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RESEARCH ARTICLE

Extraction of Pectin from Lemon (*Citrus limon* L.) fruit peels and its utilization in the Production of Watermelon (*Citrullus lanatus*) Jam

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Abstract: Citrus fruits peels are very rich in pectin and can be used as source of pectin for its commercial production. Moreover, the citrus fruit peels contained several bioactive compounds, including carotenoids, essential oils, antioxidants and flavors are widely incorporated into food products in order to enhance their sensory properties and to improve their nutritional and health benefits. Therefore, aim of this study was to make use of lemon peels as a source of pectin in making watermelon jam along with different levels of sugar and pectin. Pectin was extracted from lemon peel by acid extraction method at pH 1.5, 80℃ for 1 hour. The physico-chemical, sensorial and microbiological properties of the formulated jam were assessed using standard AOAC methods. The physico-chemical analysis of freshly made watermelon jam revealed that an increasing trend in titratable acidity from 0.27 to 0.61% (as citric acid), moisture from 52.9 to 63.1% and decreasing trend in pH from 3.95 to 3.31 and total soluble solids from 68.1 to 66.1°Brix when the pectin levels increased from 1.8 to 3.3 g per 500g watermelon pulp. According to Kruskall-Wallis Method the mean scores of the sensory qualities in terms of color, taste, texture, aroma and overall acceptability varied significantly ($p<0.05$) in the freshly formulated jam. There were no significant ($p>0.05$) differences between in total plate count of all treatments. The results of this study revealed that the watermelon jam formulated with 65g of sugar, 2.8g of pectin and 500g of pulp was the best combination and it could be stored at 30±1℃ for 12 weeks without any significant changes in the quality characteristics. Therefore, pectin which was extracted from lemon peels can be used as an effective food additive in watermelon jam production.

Keywords: *Jam, Lemon peel, Pectin, Quality characteristics, Watermelon*

Introduction

Fruits are important natural foods and are very good sources of several vitamins, minerals, phytochemicals and dietary fibers, all of which are essential for healthy life (Lamikanra, 2002). Most of the fruits are available only in particular season and their shelf life are limited, this requires some processing to preserve the nature of the fruits and to maintain its quality attributes. The techniques impart to increase the consumption of fresh fruits and preserved the fruits by processing into different products like jam, jelly, marmalades, candy, squash and increasing levels of essential nutrients through fortification and improving nutrients bioavailability. Jam, jellies and fruit bars are the most important fruit products which are manufactured in industries based on the high solids high acid principle and prepared from a combination of two or more fruits and they possess substantial nutritive value (Vidhya and Narain, 2011).

According to the Fruit products order specification, jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency and firm enough to hold the fruit tissues in position (45% of fruit pulp should be used for every 55% of sugar) and the prepared jams should contain not less than 68.5°Brix. Proper amount of four key ingredients such

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as fruit pulp, pectin, sugar, and acid are essential for jam making. Boiling releases pectin from the cells, after which, with a little encouragement, the molecules coalesce, joining together to form a network. This trap and immobilizes the water molecules in fruit juice, turning it from a slurp liquid into a gel.

Citrus is the most abundant crop in the world. The amount of peel obtained from citrus fruits accounts for 50% of the original mass of the whole fruit (Davies and Albrigo, 1994). It has been estimated that an average a juice manufacturer squeezes up to 0.9×10^{2}tonnes of fresh fruits each year correspondingly the production of the citrus peels as a waste by the product amount around 0.45×10^{2}tonnes/year. The peels, if treated as waste materials, may create environmental problems, particularly water pollution. This problem could be turned into an asset, if potentially marketable by-products such as pectin could be extracted from the peels. Industrial pectin is extracted in a multiple-stage physico-chemical process characterized by an extraction step with hot dilute mineral acid and recovery through alcohol precipitation (Mollea *et al*., 2008).

