*Review Article*

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# Pumpkin and Papaya Fruit and Study of its Physico-Chemical Properties in Relation to Public Health Impact on the Community

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**Abstract**

Latest research on fruit leathers aimed at studying the effects of processing on organoleptic and nutritional quality of the final product. Workers have evaluated the influence of pretreatment on final product structure as well as the effect of hot air drying on colour and antioxidant retention in apple leathers with and without preservative agents. Papaya & Pumpkin were undertaken in regard to physico-chemical analysis, effect of processing treatment on organoleptic characteristics of fruit leather. Economic analysis for both type of Papaya and Pumpkin fruit leathers were performed. The results revealed that total cost for manufacturing 1kg of papaya leather was Rs. 140 and 1kg of pumpkin leather was Rs. 88.

**Keywords:** Fruit Leather; Anti-Oxidant Properties; Pumpkin; Papaya.

The present paper involved the development of leather from pumpkin and papaya fruit and study of its physico-chemical properties. The literature relevant to the present investigation reviewed in the following paragraphs.

## Cultivation

Papaya (*Carica papaya L.*) is grown extensively in all tropical and sub-tropical parts of the world. Papaya has been regarded as one of the most valuable tropical fruits thatcontain beta carotene, protein, carbohydrate, vitamins and minerals. Hence, processing and preservation of papaya is important to retain the product quality and its nutritional value. Dehydration is one of the important preservation methodemployed for storage of fruits besides its application in product processing (Muhamad*et al.*, 2007).

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Salunakhe, (1984) said papaya was fast growing mainly unlignified and perennial herbaceous plant, its main cultivation areas were Tropical Central and South America, whereas Delahaut, (2006) said pumpkin was a vine crop and plays important role in traditional setting as cover crop, its main cultivation was in Nigeria.

FAOSTAT, (2012) reported that total annual world production of papaya was estimated at 6 million tonnes of fruits. India leads the world in papaya production with an annual output of about 3 million tonnes and that of pumpkin was estimated over 24.3 million tons harvested from 1.7 million hectares(FAOSTAT, 2013).

NASS, (2013) reported that the top pumpkin producing states Illinios, followedby California, Ohio, Pennsylvania, New York and Michigan. In 2012, US pumpkinproduction was nearly 12.4 million cwt which increased from 10.7 million cwt in2011, harvested from 47800 acres(NASS, 2012).

### *Physico -Chemical Properties*

Lobo (1998) reported that fresh papaya had high content of vitamin C and pro vitamin A, which protects from cancer, also papaya recommended for low hypo caloric diets, Nakasone, (1998) noted that papaya also a good source of enzyme papain, which plays a key role as digestive protein, meat tenderizer, digestive medicine, in case of pumpkin Sentu & Debjani (2007) noted was used to relieve intestinal inflammation, dyspepsia and stomach disorders. Gonzalez, (2008) demonstrated that fruit papaya contain bioactive compounds with anti microbial and antioxidant capacities and were good source of carotenoids, phenolics and vitamins, whereas in pumpkin Pratt & Mathews (2003), and Ward, (2007) observed that pumpkin contained high amount of vitamins like Vitamin A, Vitamin C, Vitamin E, Lycopene and dietary fibre.

Malik *et al*., (2010) reported that pumpkin had therapeutic and medicinal properties, whereas Hu, (2003) noted that papaya had properties to prevent against cancer and cardiovascular disorders.

Zaman, (2006) studied the chemical composition of papaya fruit having pulp percentage 87.12% and pH ranges 2.0 to 5.5.Modi, (1967) noted that there was decrease in ascorbic, malic and citric acid by 10 and 2.5 folds, McCollum *et al*., (1988)observed that pumpkin fruit pH ranges 5.6 to 6.7 and titrable acidity declined from 0.64% to 0.38% at ripened stage.

Villegas,(1997), Nakasone &Paull, (1998) noted color of papaya from yellowish to red and that of pumpkin from yellowish on young stage to orange on ripening stage Rodriguez & Amaya (1999), Cazzonelli&Pogson, (2010).

