotenoids and render them to be easily extractable, the findings revealed β-carotene content to increase from 84µg/100g(fresh sample) to 100.8µg/100g in 3min blanched sample, which again reduced to 88.6µg/100g on blanching for 5 minutes.

Dragojevic, 1997 carried out a study on Effect of blanching, drying, freezing, and storage on degradation of β- carotene in different fruits. The results revealed that the decomposition degree of β-carotene increases significantly with storage time. No significant differences have been found after a longer storage between blanched and non-blanched fruits, either dried or frozen.

Henry and Massey, 2001 carried out a study on changes in β-carotene content of vegetables during various processing techniques. The findings revealed percentage loss of β-carotene content of carrots to be highest (32.1per cent) in case of boiling and least (1.9per cent) when carrots were steamed. Further, when pumpkin was processed, using three cooking methods, highest β-carotene content loss (48.8per cent) was found when the vegetable was boiled. However, in contrast to the results of carrot processing, steaming showed slightly higher loss of β-carotene content (25.6per cent), in pumpkin when compared to shallow frying effect (22.7per cent).

1.5.1 (ii) Drying

Drying is one of the most energy consuming method in food processing. Microwave drying offers opportunities to shorten drying time, improves the final quality of dried products and reduces energy consumption. Microwave drying process, consists of three drying periods: heating up period, rapid drying period and falling rate drying period. Microwave drying method can be used to dry heat- sensitive materials as one of new drying technologies because of the high drying efficiency (Yan, et al., 2010).

Yan, et al., 2010 carried out studies on different combined microwave drying of carrot pieces. In this study there different microwave drying methods were compared, namely microwave-assisted vacuum drying (MWVD), microwave-assisted freeze drying (MWFD), microwave-enhanced spouted bed drying(MWSD),in terms of drying rate, drying uniformity, product color, rehydration ratio, retention of β-carotene. According to the results, the β-carotene content in MWFD carrot pieces was the highest and value was close to the number of fresh carrot (control value). However, compared to the fresh carrot, the β-carotene contents of MWSD and MWVD carrot pieces decreased to the similar level (about 70 percent of the control). This result explained that the temperature of MWFD was low and carrots were dried under a high vacuum condition which reduces the oxidation and degradation of β-carotene but in MWVD and MWSD, samples were exposed to the higher temperature and the hot air so more degradation and oxidation of β-carotene existed.

Hornero and Minguez, 2007 carried out a study on bio accessibility and effect on carotene from carrots by cooking and addition of oil. In this study, β-carotene and α-carotene were affected in a similar way by the cooking process, α- carotene appeared to be more efficiently incorporated into micelles when olive oil was added to the sample. It concluded that, both processing and mainly lipid content (cooking oil) significantly improved carotenoid bio accessibility from carrots and increased bioavailability in humans.

In 2004, Dawula, et al., conducted a study on alteration of β- carotene in fruit and vegetable caused by open-sun-drying, visqueen-covered and polyethylene-covered solar-dryers. This study investigated the effects of three drying methods on β-carotene of edible portions of mango fruit (*Mangifera indica*). Open sun drying method caused the greatest β-carotene loss, i.e. 58 per cent, while the visqueen-covered solar dryer caused the least loss, i.e. 34.5 per cent. The β-carotene content of fresh ripe mango fruit was 5.9 mg/100g. The open sun drying method caused the greatest β-carotene 94.2per cent loss, while the visqueen-covered solar dryer caused the least 73per cent. These results showed that the three solar drying methods cause significant loss of pro-vitamin A in dried fruits and vegetables. However, open sun drying causes the most loss and the visqueen-covered solar dryer the least. The drying technologies should be improved to enhance vitamin retention.

1.5.2. Effect of processing on Rheological properties of fruits

Food rheology is the study of the rheological properties of food, that is, the consistency and flow of food under tightly specified conditions. The consistency degree of fluidity, and in determining by food texture. Food rheology is important in quality control during food manufacture and processing (www.Wikipedia.com). Rheological properties play an important role in the handling quality attribute of both minimally processed foods, such as fruits and vegetables. One of the important characteristic of rheological behavior is the material properties dependence on temperature (Maceiras et al., 2006).Fruits and vegetables processing improve their rheological properties like texture, color, bulk density, viscosity and consistency.