Watermelon (*Citrullus lanatus*) botanically considered as the fruit is belonging to the family Cucurbitaceae and used as a dessert fruit primarily for its sweet, crisp qualities. Watermelon has garnered interest as a source of lycopene, beta-carotene and the non-essential amino acid, arginine precursor, citrulline (Edwards *et al*., 2003). Sugar not only sweetens the jam and helps the fruit maintain its brilliant color, but it also helps pectin do its stuff. Sugar attracts water, yanking it away from the pectin, which boosts network formation and enhances gelling in regular jams, jellies and preserves (Vidhya and Narain, 2011).

Citric acid is a weak organic acid, it occurs naturally in citrus fruits. It is important in helping the pectin to set. The COOH groups in the pectin are usually ionized and negative charges on the molecules this ionization causes repulsion and prevent pectin chains from being able to form the gel network. To avoid this, we need pH of the mixture to be roughly in the range of 2.8-3.3. Accordingly, the objectives of the present study are to develop watermelon jam using pectin extracted from lemon peels, to identify more suitable combination of sugar and pectin mixture and to assess the nutritional qualities, microbial safety and consumer acceptability of watermelon jam.

Materials and Methods

Extraction of Pectin from Lemon Peels

The lemon peels were collected from juice processing centers and sun dried for 4 days. The dried peels were ground into fine powder, sieved through a 60-mesh sieve and stored in air tight glass containers at room temperature for further use. The extraction procedure was based on the method given by Georgiev *et al*. (2012). Dried lemon peel power of 20 g was transferred into 1000 ml beaker containing 300 ml of 0.05M citric acid (pH 1.5). Thereafter, the mixture was heated while stirring at 80°C water bath for 1 hr. The hot acid extract was filtered through filter funnel equipped with two-layer of muslin cloth. To the filtrate, an equal volume of 95% ethanol was added and allowed to precipitate for overnight at 4°C. The gelatinous pectin flocculants were skimmed off, washed with ethanol twice to remove impurities and then dried in a vacuum oven at 40°C. The dried pectins powders were dissolved in fresh Milli-Q water, for 5 hrs and centrifuged at 5,000 rpm for 15 min, at 30°C to remove the insoluble fraction. The supernatants were filtered and vacuum-dried at 40°C for 3 hrs and weighed. The dried pectin was ground into powder and stored in airtight glass containers at room temperature for further use.

Preparation of Watermelon Jam

Watermelon jam was prepared according to Sri Lankan Standard Specification (SLS.265:2007) of a general recipe for fruit jam. Watermelon fruits were washed peeled, and the seeds were removed. The fruits were chopped into small pieces by using clean stainless steel knife. Then the chopped watermelon was blended by using electric grinder (KENSTAR CLASSIQUE-540) to make watermelon pulp. Watermelon pulp, sugar, citric acid was weighed by using electric balance (METTER PJ-300). Addition of watermelon pulp and sugar in the ratio of 500:80, 500:75, 500:70, 500:65 and 500:60 (W/W) respectively into the stainless pan, mixed thoroughly and slowly cooked for 15 minutes with occasional heating until temperature reach 105°C, while adding pectin (g/100g) and citric acid (g/100g) in the ratio of 0:2, 1.8:2, 2.3:2, 2.8:2 and 3.3:2 (w/w) respectively in to the pan and cooked by stirring continuously until it reach the end point (where total soluble solid in terms of 68ºBrix). End point was determined by sheet or flake test. Finally, the pan was removed from the fire and cooled for 5 minutes. The plastic cups were sterilized by spraying water at 68-70°C of maintaining the inner pressure at 10-12 kPa to sterilize the inner and outer surface of the cups and allowed to dry. Then jam was filled into plastic cups and sealed with lids.

Preliminary Studies on Development of Watermelon Jam Using Pectin Extracted from Lemon Peels

Several preliminary experiments were conducted to find out proper amount of Watermelon pulp, sugar, pectin, Citric acid and to develop the recipe for the watermelon jam formation at different combinations of sugar and pectin.

