Journal of Postharvest Technology
2018, **06**(4): 106-115
http://www.jpht.info

RESEARCH ARTICLE

Development of herbal candy using ginger essential oil

Preeti Shukla[1], Suresh Bhise[2]* and Balaji Gaikwad[3]

[1]Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, Punjab
[2]College of Horticulture, Anand Agricultural University, Anand, Gujarat.
[3]Department of Food Science and Technology, G.B. Pant University of Agriculture and Technology, Pantnagar

Received: 18.08.2018 Accepted: 12.09.2018

ABSTRACT

Herbs and spices play an important role for medicinal purposes. Ginger and tulsi are herbs being used in Indian system of medicine during cold and cough. Candy is a fast and effective delivery system for medications. An investigation was planned to prepare herbal candy by standard method and used ginger oil to enhance medicinal value in sugar based candy. Hard boiled sugar candy was developed by optimization of citric acid and ginger oil. The results of physio-chemical and sensory characteristics of herbal candy revealed that sugar candy prepared using sugar and corn syrup (70:30) and 0.5 per cent citric acid produced candy with higher overall acceptability score (7.7) The moisture, reducing sugar, total sugar, titratable acidity of herbal candy were 1.85, 60.7, 92.85 and 0.81 per cent respectively. Total soluble solids, hardness and pH of herbal candy using ginger oil were 93°Brix, 595.083 N and 3.86, respectively. The ginger oil concentration at 2.5 per cent produced maximum overall acceptability score (7.05) with less score for colour, texture and mouth feel as compared to herbal candy produced at 2.0 per cent ginger oil. The temperature at 145°C produced best consistency, moudlability, thread forming ability, brittleness along with desirable taste and colour. The herbal candy prepared at 145ºC had best hardness with desirable sensory characteristics, maximum overall acceptability score (7.35) with less score for colour and taste as compared to herbal candy produced at 155ºC.

Keywords: herbal candy, ginger candy, hard boiled candy, ginger oil

Citation: Shukla, P., Bhise S. and Gaikwad B. 2018. Development of Herbal Candy using Ginger Essential Oil. *Journal of Postharvest Technology*, **6** (4): 106-115.

INTRODUCTION

Medicinal plants (including herbs and spices) are natural, safe and having no side effects, offer wide range of cost effective, preventive and curative therapies, which is useful in achieving goal of health for all (WHO, 2002). The international market of herbal product is estimated to US $62 billion, which is posed to grow US $5 trillion by the year 2050. The Indian share in the global trade is negligible (0.5 %) compare to many countries including China, where export based on plants including raw drugs, therapeutics and other estimated to be around Rs. 18,000 crores (Singh, 2005). Due to this immiscible importance, the demand of medicinal plant and medicinal plant-based products has been increasing. Today, consumers are seeking food that is healthy flavorful, fresh and aromatic. They want to indulge but at the same time be well (Uhl, 2000). Thus human consumption of bioactive natural product is not limited to pharmaceutical products. A much greater number is ingested as food or dietary supplements (nutraceuticals).

* *For correspondence:* Suresh Bhise (Email: sureshbhise_cft@yahoo.co.in)
ISSN: 2348-4330

During the last few decades major transformation have taken place in Indian lifestyle, which in turn markedly affected dietary habits. Consumers are willing to eat more wholesome health food (Grijpaardtvink, 1995). When it comes to confectionary, it becomes more common among consumer looking for tasty snacks and which still have some health improving properties.

