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La Société Canadienne de Génie Agroalimentaire et de Bioingénierie
La société canadienne de génie agroalimentaire, de la bioingénierie et de l'environnement

Paper No. 06-208

Microwave Drying of Enriched Mango Fruit Leather

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Written for presentation at the
CSBE/SCGAB 2006 Annual Conference
Edmonton Alberta
July 16 - 19, 2006

Abstract

Mango fruit leather is becoming popular for their taste, chewy nature and nutritive value. A study was undertaken to find out the effect of incorporating of defatted soy flour to process nutritionally enriched mango leather with alphonso mango pulp(TSS 16º Brix) and defatted soy flour (protein 52%) with addition of sugar and lime juice . The different levels of incorporation such as 10, 15, 20 and 25 percentage were studied along with drying characteristics by using microwave drier. A 750W, 2450MHz microwave oven was used to dry the sample from 30 to 15 % moisture content at five different power levels (4, 8, 12, 16 and 20 W/g using 50g of sample) with power cycle of 30s on / 30s off. All combination of these variables was tested in triplicate. The dried fruit leather was evaluated for quality parameters *viz*., dehydration behavior, texture, colour, water activity and sensory properties. The results showed that mass reduction of the sample was rapid at higher microwave power level and drying time was very short (one minute) at higher power level whereas it was longer at lower power level. With increase in the soy flour concentrations at higher micro wave power level the colour values for lightness and yellowness increased. The water activity level was within the safer limit. The sensory evaluation showed that 10 to 15% of soy at microwave power level of 2 and 4 were highly significant in terms of colour, texture, flavour and taste.

Introduction

Microwave can be a real time saver by reducing the amount of time it takes to dehydrate a product. The microwave dries the food material faster than a conventional drier by using short high-frequency energy waves similar to TV radar and radio waves. Mango (*Mangifera indica L.*) is a popular and most commonly used fresh fruit by the people around the world. The fruit contains about 15% sugar, up to 1% protein and significant amounts of vitamin A, B and C. Also it helps to lower cholesterol. Due to inadequate post harvest handling facilities the losses are as high as 18% (Srinivas et al., 1997). To reduce the wastage, the fruit can be preserved in the form of frozen, dried and canned. It is also processed into various products like jams, jellies, preserves, juice, puree, custard, mango slices in nectar, pies, chutney, ice cream etc.

Mango leather is a traditional product prepared from fresh ripe mango or from mango pulp using sun drying method, which results in unhygienic and discolored product because of the exposure to dirt and longer drying time. Whereas the convective air dried products were better in quality due to controlled temperature and closed drying conditions (Heikal et al., 1972; Mir & Nath, 1995). But in both the drying methods, processing time is too longer due to low thermal conductivity and low heat transfer to the inner sections of food during conventional air heating. To over come this problem, and to achieve a fast and effective thermal processing, the use of microwave dryer for food drying industry is becoming popular. Since, the micro wave drying is rapid, more uniform and more energy efficient compared with conventional hot air drying (Wang et al., 2004). Mango leather has very low protein content (1-2%) and it can be enriched by adding shrimp flour, rice flour, whey protein isolate and soy protein isolate (Exama and Lacroix, 1989; Payumo et. al., 1981; Chauhan et al., 1998).

The objectives of the present investigation were to study the effect of addition of defatted soy flour by drying at different microwave power levels. Also to study the drying properties, colour, water activity, textural and sensory properties of dried mango leather.

Materials and Methods

The alphonso mango pulp with 16% TSS was procured from the local market. Various specified level of food ingredients such as sugar (50g), corn flour (5g), and lime juice (2g) were added to the mango pulp. Then roasted defatted soy flour with protein content of 51.8% and skim milk powder were mixed in the ratio of 1:1 and the mix was added to the mango pulp at different concentrations such as 10, 15, 20 and 25% for conducting the experiment. The whole contents (pulp mixed with specified food ingredients, soy and skim milk powder) at each concentration was heated to 80°C for 15 minutes before drying.