Experimental Formulations

Treatment 1 (T_1): 80g sugar and no pectin added
Treatment 2 (T_2): 75g sugar and 1.8g pectin extracted from lemon peels
Treatment 3 (T_3): 70g sugar and 2.3g pectin extracted from lemon peels
Treatment 4 (T_4): 65g sugar and 2.8g pectin extracted from lemon peels
Treatment 5 (T_5): 60g sugar and 3.3g pectin extracted from lemon

Physico-chemical Analysis

Pectin quality characteristics such as color, solubility in cold and hot water, solubility in cold and hot alkali, pectin yield, ash content, equivalent weight, methoxyl content, and anhydrouronic acid content were analyzed as described by Ranganna (2005).

Physico-chemical properties of the freshly prepared watermelon jam were analyzed using recommended standard methods (AOAC, 2002). Titratable acidity was determined by titrating the jam samples with standard NaOH and the results were expressed as % of citric acid. pH was measured by using Digital pH meter (Model HANNA HI 98130). The Ascorbic acid content was titrimetrically estimated by 2, 6 dichlorophenol indophenol dye. Moisture content was determined by oven drying method. Total Soluble Solids (TSS) was measured by using the handheld refractometer (Model: ATAGO-S-28E) and Total sugar of jam samples was determined by Lane-Eyon method. Each parameter was triplicated during analysis.

Microbial Examination

Potato Dextrose Agar (PDA) preparation was carried out without any external contamination. Total plate count was taken as described below:
Peeled potato was cut into small pieces and added in 250 ml of distilled water and boiled. Weighed agar was boiled with 250 ml of distilled water until agar dissolve and placed in a 1000 ml of flask. Then required amount of sucrose and potato extraction were added into the flask and stirred. Then conical flask containing media was plugged with a cotton wool and wrapped aluminum foil. Then it was put into the autoclave at 121°C, 15psi for 20 minutes and the media was allowed to cool. Petri dishes, forceps and needles were kept in the oven at 180°C for one hour and allowed to cool. All the equipment were sterilized by 70% of alcohol. Then it was poured into petri dishes and they were kept in lamina flow until solidify. Different treatment samples were placed in agar plate. Then petri dishes were covered and labeled. The plates were observed after 4 days for plate count.

Shelf-life Evaluation

The shelf life of watermelon jam was assessed based on the nutritional and sensory qualities. The jam formulations were organoleptically examined once in two weeks.

Sensory Evaluation

Sensory evaluation offers the opportunity to obtain a complete analysis of the various properties of food as perceived by human sense. Sensory attributes including color, taste, texture, aroma and overall acceptability were assessed by 20 semi-trained panelists. The seven-point hedonic scale was used to evaluate the degree of liking (7) and disliking (1) for preference of the watermelon jam following storage. A structured questionnaire was used for the sensory evaluation. Test was conducted between 9.00 – 11.00am morning session and 2.00 – 4.00pm evening session.

Statistical analysis

Each formulation was triplicated in experiments and they were in Complete Randomized Design. Data of the physico-chemical parameters were subjected to analysis of variance (ANOVA) ($\alpha = 0.05$). Data related to sensory evaluation was analyzed using the Kruskall-Wallis test. Both physico-chemical and organoleptic analysis were undertaken using Statistical Analysis System (SAS) software statistical package.

Results and Discussion

Characterization of Commercial Pectin and Pectin Extracted from Lemon Peels

The extracted pectin and commercial pectin were characterized in terms of pectin color, solubility in cold and hot water, solubility in cold and hot alkali (NaOH), pectin yield, ash content, methoxyl content, anhydrouronic acid content and gel grade, as these properties determines the suitability of pectin for different purposes. The results are given in Table 1.