Lazos, (1986) noted that seeds of pumpkin were excellent sources of both oil (37.82-45.4%) and protein (25.2-37%). Yarnell*et al*., (2003) reported that seeds can be used to treat prostate cancer. Leung & Foster, (1996) noted combination of seed oil & kava used to treat irritable bladder. Rachel B.Levinnoted that seed is a rich source of Zn helps to guard body against osteoporosis (hip & spine). Marfo*et al*., (1986) noted that papaya seeds are gaining importance because of its medicinal properties. Imaga*et al*., (2009) observed papaya seeds are used to cure sickle cell diseases, and Okeniyi*et al*., (2007) worked in order to cure anti helminthes, Olagunju*et al*., (2009) worked for renal disorders cure.

Foods show extended variability in composition (mainly water, proteins, carbohydrates, fat, ash, and fibre) and structure, and can be turned into even more complex composite materials when heated (Barbosa-Cánovas*et al*., 2006) as in the case of fruit-sweetpotato leather.

Physical and chemical properties of foods are important in determining quality and acceptability of food products. In fruit leather production, properties such as brix, pH, total soluble solids, acidity, vitamin C, ash and carbohydrate are useful nutritional indices which subsequently affect organoleptic properties.

Jain and Nema, (2007) used three recipes of guava pulp in preparing fruit leathers and found that leather acidity was affected by cultivars significantly ($P<0.05$) and the total soluble solids (TSS) of pulp ranged from 11.8-13.3; pH (3.57-3.98), acidity (0.42-0.48%) and ascorbic acid (165.41-246 mg/100g). Sugar in three different quantities (10, 20 and 30%) showed significant difference in the mean acidity value with different recipes. However, a report by Harsimarat and Dhawan, (1998) showed a positive correlation of acidity and shelf life. A significant increase in acidity of guava fruit bar during storage was observed.

In a similar study by Babalola*et al*., (2002), pH of pawpaw leather stored for one month at cold temperature condition was significantly higher than other samples (0 and 2 months); while the pH of guava leather at one and two months of storage were significantly lower when compared with initial pH. These differences were reported to be due to fermentation by microorganisms. Sugar content has been found to have significant effect on the ascorbic acid content (Babalola*et al*., 2002).

The same trend was reported by Ashaye*et al*., (2005) when pawpaw and guava leathers were studied. The statistical analysis showed significant difference in the mean ascorbic acid content of leather due to different recipes. Drying method, type of fruit, method of preparation and varietal differences can influence the physico-chemical properties of leathers. This is evident in the Tables 1 and 2.

**Table 1:** Chemical composition of guava and pawpaw fruit leathers

| Fruit | Moisture | Protein | Fat | Carbo hydrate | Crude fibre | Ash | Vitamin C |
|---|---|---|---|---|---|---|---|
| Pawpaw | 18.47 | 2.1 | 0.49 | 76.8 | 2.4 | 2.67 | 74.7 |
| Guava | 16.4 | 2.67 | 1.37 | 74.5 | 2.67 | 2.87 | 237 |

Source: Ashaye*et al*., (2005)

**Table 2:** Physico-chemical properties of banana leathers

| Variety | Moisture | TSS | pH | Acidity | Brix | Vitamin C (A&B) | |
|---|---|---|---|---|---|---|---|
| Seemi | 68 | 17.42 | 4.5 | 0.26 | 67 | 13 | 2.2 |
| Embul | 69 | 23.42 | 4.2 | 0.4 | 58.55 | 9.3 | 1.8 |
| Anamalu | 72 | 19.62 | 4.4 | 0.33 | 59.45 | 7.4 | 1.8 |

Source: Ekanayake and Bandara, 2002 B=before drying, A=after drying

Ekanayeke and Bandara, (2002) worked with 3 varieties of banana in Sri Lanka and found that variety affected moisture content and total solids. Results showed that it had low pH, high TSS (12-14 %), 62-72 Brix and high vitamin C content.