Rodrigues, et al., 2002 studies on Rheological properties and color evaluation of papaya during osmotic dehydration processing. In this study, four types of solutions with different concentration of sucrose, citric of lactic acid and sodium lactate or calcium chloride were employed for osmotic dehydration. The findings revealed that when $CaCl_2$ was added in the osmotic solution it improved the impregnation of sugar in the papaya pieces. Calcium chloride showed to be effective in reinforcing tissue structure, presented stress at fracture values for dehydrated papaya get three fold higher than other treatments because of calcium salt. Processing at 50ºC with sodium lactate prevent over- softening of the tissue during whole process, with greater water activity reduction.

In a study carried out by Yan, et al., 2010 on different combined microwave drying of carrot pieces, were found that the MWFD products had the best color, MWVD products decrease in yellowness and MWSD dried carrot pieces was decreased not only in redness but also in yellowness. So the result indicated that the carrot slices color dried by MWFD and MWVD methods were very close to those dried by FD method and combined MW drying maintain the color of product well after blanching.

Balestra, et al., 2010 carried out a study on evaluation of rheological and sensorial properties of wheat flour dough and bread containing ginger powder. This study showed that addition of ginger powder at different percentage (from 0percent to 6percent) changes dough machinability, viscoelasticity and bread making performances. The dough with the highest amount of ginger powder (6percent) showed the highest value of elastic modulus evaluated by fundamental rheological measurements. The result showed that 3percent of ginger powder could be included in bread formulation without altering dough handling and bread rheological properties.

Eren, et al., 2007 carried out a study on modeling bulk density, porosity and shrinkage of quince during drying. In this study, the effect of drying method on bulk density, substance density, porosity, and shrinkage of quinces at various moisture contents was investigated Bulk density of freeze dried materials decreased with moisture content while for all other dehydration processes, bulk density and porosity increased with decreasing moisture content. Freeze dried materials developed the highest porosity whereas the lowest was obtained using osmotic dehydration. Freeze dried samples had limited shrinkage. Although differences in shrinkage with the drying method were detected, the same model as a function of moisture content could be used for all drying methods but with different coefficients.

1.5.3. Organoleptic properties of value added products

According to studies organoleptic properties of value added products get improve by processing of sample (fruits and vegetables). Formulation of value added product using processed fruits and vegetables have more organoleptic properties like flavor, taste, color, texture and overall acceptability. Yan, et al., 2010 carried out a study on Different combined microwave drying of carrot pieces. In this study organolaptic findings were, the total score of carrot slices dried by MWFD (microwave freeze drying) was highest followed by MWVD (microwave vacuum drying) and MWSD (microwave spouted bed drying). There were significant differences in appearance and texture among different drying methods and no significant differences in color and flavor.

Raychaudhuri, et al., 2007 conducted a study on effect of beet and honey on quality improvement and carotene retention in a carrot fortified milk product. In this study sample were prepared and stored in a close container at 30℃ for 10 days. Regarding sensory evaluation both proportion of honey gave better synergistic result than beet or its mixture with beet. Equal mixture of carrot, beet and honey was the best with respect to antioxidant activity and retention of carotene. So, after considering all the results it can be suggested that equal mixture of beet and honey with carrot is essential to improve quality and carotene retention in carrot fortified milk product.

Basu and Shivhare, 2010 carried out a study on rheological, textural, micro-structural and sensory properties of mango jam. In this study, the sensory evaluation of mango jam was carried out after 3 days of the jam manufacturing. The mango jam samples were stored at 5 ℃ and were taken out 3 h before serving. The overall acceptability score improved with increasing sugar concentration and pH levels in all mango jam samples. The overall acceptability was rated highest for mango jam prepared with 65per cent sugar, 1per cent pectin at pH 3.4.