Table 1: Quantitative Analysis of Pectin

Quantitative parameters	Lemon peel pectin	Commercial pectin
Pectin yield (%)	20.4	-
Ash content (%)	6.6±0.11	15.2±0.12
Equivalent weight (g/mol)	476±0.12	493±0.11
Methoxyl content (%)	1.56±0.15	3.57±0.13
Anhydrouronic acid (%)	60.95±0.12	68.95±0.10
Gelling grade	113±0.10	150±0.11

The values are means of triplicates ± standard error

Yield of Pectin

Pectin yields extracted with 0.05M citric acid at 80°C for 60 min yielded 20.4% (dry basis) of pectin, similarly the best extraction condition by using citric acid at 80ºC, 60 min, and 1.5 pH as reported higher in pectin yield reported by Devi *et al*. (2014). This value was remained in close agreement with the results reported by Elizabeth *et al.* (2014) extracted pectin from sweet lime peel by two different acids (citric and nitric) and at three different temperatures (60, 70 and 80ºC), time (30, 45 and 60 min) and pH (1.5, 2 and 2.5). Pectin yields varied from 21.4% to 76.0% extracted by using citric acid, and 17.4% to 46.4% extracted by using nitric acid.

Ash Content

Ash content of pectin extracted from lemon peel powder using citric acid was found to be 6.6% against commercial pectin which is about 15.2% for commercial pectin. Low ash content is good for gel formation. This parameter as reported in literature is varied in a wide range depending on the method and the nature of the citrus fruit peel used for extraction. The upper limit of ash content for good-quality pectin is considered to be 10%, from the viewpoint gel-formation (Devi *et al*., 2014). Therefore, with respect to this parameter, the pectin isolated in this study may be considered to be of satisfactorily good quality.

Equivalent Weight

Equivalent weight of pectin extracted from lemon peel powder was found to be 476g/mol in comparison to commercial pectin (493g/mol). However, according to (Ismail *et al*. 2012) this level can be varied from 476 to 1209g/mol and it is depending on the composition of the source.

Methoxyl Content

Methoxyl content is an important factor in determining the gel formation capacity, controlling the setting time of pectin and the ability of the pectin to form gels (Rahman and Moshiur, 2017). The methoxyl content of pectin extracted from lemon peel powder was found to be 1.562%, this result was supported by Azad *et al*. (2014) which was 2.98% in dragon fruit pectin. Spreading quality and sugar binding capacity of pectin are increased with increase methoxyl content (Saha *et al*., 2010). Based on methoxyl content value of this study which indicates that lemon peel pectin was categorized as low methoxyl pectin (Methoxyl content < 7%).

Anhydrouronic Acid (AUA) Content

The AUA indicates the purity of the extracted pectin and its value should not be less than < 65% (Food Chemical Codex, 1996). The Anhydrouronic Acid (AUA) content of pectin extracted from lemon peel powder was found to be 60.95%. Resembled value was found in apple pomace pectin 59.52 to 70.50%, (Azad *et al*., 2014). Low value of AUA means that the extracted pectin might have a high amount of protein, starch and sugars in the precipitated pectin (Ismail *et al*., 2012).

Gelling Grade

Gelling grade is defined as the number of grams of sugar with which one gram of pectin will form a 65% soluble solids gel of specified strength under suitable acid conditions. While the gelling grade of pectin extracted from lemon peel was found to be 113-grade, it was for the commercial pectin 150-grade. It indicates that water, sugar to give 65% solids, and acid to give the optimum pH. One unit weight of pectin will give a perfect jelly with 150 times that same weigh of sugar.

Quality Characteristics of Watermelon pulp and Lemon Peels

Nutritional analysis was carried out for the watermelon pulp initially with a view to develop the standard recipes of watermelon jam. Table 2 shows the physico-chemical parameters of watermelon pulp (*Citrullus lanatus*) and lemon peels.