The effect of solar drying on the quality and acceptability of jackfruit leather was assessed by Okilya*et al.*, (2010). Colour, texture and moisture content were evaluated since they are the most important quality parameters of fruit leathers that are usually affected by drying. Results showed that solar drying significantly reduced the moisture content and colour readings of the jackfruit leather compared to oven drying and cabinet drying respectively.

*Medicinal Properties*

*Pumpkin Shows Following Medicinal Properties*

Antioxidant properties: Oxidative stress can lead to production of unwanted radicals leading to health complications such as heart diseases, Alzheimer's diseases, as well as cancers. In 2009 scientists from Greece showed that pumpkin seeds are very rich in antioxidants and has a high content of vitamin E (tocopherol) which is also a very good antioxidant.

*Anticancer Properties*

The carotenoid pigments found in pumpkin seeds oil have been linked to the prevention of prostate cancer. Those that consumed diets high in pumpkin seeds showed lower risk of gastric, breast, lung and colorectal cancers.

*Anti Diabetic*

Pumpkin was used for treating type 2 diabetes in Mexico where the traditional healers administered crude extract of the pumpkin fruit to the patients.

*Antibacterial and Anti-Parasitic*

Pumpkin seeds were used to be treat people with acute schistosomiasis, a severe parasitic disease that is transmitted through snails.Proteins and oil extracted from pumpkin seeds are good candidates for such drugs since they inhibit growth of wide range of bacteria, fungi and yeast.

*Anti-Bladderstone*

Pumpkin seeds are known for reducing the levels of substances that promote stone formation in the urine and increase levels of substances that inhibit stone formation.

*Antidepressant*

Due to high levels of tryptophan content in pumpkin seeds, the seeds have been recommended to treat depression.

*Anti-Inflammatory*

Oil extracted from pumpkin seeds has anti-inflammatory properties similar to indometacin, a well known anti-inflammatory drug.Despite of their so much beneficial effects, the shelf life of papaya and pumpkin is limited because of their perishability. The shelf life of these fruits can be increased by utilizing in manufacturing of different products having low water activity. In the past, lots of efforts had been done in this line.

*Papaya Shows Following Medicinal Properties*

*Colon Cancer*

The fibre of papaya is able to bind cancer-causing toxins in the colon and keep them away from the healthy colon cells. These nutrients provide synergistic protection for colon cells from free radical damage to their DNA.

*Anti-Inflammatory Effects*

Protein enzymes including papain and chymopapain and antioxidant nutrients found in papaya; including vitamin C, vitamins E, and beta-carotene, reduce the severity of the conditions such as asthma, osteoarthritis, and rheumatoid arthritis.

*Rheumatoid Arthritis*

Vitamin C-rich foods, such as papaya, provide humans with protection against inflammatory polyarthritis, a form of rheumatoid arthritis involving two or more joints.

*Promote Lung Health*

if you are smoker or if you are frequently exposed to second hand smoke. Eating vitamin A rich foods, such as papaya, help your lung healthy and save your life.

*Anticoagulant Effect*

Injection of papain extract in a dog increases prothrombin and coagulation threefold. It is also reported that the enzyme eliminates necrotic tissues in chronic wounds, burns and ulcers. Papain is also of commercial importance in the brewery industry, in the food industry and in the textile industry.

*Food Preservation Through Dehydration*

In food preserving control of enzymes and microorganisms is very important. Microorganisms which grow rapidly on raw or fresh food products can be controlled by drying because the lack of water limits the growth of microorganisms. Drying is a process in which water is removed to halt or slow down the growth of spoilage microorganisms as well as the occurrence of chemical reaction (Barbosa-Canovas and Vega-Mercado, 2006). However, drying does not kill the microorganisms (Barbosa-Canovas and Vega-Mercado, 2006).

Heat required for drying may be supplied by convection, conduction and radiation. Drying of food products does not only affect the water content on the product, but also alters other physical, biological, and chemical properties such as enzymatic activity, microbial spoilage, crispiness, viscosity, hardness, aroma, flavour and palatability of the foods.