“Confectionary”, delicacies or sweet matter that have sugar as a principle ingredients , combine with water, coloring matter and flavoring matter and often with fruits or nuts. In the US, it is usually called as “Candy”. Thus “candy” is a synonym of “confectionary”. Sugar based candies are classified as high boiled or low boiled, depending upon the amount of residual moisture. Hard candies are glasses-amorphus, non-crystalline, while softer candies may have fine crystals (Clark, 2004). Sugar confectionary includes fruits, drained and glazed or crystallized candies, nut mixed with sugar and honey. It was introduced in Britain during the middle ages. It consists of candies and other treats that are sugar based. Candies are categorized as hard or soft. Hard candies include butterballs, lemon drops etc. while soft candies consists of toffees, jelly etc (Palma, 2002). Several types of candies and toffees have been developed using different fruits singly or in combination. These are called as fruit candies or toffees. Fruits, which are commonly used for the preparation of candies, are banana, apple, pear and ber etc.

Herbs and spices play an important role in Indian kitchen and have been used since time immemorial for flavoring foods and beverages and for medicinal purposes (Draghan, 2004). As the herbs and spices provide not only flavor and taste but also photochemical, which shows various health benefits. One of the best studied “kitchen cures” i.e ginger and tulsi except other medicinal effects, proven to be beneficial for cough and cold. The cough and cold both are common in the cold regions, in the winter season. Change in season, leads to bacteria, virus which cause cold, leads to over production of mucous, which initiates cough. Ginger and tulsi are herbs and spices from kitchen or plant medicines being used in Indian system of medicine “Ayurveda” from ancient times, during cold and cough.

Ginger is used in various food products and confectionaries. It also shows various pharmacological properties such as stimulant in digestion and absorption etc. About 0.5 to 1 g of powdered ginger has shown to reduce pain, swelling, and morning stiffness in patients suffering from arthritis (Polasa and Nirmala, 2003). The most popular and effective use of ginger is for respiratory tract infections like cough and cold, bronchitis, asthma and whooping cough. Thus it is commonly recommended at the onset of cold, to help in reducing mucus and fever, and to shorten the duration of symptoms. Candies are food items of confectionary category. The term confectionary describes a spectrum of sweet goods and takes different meaning depending on the country in which it is used. According to Indian standards (IS: 9328-1979), sugar confectionary includes boiled sweets toffees, fudge, fondants, jellies and other confectionary not coated with chocolates.

MATERIALS AND METHODS

Raw material

White crystalline sugar was procured from local market. Corn syrup was obtained from M/S Ridhi Sidhi Gluco Biols Ltd. IIE, Pantnagar and stored in plastic bottles in refrigerated conditions till required. Giloy powder was procured from local market. Ginger rhizome was procured from local market and essential oil of ginger was obtained by hydro distillation method. Low Density Poly Ethylene (LDPE) and butter paper were procured from local market of Rudrapur, for packaging and wrapping of herbal candy.

Extraction of Essential oils

Essential oils of ginger rhizome were extracted using a hydrodistillation method (Sellar et al., 2001).

Hydrodistillation

The plant material is immersed in water and boiled. The steam and oil vapor flow into a cooling tank, and as the steam condenses, the essential oil, which is lighter than water, floats on top. The water is referred to as hydrosol or plant water essence. The distillation temperature should be about 60 ^{o}C. Care needs to be taken to prevent the plant material being damaged by contacting the overheated flask walls.

Distillation time depends on the plant material being processed. The oil is then extracted from hydrosol by organic solvent such as ether and ethyl acetate where two phase system of water and the organic compounds will form. The oils actually will dissolve in organic solvent forming the organic layer. After separating the organic layer from water, anhydrous magnesium sulfate is added to the oil to get rid of all the water molecules (Sandra *et al.,* 1987). The reaction occurred can be shown as below:

$$MgSO_4 + x\,H_2O \longrightarrow MgSO_4 \times H_2O$$

The resulting essential oil will then be filtered and kept in a tightly closed vial.