Table 2: Physico-Chemical Characteristics of Watermelon Pulp and Lemon Peels

Quality Characteristics	Watermelon pulp	Lemon peels
Titratable Acidity (% of citric acid)	0.19±0.12	0.16±0.12
pH	6.13±0.012	1.72±0.01
Total soluble Solids (TSS as °Brix)	13.0±0.03	6.80±0.02
Vitamin C content (mg/100ml)	5.81±0.01	0.238±0.01
Total sugar (%)	5.25±0.02	2.37±0.02

The values are means of triplicates ± standard error

Physico-chemical Analysis of Freshly Prepared Watermelon Jam Formulations

Titratable Acidity

The acidity of any fruit-based jam are mainly due to the content of organic acids such as citric, with some malic acid and, less commonly, isocitric acid. Watermelon jam formulations with 3.3g lemon peel pectin (T_5) had the highest mean value (0.610) followed by watermelon jam formulations with no lemon peel pectin added (T_1) had the least mean value (0.273) for titratable acidity. This might be due to the increase in the amount of lemon peel pectin from 1.8g to 3.3g as shown in Figure 1. This can be partially breakdown of pectin into pectic acid and degradation of ascorbic acid (Singh *et al*., 2015). Similar increasing in trend in titratable acidity reported by Muhammad *et al*. (2008) in carrot and apple blend jam (0.31-0.46) using pomelo peel pectin.

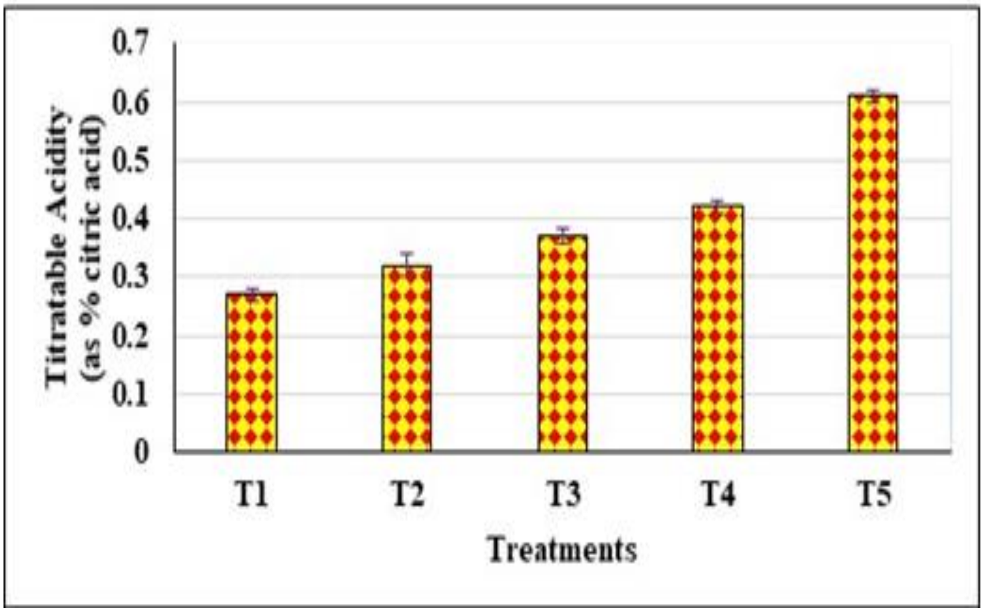

Figure 1: Titratable Acidity of Freshly Made Watermelon Jam

The values are means of triplicates.
Vertical bars indicate the standard errors.
(T_1 - 80g sugar and no pectin added; T_2 - 75g sugar and 1.8g pectin extracted from lemon peel; T_3 - 70g sugar and 2.3g pectin extracted from lemon peels; T_4 - 65g sugar and 2.8g pectin extracted from lemon peels; T_5 - 60g pectin and 3.3g pectin extracted from lemon peels).

pH

Fruit products are being effectively preserved at low pH. The pH value plays an important role in formation of optimum gel in preparing of jam. Fruit jam normally persists in the range of 3.1-3.3 pH (Knox, 2002). Pectin has a significant effect on the pH of jam (Fellows, 2007). According to DMRT, the pH values of all jam formulations were decreased significantly ($p<0.05$) with the increment of lemon peel pectin (Figure 2). This might be due to the hydrolysis of pectin and formation polygalacturonic acid while processing. In agreement within the ranges reported by Gonzalex *et al*. (2010) for kiwi jam and orange marmalade (3.04-4.68) with pectin obtained from grapefruit peels. While the formulation (T_5) had the least pH value of (3.31), highest value (3.95) was recorded by the formulation with no pectin added (T_1) as shown in Figure 2. Increasing in lemon peel pectin gave the results of lower pH in the jam samples. The pH of the sample was caused for optimum gel formation in jam which imparted to have a real appearance and consistency.