Jood, et al., 2001 carried out a study on effect of storage on organoleptic characteristics and nutrition evaluation of β- carotene rich products. In this study, an effort had been made to combat the vitamin A problem by developing beta-carotene products, namely biscuits and shakarpara by adding cauliflower leaves powder and these were stored to see the effect of storage on their organoleptic and nutritional evaluation. Fresh biscuits and shakarpara were found organoleptically acceptable, whereas the mean scores of organoleptic characteristics decreased gradually after 60 days of storage. β- Carotene content was 1.42 mg/100 g in biscuits and 1.55 mg/100 g in shakarpara, which decreased significantly after 60 days of storage. These products can be stored for up to 30 days without any significant change in organoleptic and nutritional characteristics.

Konopaka, et al., 2009 carried out a study on the usefulness of cucurbita maxima for the production of ready-to-eat dried vegetable snacks with a high carotenoid content. This study indicated a beneficial influence of a diet rich in β-carotene on human health. The suitability of winter squash for drying purposes depended mainly on the dry matter content in the raw material. The dried ready-to-eat crispy vegetable snacks made from the new cultivars of winter squash could be exploited as a novel attractive product with the attractive taste and color to serve as a valuable source of carotenoids in human diet.

Vijaylakshami and Malathi, 2006 carried out a study on development of β- carotene rich noodles through fortification of mango pulp. In this study, the organoleptic evaluation revealed no significant difference between the standard and the formulated noodles, indicating that all the noodles based recipes were acceptable organoleptically or were at par with the standard noodle recipes.

1.5.4. Effect of processing on shelf life of formulated products by using fruits

Hendrickx, et al., 2008 carried out a study on effect of high- pressure processing on colour, texture and flavor of fruit and vegetable based food product. This study showed that various processing methods are used not only to increase the edibility and palatability of fruits and vegetables but also to prolong their shelf life. At elevated temperatures, the effects of pressure-enhanced chemical reactions on sensory properties could give additional contributions to the effects of pressure-induced enzymatic reactions and inactivation.

1.6. Significance of the study

According to WHO, 2009 globally, night blindness affects 5.2 million pre school age children and 9.8 million pregnant women, which corresponds to 0.9 per cent and 7.8 per cent of the population at risk of Vitamin A Deficiency, respectively. WHO, 2006 estimates show that the South-East Asia contains highest proportion of vitamin A deficiency. According to NNMB, 1999 the prevalence of bitot spots in India is above the WHO cut off level of 0.5per cent. Yellow/orange/red fruits and vegetables are the rich sources of β-carotene, and should be consumed daily, especially by those who are vegetarian because the consumpstion of β-carotene rich fruits and vegetables help to combat vitamin A deficiency. All these fruits are also good sources of antioxidants/phenolic compounds like carotenoids, lycopene, flavonoids and phenols which help to reduce the cancer and cardiovascular diseases risks. Processing of these fruits can make them available off season as well, and their perishability also reduces, According to many studies processing improves rheological properties like texture, colour and density. Products formulated by incorporating these fruits and vegetables, can be consumed any time of the day and in between meals. Also they are likely to be preferred by people of all age groups. Processing of fruits can improve their shelf life and digestibility in comparison to raw fruits. The formulated products, by incorporating β-carotene rich papaya, can be used to prevent as well as treat micronutrient deficiencies and life threatening diseases.

In the present study an effort shall be made to formulate value added products, using papaya as it is rich sources of micronutrients like β- carotene, vitamin C, potassium etc. and have high antioxidant properties.

Also, the development of a wide range of products from papaya will create more interest among the processors to diversify their processing lines and to produce value added products with their better presentation, packaging and improved overall appearance. This will not only reduce the importation of other fruit products which have been flooding Indian markets, but will also help to capture international markets. The development of value added products for commercialization will provide new scope for the expansion of the local fruit industry.

Keeping this in mind, present study has been undertaken with the following objectives –

1.7 Objectives

- To estimate nutrient content and analyze rheological properties of different varieties of papaya, at two stage i.e. pre and post processing.

- To compare the nutrient content of fresh and processed selected papaya varieties.

- To formulate and standardize value added (β- carotene rich) products, using processed papaya varieties, selected on the basis of maximum β- carotene retention.