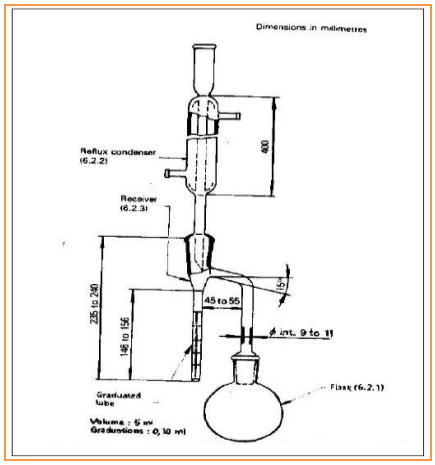

Plate 1: Schematic representation of Hydro distillation

Product Development

Optimization of Citric Acid

Mixture of sugar and corn syrup was added in the ratio of 70:30 (Rongnaphar, 1964). It was divided into five lots (each of 100 gm). Then varying amounts of citric acid i.e. 0.2 per cent, 0.4 per cent, 0.6 per cent, 0.8 per cent and 1 per cent and heated to a final temperature of 145 ºC. Immediately after heating/cooking the candy mix (sucrose, corn syrup and varying amount of citric acid) was poured out into a candy mould. Samples were stored at room temperature and then quality was compared by sensory evaluation.

Optimization of ginger oil, tulsi oil and giloy powder

Ginger oil was evaluated in combination of citric acid on the following levels for the development of herbal candy as shown in Table 1

Process flow diagram for the development of herbal candy is given below. Quality was evaluated on sensory basis. Herbal candy was evaluated for their sensory characteristics such as colour, appearance, taste, texture and overall acceptability, using Hedonic Scale.

Sugar + corn syrup (70:30)

↓

Citric acid (0.5 %) + water (just to dissolve the sugar)

Heat with gentle stirring upto 110 ºC

↓

Heat it up to 130 ºC (without stirring)

↓

Then stir it slightly and heat it undisturbed upto 145 ºC

↓

Check the end point by cold water test

(Form a drop of cooking mixture has dropped into cold water)

↓

Mix the medicated ingredient (Ginger oil, tulsi oil and giloy powder)

↓

Pour the mix in candy mould

↓

Cooling

↓

Herbal candy

Figure 1. Process flow diagram for development of herbal candy (Pandey, 2006)

Table 1 Selection of level of ginger oil

Sugar: corn syrup ratio	Citric acid	Ginger oil
70:30	0.5	0.5
70:30	0.5	1.0
70:30	0.5	1.5
70:30	0.5	2.0
70:30	0.5	2.5

RESULTS

The present investigation was envisaged to optimize the parameters for the development of herbal candy. The herbal candies were developed and evaluated for chemical, physical, organoleptic and microbial parameters. The result obtained during the course of investigation are presented and discussed under this chapter.

Chemical composition of ginger rhizome

The chemical composition of ginger rhizome is shown in Table 2. The moisture, crude protein, crude fat, crude fiber, ash, acid insoluble ash, acidity and volatile oil content in ginger rhizome were 75.15, 1.9, 0.8, 2.0, 2.4, 0.08, 0.08 and 0.37 per cent respectively.

Subbulakshmi and Naik (2002) observed that fresh ginger contained moisture – 80.9 per cent, crude fiber – 2.4 per cent, crude protein – 2.3 per cent and carbohydrate – 12.3 per cent. In this study, the acidity of raw ginger was found to be 0.08 per cent, while Shilpi *et al.* (2005) reported 0.09 per cent acidity in fresh ginger rhizome of *pohari* variety and 0.14 per cent in *desi* variety of ginger. Sethi and Meena (1997) reported that 1-3 per cent volatile oil was found in different varieties of ginger cultivated in India.

Table 2 Chemical composition of ginger rhizome

Constituents (%)	Value
Moisture	75.15
Volatile oils	0.37 (1.49)[2]
Crude Protein	1.9 (7.65)[2]
Ash	2.4 (9.66)[2]
Crude fiber	2.0 (8.05)[2]
Acidity	0.08
Acid insoluble ash	0.08 (0.32)[2]
Crude fat	0.8 (3.22)[2]

Mean of 7 replicates; [2]Values in parantheses are on dry weight basis.