Ascorbic acid

Ascorbic acid is a water-soluble vitamin which is found in fresh fruits, mainly citrus family. Ascorbic acid is an essential nutrient for humans because it aids in the synthesis of collagen in addition to protecting against oxidative damage. Watermelon pulp has 5.81mg/100ml of ascorbic acid (Patil, 2000). Ascorbic acid content in jam formulations did not significantly ($p<0.05$) change with the increment of lemon peel pectin content as shown in the Figure 2. The highest ascorbic acid content of 5.34mg/100ml had recorded in T_2 and least mean value of 4.42 mg/100ml had observed in T_3.

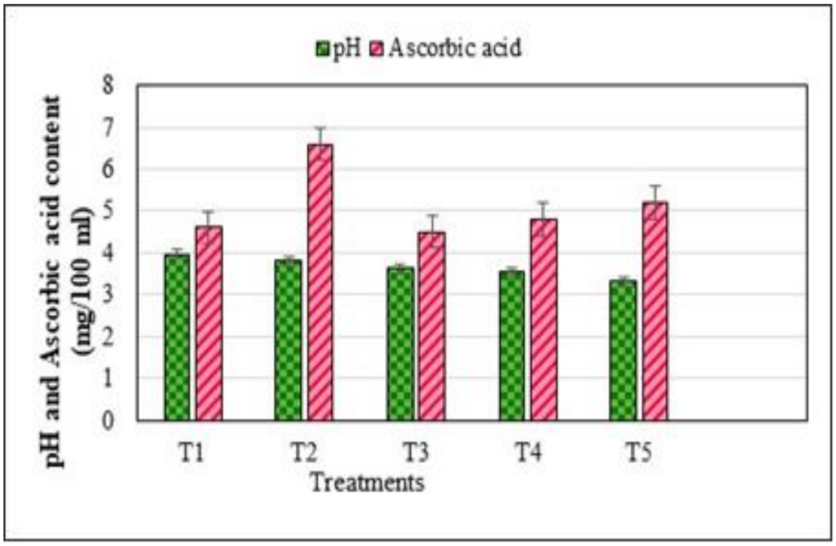

Figure 2: Ascorbic acid Content of Freshly Made Watermelon Jam

The values are means of triplicates

Vertical bars indicate the standard error

(T_1 - 80g sugar and no pectin added; T_2 - 75g sugar and 1.8g pectin extracted from lemon peel; T_3 - 70g sugar and 2.3g pectin extracted from lemon peels; T_4 - 65g sugar and 2.8g pectin extracted from lemon peels; T_5 - 60g pectin and 3.3g pectin extracted from lemon peels).

Moisture Content

Moisture content is one of the most commonly measured properties of food material as it is the key aspect which influences the shelf life of the product. It is affected to food quality while contributing to microbial stability (McClement, 2005). Controlling the moisture content of jam is one of the most important means of extending its shelf life. Moisture content less than (10%) has been reported to be responsible for the state of non-deterioration in food (Makkar *et al*., 1998). According to DMRT, the moisture content was increased significantly ($p<0.05$) with the decreasing concentration of sugar in jam as shown in the Table 3. The highest moisture content of 63.1% was recorded in the treatment T_5 (Jam with 60g sugar). The treatment T_1 (Jam with 80g sugar) had the least mean value of 52.9% of moisture. It has been reported by Ehsan *et al*., (2002) that moisture has a great impact on the shelf life of watermelon lemon jam. Muhammad *et al*. (2008) also stated that the moisture content of diet jam from apple is a measure of its quality and shelf life.