- To study the rheological properties, nutritional composition and shelf life and calculate the price of the most accepted product/s.

2. Methodology

For the present study 3 to 4 varieties of papaya shall be selected for the analysis of their nutritional and rheological properties. Further an attempt will be made to formulate value added products by incorporating processed papaya in the standardized recipes. The study will be carried out in 11 steps.

2.1 Step - 1

Procurement of papaya varieties from Horticulture Centre, Jaipur and Jobner, Rajasthan .

2.2 Step - 2

Analysis of Nutritients and Rheological properties of papaya (Fresh/Pre-processed).

2.2. i. Nutritional properties

1. Macronutrients

Name of nutrient	Methods	References
1. Moisture (g/100g)	Oven drying method	AOAC, 2005
2. Protein (g/100g)	Micro-kjeldhal method	AOAC, 2005
3. Ash content (g/100g)	Muffle Furnace method	AOAC,2005
4. Crude fibre (g/100g)	Acid- alkali treatment	AOAC, 2005
5. Fat (g/100g)	Ether Extractive	AOAC, 2005
6. Carbohydrate (g/100g)	Calculation based	AOAC, 2005
7. Reducing sugar (g/100g)	Titration method	AOAC, 2005
8. Titrable Acidity (g/100g)	Titration method	AOAC,2005
9. pH	pH paper / pH meter	AOAC, 2005

2. Micronutrients

Name of nutrient	Methods	References
1. β – carotene (µg/100g)	Spectrophotometry	NIN, 2003
2. Vitamin C (mg/100g)	Titration method	AOAC, 2006
3. Calcium (mg/100g)	Titration method	NIN, 2003
4. Magnesium (mg/100g)	Atomic absorption method	NIN, 2003
5. Potassium (mg/100g)	Flame photometric method	NIN, 2003

2.2. ii. Rheological properties

Rheological Property	Method	References
1. Texture	Using instrument (Magness Taylor Pressure Tester)	Rangana, 2010
2. Colour	Using Spectrophotometer	Rangana, 2010
3. Bulk density	Using formula (bulk density = wt. of sample (g) / sample volume (cm^3)	Okaka and Potter, 1979

2.3. Step- 3 - Processing of papaya

1. Blanching: For blanching of fruits and vegetables, first they shall be washed, then peeled and sliced to 8×8×8mm, thereafter blanched in a water bath at 90ºC for 10 minutes and cooled in cold water (10-12ºC) for 60 seconds (Yan, et al., 2010).

2. Drying (Microwave): Before microwave drying of blanched fruits and vegetables, surface water of the slices shall be removed by clean cloth and then dried (Sagar and Suresh, 2010).

2.4. Step- 4 - Nutritients analysis and rheological properties of papaya (Post-processing).

2.4. i. Nutritient analysis

1. Macronutrient
2. Micronutrient

2.4. ii. Rheological properties

1. Texture
2. Colour
3. Bulk Density

2.5. Step- 5 - Formulation of Value added products

2.5. i. Standardization of recipes

1. *Ladoo*
2. *Murukku*
3. Dry mixes
4. Biscuits

2.5. ii. Formulation of Value added Products using processed papaya

2.6. Step- 6

Sensory evaluation of products formulated using processed papaya (using 5 point scale).

2.7. Step- 7

Analysis of Rheological properties of most accepted formulated products

2.8. Step- 8

Analysis of shelf life of most accepted products

2.8. i. Physicochemical Properties

Physicochemical	Methods	References
1.Moisture(g/100g)	Oven method	AOAC, 2005
2.Lipid oxidation	Peroxide value	Rangana,2010

2.8. ii. Microbiological Properties

Total Bacterial and fungal count by total viable count method.

2.9. Step- 9

Cost analysis of most accepted products

- The costs of the most accepted products shall be calculated by taking into account the average cost during the period of product formulation.

2.10. Step 10

Statistical Analysis of Data -

- The mean and standard deviation of all the estimated values related to nutrient content and scores of formulated products will be calculated.
- The least significant difference tests (t – test, ANOVA) shall be used to determine difference between means of organoleptic scores of all the formulated products.

2.11. Step 11

Report writing

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