Gopalan et al. (1984) reported that 100 gm of edible portion of ginger contained 80.09 gm moisture, 0.9 gm fat, fiber 2.4 gm. Tripathi and Nath (2004) reported that raw ginger contain 0.09 per cent acid insoluble ash, crude protein 1.6 per cent, crude fiber 0.71 per cent. The results obtained for crude protein, crude fat, crude fiber and volatile oil were similar reported by Subbulakhmi and Naik (2002).

Preparation of herbal candy

Effect of citric acid on sensory characteristics of sugar candy

The effect of citric acid on sensory characteristics of sugar candy is shown in Table 3.

Table 3 Effect of citric acid on sensory characteristics of sugar candy[1]

Citric acid (%)	Mean sensory scores[2]					
	Colour	Taste	Texture	Mouth feel	Appearance	Overall acceptability
0.0	4.1	4.4	4.2	4.4	4.5	4.0
0.2	5.4	6.55	6.3	6.1	6.1	6.0
0.4	6.05	6.1	6.3	6.0	6.5	5.9
0.5	7.5	7.45	7.8	7.3	7.65	7.7
0.6	7.3	6.95	7.2	6.5	7.5	7.3
0.8	7.2	6.5	6.65	5.9	6.4	6.4
1.0	7.05	6.0	6.3	6.0	6.5	6.0
Sem	0.28	0.45	0.34	0.49	0.33	0.29
CD(AT 1%)	1.05	1.70	1.28	1.86	1.24	1.09

Mean of 10 replicates; Sugar: corn syrup ratio in candy was 70:30

Effect of levels of ginger oil on the sensory characteristics of ginger oil based herbal candy

Effect of levels of ginger oil on the sensory characteristics of herbal candy was reported Table 4.

Table 4 Effect of levels of ginger oil on the sensory characteristics of ginger oil based herbal candy[1]

Ginger oil (%)	Mean sensory scores[2]					
	Colour	Taste	Texture	Mouth feel	Appearance	Overall acceptability
0.0	4.1	4.4	4.2	4.4	4.5	4.0
0.5	7.0	7.15	6.55	6.1	7.0	7.0
1.0	7.05	6.5	6.9	6.0	6.9	6.65
1.5	6.0	5.5	6.7	5.8	6.0	5.85
2.0	7.25	6.5	7.5	6.25	7.15	6.55
2.5	7.15	7.15	6.7	6.3	7.0	7.05
Sem	0.30	0.36	0.26	0.37	0.34	0.27
CD(AT 1%)	1.14	1.36	0.98	1.41	1.29	1.04

Mean of 10 replicates; Sugar: corn syrup ratio and citric acid level in candy was 70:30 and 0.5 per cent.

Ginger oil affected significantly all the sensory score for colour, appearance, taste, texture, mouth feel and overall acceptability. It was observed that increasing level of ginger oil showed significant effect on colour score of herbal candy as colour score increasing significantly from4.1 at 0.0 per cent to 7.25 at 2 per cent ginger oil. There after colour score declined to 6.0 at 1.5 per cent ginger oil, this may be due to dextrose powder as it was used as carrier of essential oil. As concentration of ginger oil along with dextrose powder increased, the colour of herbal candy turned from yellow to faint yellow.

Additions of ginger oil improved taste score of herbal candy at all the levels than control. Increasing ginger oil concentration showed significant effect on taste score. The taste score increased from 4.4 at 0.0 per cent to 7.15 at 2.5 per cent level of ginger oil, increased level of ginger oil gives better taste, this may be due to pungency of ginger oil. Therefore 2.5 per cent ginger oil yielded maximum taste score and considered as optimum for further results. Addition of ginger oil showed significant effect on texture score of herbal candy. Texture score increased significantly from 4.2 at 0.0 per cent to 7.5 at 2.0 per cent of ginger oil. Further increase in the level of ginger oil showed decline in texture score to 6.7 at 2.5 per cent citric acid this may be due to addition of dextrose powder as increasing level of oil along with dextrose powder leads to thickening of final product.