Total Soluble Solids (TSS)

Total Soluble Solids is the sum of the sugar (sucrose and hexoses), acids (citric and malate) and other minor components (amino acids, soluble pectin, ascorbic acid and minerals) in jam. A total soluble solid is an important parameter which indicates quality of jam. Total soluble solid content lower than 60°Brix make the gel week whereas the total soluble solid content is higher than 70°Brix may cause crystallization of the sugar, an undesirable change in the texture of jam. Table 3 shows the TSS content of watermelon jam. According to the DMRT, the TSS was decreased significantly ($p<0.05$) with the decrement of sugar in jam formulations. While the highest TSS value 68.1°Brix was observed in the treatment T_1 (Jam with 80g sugar), the lowest value (66.1 Brix) was recorded in T_5 (Jam with 60g sugar). Fasogbon *et al.* (2013) observed that the soluble solids content ranged from 68.40 to 72.18 °Brix during storage for jam from osmotically dehydrated pineapple slices.

Table 3: Moisture and Total Soluble Solids Content of Freshly Prepared Watermelon Jam

Treatments	Moisture Content (%)	TSS (°Brix)
T_1	52.9±0.001e	68.1±0.017a
T_2	55.3±0.001d	67.8±0.001b
T_3	56.1±0.001c	66.6±0.002c
T_4	56.9±0.001b	66.6±0.002d
T_5	63.1±0.001a	66.1±0.003e

The values are means of triplicates ± standard error

The means with the same letters are not significantly different at 5% level

(T_1 - 80g sugar and no pectin added; T_2 - 75g sugar and 1.8g pectin extracted from lemon peel; T_3 - 70g sugar and 2.3g pectin extracted from lemon peels; T_4 - 65g sugar and 2.8g pectin extracted from lemon peels; T_5 - 60g pectin and 3.3g pectin extracted from lemon peels).

Sensory Analysis of Freshly Made Watermelon Jam

Sensory evaluation is an important and best method for evaluating new products developed which provide quality measure and production control. The flavor, color, and taste of fruit jams are very important because it determines the acceptability and marketability of jam. The sensory evaluation of watermelon jam revealed that there was a significant difference between the treatments when the amount of sugar decreased from 80g to 60g and amount of pectin increased from 1.8g to 3.3g in color, taste, texture, aroma and overall acceptability at 5% level of significance. Mean values of formulations according to Kruskall-Wallis Test are shown in Figure 3. The treatment T_4 (Jam with 2.8g pectin) had highest score in color, aroma, taste and finally overall acceptability. T_5 had a highest score for texture according to Kruskall-Wallis Test

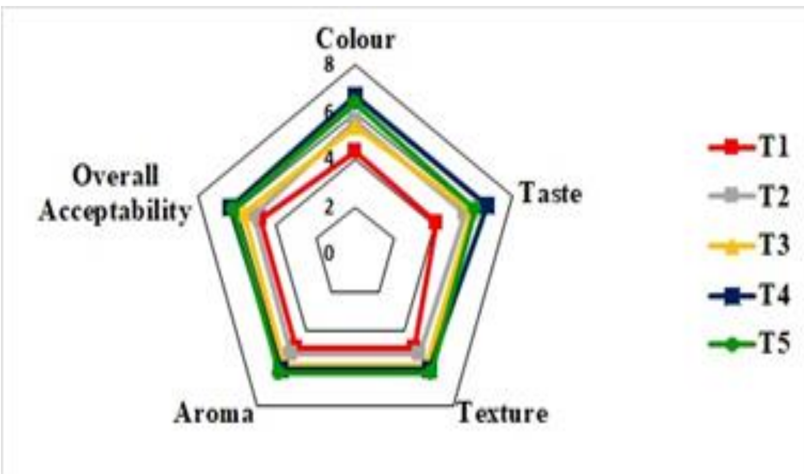

Figure 3: Sensory Properties of Freshly Made Watermelon

The values are means of triplicates

Vertical bars indicate the standard error

(T_1 - 80g sugar and no pectin added; T_2 - 75g sugar and 1.8g pectin extracted from lemon peel; T_3 - 70g sugar and 2.3g pectin extracted from lemon peels; T_4 - 65g sugar and 2.8g pectin extracted from lemon peels; T_5 - 60g pectin and 3.3g pectin extracted from lemon peels).