Water in foods can be free or bound. Free or unbound water is defined as water within a food that behaves as pure water. Unbound water is removed during the constant rate period of drying when the nature of the food does not have a great effect on the drying process. Okos*et al.,* (1992) and Leung, (1986) defined the term bound water as water that exhibits a lower vapour pressure, lower mobility, and greatly reduced freezing point than pure water. Bound water molecules have different kinetic and thermodynamic properties than ordinary water molecules. Through physical interaction with proteins, polysaccharides, lipids and salts, water contributes significantly to the texture of food (Belitz*et al*., 2009).

When the moisture content of dried fruit is allowed to exceed the maximum permissible level for safe storage then mould growth may occur (Doymaz, 2004). In very moist fruit, mucoraceous fungi may predominate and are visible as white fluffy growths on and within the fruit. According to Doymaz, (2004) severe mite infestations are often associated with the growth of osmophilic yeasts in fermenting dried fruit products. Nonetheless, many of these mites are unable to complete their development in the absence of yeast. They have been reported as occurring on dried fruits and such infestations are difficult to eradicate and affect consumer acceptance of the contaminated products.

Water activity ($a_w$) is a key factor in microbial growth, toxin production, and enzymatic and non-enzymatic reactions (Leung, 1986). Other factors combined with water activity that affect inhibition of microorganisms are pH, oxygen, preservatives, temperature and radiation. By measuring water activity, it is possible to predict which microorganisms will and will not be potential sources of spoilage. Hence drying is very critical to ensuring safe foods for people of all ages and increasing shelf life.

*Thin Layer Drying*

Thin-layer drying simulation is the best criterion to model the food drying process (Kumar *et al*., 2005). Drying studies are usually performed at constant drying conditions of temperature, velocity and humidity using a thin layer sample. In thin layer drying, particles are carefully exposed fully to the airstream or power source and the sample approaching the stream should be as uniform as possible. Continuous recording of the sample mass loss is a requirement in thin layer drying and the interval timing depends to a higher extent on the dry bulb air and the temperature of drying. Several researchers have investigated the drying kinetics of various agricultural products in order to determine the best mathematical models for describing thin-layer drying, such as solar drying of prickly pear cladode(Lahsasni*et al.,* 2004), raw mango slices (Goyal*et al.,* 2006), amaranth seeds (Abalone *et al.*, 2006) and convectional drying of cocoa bean (Chinenye, 2009), kiwifruit (Emam-Djomeh*et al.,* 2008) and bell pepper, (Taheri-Garavand*et al.,* 2011).

In a study by Pathak*et al*., (1991), drying temperature was the single most important factor that had an effect of on thin-layer drying of strawberries. Other factors such as initial moisture content, air velocity and relative humidity warranted its exclusion from consideration in the evaluation of thin-layer drying rate of rapeseed. Drying experiments of pre-treated and untreated strawberries carried out by Doymaz, (2007) showed that the drying rate increased with increasing the surface area exposed to heated air. The pre-treatment yielded structurally a more compact product after drying process.

Similar to the work of Doymaz is the thin layer drying of kiwifruit using Page's model (Mohammadi*et al*., 2008). In this work, drying took place during the falling rate period and temperature of drying air had effect on the drying constant and coefficient of the model.

Kajuna*et al*., (2001) studied the thin layer drying of cassava roots. A parallel sun drying experiment was compared to thin layer drying on the sun and thin layer drying in the fabricated dryer. It was found that both temperature and depth of layer affected the drying characteristics. The generally accepted thing layer drying equations were fitted to the data and the Page model had the highest accuracy for the artificial drying but not for sun drying.

The drying kinetics of tomato has been experimentally studied in a pilot scale convective dryer (Taheri-Garavand, 2011). Different air temperatures and relative humidity were used to model the drying kinetics. Model could appropriately describe the drying characteristics of tomato. It was observed that increasing air temperature decreased the drying time.

Thin layer drying has been employed in cocoa bean drying. This was done to study the effect of drying on some drying parameters and conditions of cocoa bean. The drying rate increased with increase in temperature and air velocity but decreased with time. The drying constant had a strong relationship with the drying temperature and drying air velocity (Ndukwu, 2009).