Addition of ginger oil improved mouth feel of herbal candy and mouth feel score increased significantly from 4.4 at 0.0 per cent to 6.3 at 2.5 per cent ginger oil. Initially mouths feel score declined due to low concentration of ginger oil and did not feel effect of ginger oil. Addition of ginger oil showed significant effect on appearance score of herbal candy. Appearance score increased from 4.5 at 0.0 per cent to 7.15 at 2.0 per cent ginger oil. Similar trend in overall acceptability score was observed by 2.5 per cent ginger oil level showed highest overall acceptability score (7.05) than control, primarily due to significant differences in the colour, taste and texture (Table 4). The product with 2.5 percent ginger oil was liked most and its score for individual sensory characteristics was also highest.

Effect of boiling temperature on physical and textural characteristics of herbal candy

When sugar containing mixtures are heated, it undergoes physical change due to melting, dehydration which affects the sensory characteristics of herbal candy (Table 5). Herbal candy i.e. hard boiled sweets were produced by boiling sucrose; water flavoring compound such as ginger oil, tulsi oil, giloy powder and combination of three etc. Boiling of sugar mix was

done at about 145°C in an open pan and concentrated to 93-94% soluble solids. The boiling is done to remove most of the water from the syrup. Herbal candy gives a gloss and a golden colored appearance. Variations in boiling temperature can make a difference between a sticky, cloudy sweet and dry, clear sweet.

Table 5 Effect of temperature on sensory characteristics of herbal candy

Temperature	Mean sensory scores for					
	Colour	**Taste**	**Texture**	**Mouth feel**	**Appearance**	**Overall acceptability**
130	6.6	6.6	4.0	4.9	5.55	5.4
135	6.95	5.75	5.0	5.0	6.35	5.9
140	7.55	7.35	6.3	6.5	6.7	6.9
145	7.55	4.0	7.05	7.1	7.0	7.35
150	7.10	6.0	6.5	6.65	6.85	6.1
155	7.75	7.2	6.7	6.6	7.45	7.1
160	5.45	6.7	5.1	4.15	5.15	4.9
Sem	0.38	0.37	0.33	0.39	0.33	0.36
CD (AT 1%)	1.43	1.40	1.26	1.46	1.26	1.35

Mean of 10 replicates; Sugar: corn syrup ratio and citric acid level in candy was 70:30 and 0.5 per cent.

The observation of present study reveals that the consistency improved with the increase of temperature. At 145°C consistency of sucrose solution was better than 130°C and 135°C further increase in the temperature beyond 145°C, yield bitter taste, darker colour due to over caramalization of sugar. Mouldability increased gradually from 135°C but further heating lead to cracking of the structure. The mouldability was best occurred at 145°C than 135°C. Thread forming ability increased with the temperature rise up to 145ºC due to inversion (fructose). Beyond 145ºC thread forming ability decreased due to decomposition of fructose. Brittleness of candy was dependent on temperature up to 140°C. The candy was hard. At 145ºC and above the candy thus prepared was hard and brittle. Therefore 145ºC was found optimum for production of herbal candy. The taste of herbal candy was dependant on temperature. As temperature increased from 130°C to 145ºC, the product yield sweet taste to slight bitter taste, beyond 145ºC the herbal candy gave a definite and strong bitter taste. Thus candy could be prepared only up to 145°C. At 145 °C heated sugar, glucose syrup and flavoring agent such as ginger oil, tulsi oil and giloy powder had a good consistency, yellow brown color, good mouldability and good thread forming ability with good taste.

Effect of temperature on hardness of herbal candy

Effect of temperature on hardness is shown in Table 6. The hardness of herbal candy increased with increase in temp from 130°C to 145°C. Further increase in temperature reduced hardness of herbal candy due to brittleness of sugar crystals.