Colour

Color which is a sensation that forms part of the sense of vision, judges the appearance of a food. Therefore, among this color is a one of the most important sensory quality. Attractive color of the end product gives good demand for it (Al-Hooti and Sidhu, 1997). According to the Kruskall-Wallis test, there were significant differences between treatments. As shown in the Figure 3. The highest mean value (6.74) had jam formulation with 2.8g of pectin and least mean valve (4.30) had no pectin added to the jam.

Taste

Taste is an important parameter when evaluating sensory attribute of food and it has the highest impact as far as market success of product, is concerned. According to Kruskall-Wallis test, there were significant differences between formulations for taste shown in Figure 3. The jam 2.8g pectin (T_4) had maximum mean value (6.70) and minimum mean value (4.10) had no pectin added to the jam.

Texture

The most important attribute in food selection is texture. Which consists of those properties of product which judges visually or by touch. As shown in Figure 3. There were significant differences between treatments. Highest mean value (6.30) for jam with 3.3g pectin and poorest mean value (4.92) for formulation with no pectin added to jam. Similar findings in texture were expressed by Ehsan *et al*. (2002) in grape and apple marmalade.

Aroma

Aroma is an integral part of taste and general acceptance of the food before it is put in the mouth. It is therefore an important parameter when testing acceptability of formulated foods. According to Kruskall-Wallis test there were significant differences among the treatments shown in Figure 3 jam formulations with 2.8g pectin had the highest mean score and jam with no pectin added had least mean score.

Overall Acceptability

There were significant differences among treatments. According to Kruskall-Wallis test the highest mean value (6.57) had in T4 and least mean value (4.09) had in T_1 (no pectin added). The treatment T_4 (Jam with 2.8g pectin) had highest score in color, aroma, taste and finally overall acceptability.

Microbial Analysis

Contamination of food by moulds and bacteria is common. The results of microbial analysis revealed no counts of yeast, molds and coliforms in all treatments of the freshly made watermelon jam. Initial quality of freshly made watermelon jam was good with no microbial growth. This may be due to sterilization of plastic cups, sterilization of other equipment; hence a sterilized jam was obtained at earlier. Therefore, the heat treatment was sufficient to destroy initial microbial load in the watermelon jam. Regarding microbiological analyses in jam during storage, the population of yeast, molds and coliforms were within the limits advocated by the legislation, which is 10^4 CFU/g, indicating that the jams obtained were in accordance with the hygienic standards.

The processed fruit products such as fruit concentrates, jellies, jams, preserves and syrups have osmophilic yeasts and molds. Thus, there is a possibility to occur spoilage of fruit products and foodborne diseases related to these microorganisms. Acidified food required sufficient heat treatment sufficient to kill the non-spore forming bacteria (Acetobacter) and fungi (*Saccharomyces* spp.) that could spoil the product as the temperature of the heat treatment increases population of microbes decreases (Michael and Doyle, 2009).

Conclusion

This study revealed that lemon peel is a good source of pectin it gives a significant amount of pectin there by it can be considered as a potential commercial source. Considering the result of the study, the pectin yield was found to be 20.4%, comparing the commercial pectin. The extracted pectin had lower ash content of 6.6%, equivalent weight of 479g/mol, methoxyl content of 1.56%, anhydrouronic acid 60.95% and gelling of 113-grade. Methoxyl content of the extracted pectin was found to be < 7%. Hence, the lemon peel pectin is considered as low methoxyl pectin. Watermelon jam could be produced using extracted pectin from lemon peels. Watermelon fruit with 65g sugar and 2.8g pectin is the best formulation for commercial preparation of jam with acceptable physico-chemical and organoleptic qualities.

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