Near infra-red (NIR) drying of blanched and unblanched apple slices was done at wavelength of 1 cm and air velocity 0.5 m/s. The drying curves were seen as typical to ones for similar fruits and vegetables. The moisture content decreased exponentially with elapsed duration of drying and the moisture content of apple slices increased during blanching procedure but the drying duration of blanched samples was shorter by 44 minutes.

Review on thin layer drying of various Agricultural materials has shown that the ability to fit experimental data to existing models depend on the type of dryer used, the drying conditions and the characteristics of the material under study. Additionally, moisture content of materials decrease with elapsed duration of drying and in some cases increased air velocity.

*Processing of Leather*

Scientific production in fruit leather began around 1978 and, despite the healthy character of fruit solids consumption, has kept an irregular pace until the beginning of the XXI century, from which fruit leathers began to receive more attention from researchers. Table 3 shows a list of countries where some research has been carried out and the fruit utilized to prepare the leathers, according to its availability and abundance in the different regions.

**Table 3:** List of countries where scientific studies have been performed on fruit leathers and studied fruits

| Country | Raw Material |
|---|---|
| Australia | Strawberry |
| Brazil | Mango |
| Canada | Apple |
| India | Guava, Mango |
| Turkey | Grapes |

Early work described the physicochemical properties and sensorial attributes of pectic gels. Chan &Cavalleto, (1978) have used additives in the formulation (sugar and sodium bisulphite) and carried out sensory evaluations on the final product stored at -18, 24 and 38°C during 1, 2 and 3 months. Sulphur dioxide inhibited browning during both processing and storage. An alcohol-soluble colour index and residual $SO_2$ levels both served as measures of product quality. They suggested the use of $SO_2$ in the manufacture of papaya leather and low storage temperatures. On the other hand, Moyls, (1981) focused on dryer conditions, evaluating characteristics such as the space between trays and the fluid-dynamic regime of the drying air. Up to now, Moyls was the only one that exhibited a micrograph of the leather structure observed by electron microscopy, showing large void spaces in a porous matrix.

Bains*et al.*, (1989) prepared leathers from a commercial fruit puree, using one and two drying stages, and compared the total drying time. They concluded that the shorter process does not necessarily leads to a better quality product. Subsequent works incorporated data on quality parameters and storage stability. Irwandi & Che Man (1996) developed leathers from durian, a fruit native of South East Asia, and evaluated quality during storage, studying a control formulation composed of durian puree, water, sucrose and sorbic acid, as well as other two formulations added with maltodextrin 10%, soy-lecithin 0,1%, hydrogenated palm oil 2% and egg yellow as colouring agent. The authors performed sensory evaluation and microbial counts.

In turn, Vijayanand*et al.*, (2000) compared conventionally prepared mango leather with guava leather obtained by dehydration of an enzymatically treated puree added with maltodextrins, sucrose, soluble starch, wheat flour, pectin and antibrowning agent. Colour, texture, sensory acceptability and nonenzymatic browning were analyzed during storage. Both products maintained a high acceptability after 90 days at 27°C.

Drouzas*et al.*, (1999) reported the use of combined drying technologies to prepare leathers. They also proposed a mathematical model to interpret the behaviour of a pectic gel model system containing saccharides, citric acid, pectin and water, processed by microwave-vacuum drying (MWVD). The authors have also compared the sorption isotherms and colour variation in products prepared by MWVD and by microwave-air drying (MWAD), concluding that the colour of MWVD fruit gel was significantly lighter than the colour of MWAD product at atmospheric pressure.

In the last decade, publications included subject as the use of combined technologies, analysis of drying kinetics and evaluations of the influence of various additives in drying rate and product quality. Gujral&Khanna (2002) used additives as milk powder, soy protein concentrate and sucrose in order to increase the solid content of the initial formulation and assessed their effect on the dehydration behaviour. Besides, they observed colour, texture and sensory characteristics of samples for various concentrations and combinations of additives. In contrast, Azeredo*et al*., (2006) have developed leather from an additive-free formulation, which exhibited microbial stability for six months, although it was not organoleptically acceptable.