Effect of temperature on sensory characteristics of herbal candy

Sugar and corn syrup in the ratio of 70:30 and 0.5 per cent citric acid were added in candy. Temperature significantly affected all the sensory score for colour, appearance, taste, texture, mouth feel and overall acceptability at all the level than control.

As the temperature, the sensory score for all the attributes improved up to 145 °C. The colour, appearance, taste, texture, mouth feel and overall acceptability of herbal candy prepared at 145 °C was 7.55, 4.0, 7.05, 7.1, 7.0 and 7.35 which was higher than 130 °C,135 °C and 140 °C. Further increase in temperature beyond 145 °C decreased sensory score for all the parameters.

Table 6 Effect of temperature on hardness of herbal candy[1]

Temperature (°C)	Hardness[2] (Kg)			Average
	R_1	**R_2**	**R_3**	
130	0.459	0.669	0.334	0.4873
135	23.101	25.592	23.354	24.0156
140	62.15	62.16	62.21	62.1733
145	61.546	61.727	61.873	61.7153
150	47.928	42.402	39.996	43.442
155	29.745	31.865	29.146	30.252
160	36.36	31.621	43.804	37.2616

[1]Sugar: corn syrup ratio and citric acid level in candy was 70:30 and 0.5 per cent. [2]Mean of 3 replicates;

Physicochemical quality of herbal candy

the herbal candy contained 1.85 per cent moisture, 93 ^{0}Brix T.S.S. and 60.7 per cent reducing sugar and 92.85 per cent total sugar. It had pH 3.86 and 0.81 per cent titrable acidity. It showed hardness about 595.083 N. Sugar and corn syrup were added in the ratio of 70:30 as given by Rongnaphar (1994) in each candy and this was called as sugar mix. Citric acid affected significantly all the six sensory score for colour, appearance, taste, texture, mouth feel and overall acceptability at all the levels in comparison to the control candy.

On increasing or decreasing concentration of citric acid, the quality of product was significantly ($p \leq 0.01$) inferior to the critical range (0.2 to 1.0 per cent). Among citric acid concentration, 0.5 per cent citric acid produced significantly ($p \leq 0.01$) superior quality of sugar candy as compared to other concentration. It was observed that the increasing citric acid concentration showed significant effect as the colour score increase from 4.2 at 0 per cent to 7.5 at 0.5 per cent citric acid concentration. There after colour score declined insignificantly with the increase in concentration of citric acid to 7.05 at 1 per cent citric acid, this may be due to inversion of sucrose to enhance non-enzymatic browning. Therefore 0.5 per cent citric acid yielded maximum colour score and optimum level for further results.

Addition of citric acid also improved taste score of sugar candy. Increasing citric acid concentration showed significant effect on taste score at all concentration of citric acid, taste score increased from 4.4 at 0 per cent to 7.45 at 0.5 per cent citric acid concentration. There after taste score declined at all level of citric acid, further increase of citric acid beyond 0.5 per cent caused bitterness in sugar candy. Addition of citric acid improved the texture of products. Texture score increased significantly from 4.2 at 0 per cent to 7.8 at 0.5 per cent citric acid concentration, further increase in the level of citric acid showed decline texture score to 6.3 at 1.0 per cent citric acid. The sugar candy at 1.0 percent citric acid level showed sticky texture.

Citric acid also improved the mouth feel score of sugar candy and mouth feel score increased significantly from 4.4 at 0 per cent to 7.3 at 0.5 per cent citric acid concentration. Further increase of citric acid caused bitterness in product and mouth feel score declined to 6.0 at 1 per cent citric acid. Addition of citric acid showed improvement of the appearance, the appearance

score increasing from 4.5 at 0 per cent to 7.65 at 0.5 per cent, further increase in the level of citric acid showed decline appearance due to dark brown colour.

The similar trend in overall acceptability score was observed by 0.5 per cent citric acid level, which showed highest overall acceptability score 7.7 than control score 4.0. Further increase in the level of citric acid showed decline in overall acceptability score. But Rongnaphar (1994) reported that 1 per cent citric acid gave the best result in the formulation of hard candy where as the 0.5 per cent citric acid level was found optimum in the present investigation. The difference was due to composition of herbs and other process parameters. The citric acid concentration at 0.5 per cent produced maximum overall acceptability score (7.7) for herbal candy with better taste, colour, mouth feel and appearance.

The ginger oil concentration at 2.5 per cent produced maximum overall acceptability score (7.05) for herbal candy with less score for colour, texture and mouth feel as compared to herbal candy produced at 2.0 per cent ginger oil. The temperature at 145 $^{\circ}$C produced herbal candy with best consistency, moudlability, thread forming ability, brittleness along with desirable taste and colour. The herbal candy prepared at 145 $^{\circ}$C yielded candy with best hardness with desirable sensory characteristics. The temperature at 145 $^{\circ}$C produced maximum overall acceptability score (7.35) for herbal candy with less score for colour and taste as compared to herbal candy produced at 155 $^{\circ}$C.

The moisture, reducing sugar, total sugar, titratable acidity of herbal candy using ginger oil were 1.85, 60.7, 92.85 and 0.81 per cent respectively. Total soluble solids, hardness and pH of herbal candy using ginger oil were 93^{0} Brix, 595.083 N and 3.86, respectively.

REFERENCES

Clark P. J. 2004. Crystallization is key in confectionary processes. Food technology, 49(7): 58-59.

Draghon, E. A. 2004. Use of botanicals as biopreservatives in foods. Food technology, 50 (2): 20-28.

Gopalan, C., Ramasastri, B. V. and Balasuhramanian, S. C. 1984. Nutritive value of Indian Foods, NIN, ICMR Hyderabad, India. 85.

Grijpaardtvilvink G. 1995. Innovation key to European Confectionary market. Food technology, 49: 25.

Palma, A. C. S. 2002. Sugar confectionary keeping its sweet disposition. Food and Agri-Business monitor. University of Food and Agri-Business, Manilla.

Pandey, L. 2006. Development of herbal candy. Ph.D. Thesis G.B. Pant Univ. of Ag. & Tech. Pantnagar

Polasa, K. and Nirmala, K. 2003. Ginger: its role in xenobiotic metabolism .ICMR Bulletin, 33(16): 1-6.

Rongnaphar, P. 1994. Study on simple production of hard candy. King Mongkuf's Agricultural Journal, 12(1): 48-55.

Sandra P., Bicchi C. 1987. "Capilllary Gas Chromatography in Essential Oil Analysis". New York. Huethig. 15-21.

Sellar, W. 2001. The Directory of Essential Oil. Essex: The C.W.Daniel Company, Ltd.

Sethi, V. and Meena, M. R. 1997. Role of species and their essential oil preservatives and antimicrobial agents- a review. Indian Food Packer, 51(3): 25-42.

Singh, S., Chopra C.S. and Singh, P. 2005. Studies on physico-chemical properties characteristic of ginger rhizome. Beverage and Food World, 62(12).

Subbulakshmi, G. and Naik, M. 2002. Nutritive value and Technology of Spice: Current status and future perspective. Journal of Food Science and Technology, 39(4): 319-344.

Tripathi, V. and Nath, N. 2004. Chemical stabilization of colour of ginger paste and its antioxidant and proteolytic activities. Journal of Food Science and Technology, 41(5): 577-580.

Uhl S. 2000. Spices: tools for alternative medicines. Food Technology, 54(5): 61-64.

WHO 2002. Traditional Medicines Strategy 2002-2005. Geneva. In: WHO website, www.who.int/medicines/library/trm/trm_strat_eng.pdf.