Concerning the application of the glass transition temperature ($T_g$) theory to food matrices as those exhibited by fruit leathers, a work by Huang and Hsieh (2005) reports a correlation between the textural characteristics as hardness and chewiness, determined by Texture Profile Analysis (TPA), and the value of $T_g$ measured by Differential Scanning Calorimetry (DSC) for a pear leather.

On the other hand, Torley*et al*., (2008) had measured $T_g$ for a commercial strawberry leather utilizing two methodologies: DSC and determination of viscoelastic properties by means of a Dynamic Mechanical Thermal Analyser (DMTA). Concerning drying kinetic studies during drying of leathers, Fiorentini*et al*.,(2008) proposed a mass transfer mathematical model to predict measured data on drying of tomato leather added with polydextrose and pectin to assist the pectic gelation. Soon later, Leiva*et al*., (2009) developed a theoretical model to predict shrinkage during dehydration of apple leathers, as well as studied sorption isotherms and drying kinetics.

Jaturonglumlert&Kiatsiriroat, (2010) continued with the use of combined technologies for producing fruit leathers. They included a study on mass and heat transfer for convection and far-infrared drying, considering the effect of temperature, air velocity and the distance between sample and infrared source. They have found shorter processing times when using combined technologies.

Latest research on fruit leathers aimed at studying the effects of processing on organoleptic and nutritional quality of the final product. Demarchi*et al*., (2010) have evaluated the influence of pretreatment on final product structure as well as the effect of hot air drying on colour and antioxidant retention in apple leathers with and without preservative agents. They concluded that losses of antioxidant activity are more dependent on drying temperature than on drying time. Besides, they proposed a modified first-order kinetic model to predict the non-isothermal inactivation of the Polyphenoloxidase (PPO) in apple tissue. In parallel, Quintero-Ruiz and Giner, (2010) hadanalyzed apple leather quality for formulations with and without preservative agents over a storage period of 6 months at room temperature. Among others, the authors evaluate non-enzymatic browning and antioxidant activity, and found that the formulation added with potassium metabisulphite retarded browning and promote higher antioxidant retention.

**References**

1. Abalone, R., Cassinera, A., Gastón, A. and Lara, M.A. Thin layer drying of amaranth seeds, Journal of Biosciences and Engineering. 2006; 93(2): 179–188.
2. Anonymous. Post-harvest food conservation Report on the INSA-US-NAS JointWorkshop, New Delhi India. 1979.
3. AOAC. Official methods of analysis (16th Ed.). Washington, DC: Association ofOfficial Analytical Chemists. 1995.
4. Ashaye, O.A., Babalola, S.O., Babalola, A.O., Aina, J.O., and Fasoyiro S.B. Chemical and organoleptic characterization of pawpaw and guava leathers.World Journal of Agricultural.Science. 2005; 1(1): 50-51.
5. Azeredo H. M. C., Brito E. S., Moreira G. E. G., Farias V. L. & Bruno L. M. Effect ofDrying and Storage Time on the Physico-Chemical Properties of Mango Leathers. International Journal of Food Science and Technology. 2006; 41(6): 635-638.
6. Babalola.S.O.,Ashaye, O. A., Babalola, A. O. and Aina, J. O. Effect of cold temperature storage on the quality attributes of pawpaw and guava leathers. African Journal of Biotechnology. 2002; 1(2): 61–63.
7. Bains M. S., Ramaswamy H. S. & Lo K.V. Tray Drying of Apple Puree.JournalofFood Engineering. 1989; 9(3): 195-201.
8. Barbosa-Cánovas, G.V. and Vega-Mercado, H. Dehydration of foods. Chapman& Hall, New York;

2006; 53-59.

9. Belitz, H.D., Grosch, W., Schieberle P. Journal of Food Chemistry. Berlin, SpringerVerlag. 2009; 886–890.
10. Bron I.U. and Jocomino A.P.Ripening and quality of “Golden” papaya fruit harvested atdifferent maturity stages. Journal of Plant Physiology. 2006; 18(3): 389-396.
11. Cazzonelli, C. I. and Pogson, B. J. Source to sink: Regulation of carotenoid biosynthesis in plants. Trends in Plant Science. 2010; 15: 266–274.
12. Chan H. T. andCavaletto C. G. Dehydration and Storage Stability of Papaya Leather.Journal of Food Science. 1978; 43(6): 1723-1725.
13. Che Man, IrwandiY.B.,YusofJ., SelamatS. andSugisawa, H. Effect of different dryers and drying conditions on acceptability and physicochemical characteristics of durian leather.Journal of Food Process. 1997; 21(5): 425–441.
14. Chinenye, N.M. Effect of drying temperature and air velocity on the drying rate and drying; International Journal of Food, Nutrition and Dietetics 2016 January - April ; 4(1).
15. Cho E, Sedden J.M, Rosner B, Willet W.C., Hankinson S.E. Prospective study of intake of fruits, Vegetables, vitamins and Carotenoids and risk of age related maculopathy. Arch Ophthalmol. 2004; 122: 883-892.
16. Chweya, J. AandEyzagirre P.B. The biodiversity of traditional Leafy Vegetables, International Plant Genetic Resource Institute, Rome, Italy. 1999.
17. Delahaut K.A.,Newenhouse A.C. Growing pumpkin & other vine crops is winsconsin: Aguide for fresh market growers (A3688), University Of Wisconsin extension publications. 2006; 22.
18. Doymaz, I. Drying kinetics of white mulberry. Journal of Food Engineering. 2004; 61: 341-346.
19. Drouzas A. E., TsamiE.andSaravacos G. D. Microwave/Vacuum Drying of Model Fruit Gels. Journal of Food Engineering. 1999; 39(2): 117-122.
20. Ekanayake, S. and Bandara L. Development of banana fruit leather.Annals of the Sri Lanka Department of Agriculture. 2002; 4: 353-358.
21. Fasina, O.O., Tyler, R.T., and Pickaw, M.D. Modeling the infrared radiative heating of agricultural crops.DryingTechnology. 1998; 16(9and 10): 2065-2082.
22. Guangyuan Zhao, Bo Li. Determination of iron in Milk Powdermicrowave digestion and Flame Atomicabsorption Spectrophotometry.CCTA (Colorado Conservation Tillage Association). 2008; 3: 1629-1636.
23. Gujral H. S. and Khanna G. Effect of Skim Milk Powder, Soy Protein Concentrate and Sucrose on the Dehydration Behaviour, Texture, Color and Acceptability of Mango Leather.Journal of Food Engineering. 2002; 55(4): 343-348.
24. Pathak, P.K., Agrawal, Y.C. and Singh B.P.N. Thin layer drying model for rapeseed. TRANS. ASAE. 1991; 34(6): 2505-2508.
25. Pathak D, Pathak K, Sigla AK. Flavonoids as medicinal agents: recent advances. Fitoterapia. 1991; 64: 371-388.
26. Prabhanjan, D.G., Ramaswamy, H.S., and Raghavan, G.S.V. Microwave-assisted convective air drying of thin layer carrots. Journal of Food Engineering. 1995; 25: 283-293.
27. Pratt S.G.,Mattews K. Superfoods RX: Fourteen Foods that will change your life,Harper Collins, New York. 2003; 66: 352.
28 Quintero Ruiz N. A. & Giner S. A. Geles Pécticos Deshidratadosde Manzana (malusdomestica Borkh. L, cv Granny Smith): Seguimiento de los Parámetros de Calidad Durante el. 2010.
29. Ranganna, S. Manual of Analysis of Fruits and Vegetables products. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 1979; 2-95 and 634.
30. Temple, N.J. Antioxidants and disease.Journal of Nutrition and Research. 2000; 20(3): 449-459.
31. Torley P. J., De Boer J., BhandariB.R., Kasapis S., Shrinivas P. and Jianget B. Application of the Synthetic Polymer Approach to the Glass Transition of Fruit Leathers.Journal of Food Engineering. 2008; 86(2): 243-250.