Drying

Drying was carried out using microwave drier at different power levels such as 2, 4, 6, 8, and 10 corresponding to 4, 8, 12, 16, and 20W/g of sample with a power cycle of 30s on and 30s off, respectively. Mass reduction of the samples was recorded periodically during drying at the end of each power on and power off period by removing the sample from the oven. The samples were returned to the oven in time for subsequent power on period. Drying was terminated when the calculated moisture content of the dried sample reached 12-15%.A known weight of the sample was dried using parchment paper smeared with oil to prevent the mango leather from sticking to paper after drying. TSS of the mango mix was found to be 50-55^{o}B.

Moisture content

The moisture content of the enriched mango leather with defatted soy protein was determined by using vacuum oven at 70^{o}C for 24 h (AOAC, 1980). Triplicate samples were used for the determination of moisture content and the average values were reported.

Texture

The enriched mango leather was tested for its texture by using an Instron Universal Testing Machine. A V- blade shear test-500N-YG cutter probe was attached to the crosshead speed set at 50 mm/min. The maximum shear force required for cutting the mango leather was taken as the texture index of the dried product. The force-displacement and energy used for cutting the leather was recorded. Minimum of three replicates for all 20 samples were carried out.

Color measurement

Tritimulus calorimeter was used to measure the color of the enriched mango fruit leather samples. A yellow reference tile having values L-36.19, a-0.42, and b-0.86 was used as a standard. The mango leather was placed beneath the optical sensor and values for L, a, and b were recorded. The information given for L, a, and b is generally expressed as total color of the prepared samples with ‘L’ representing the darkness to lightness, ‘a’ for redness to greenness and ‘b’ for blueness to yellowness.

Water activity

The water activity of the fresh and dried samples was measured by using water activity meter (Aqua lab, USA) with a reference room temperature of 23.4 ± 1°C.

Statistical Analysis

All observations were reported as means of three replications. Analysis of variance (ANOVA) and least significance difference (LSD) at $p \leq 0.05$ were performed based on the factorial randomized block design (FRBD) using AGRES package to determine the significant difference in fresh and the dried samples.

Sensory analyses

A nine point Hedonic scale varying from like extremely (9) to dislike extremely (1) was used to evaluate enriched mango leather samples for flavor, color, texture and taste. The sensory panel consisted of 10 trained persons.

Results and Discussion

Dehydration of mango fruit leather

The mass reduction of mango fruit leather enriched with soy flour concentrations, dried at different microwave power level are shown in Figs.1-5.

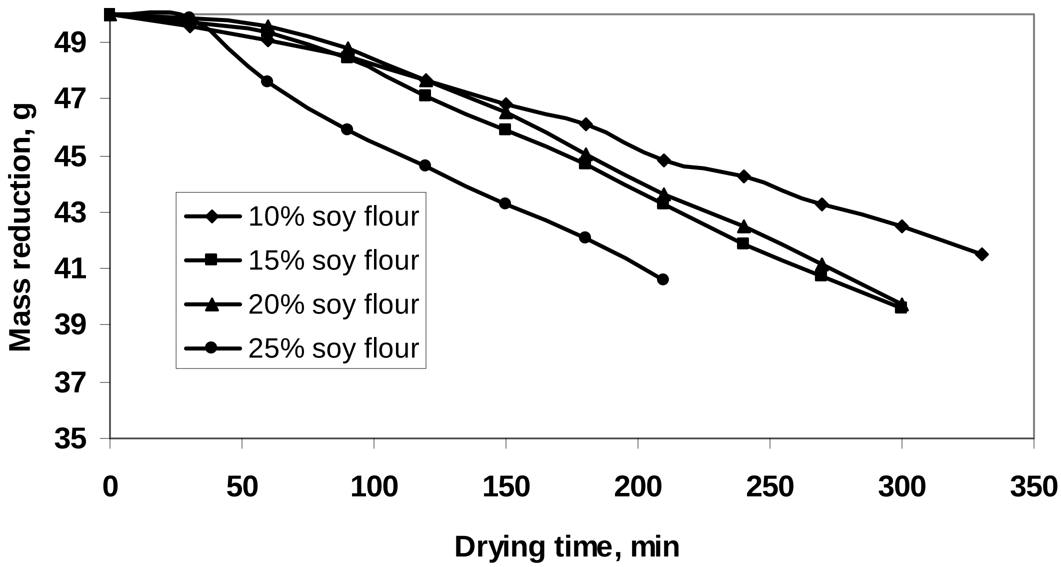


Figure 1. Microwave drying of mango fruit leather at 2 power level (4 W/g)

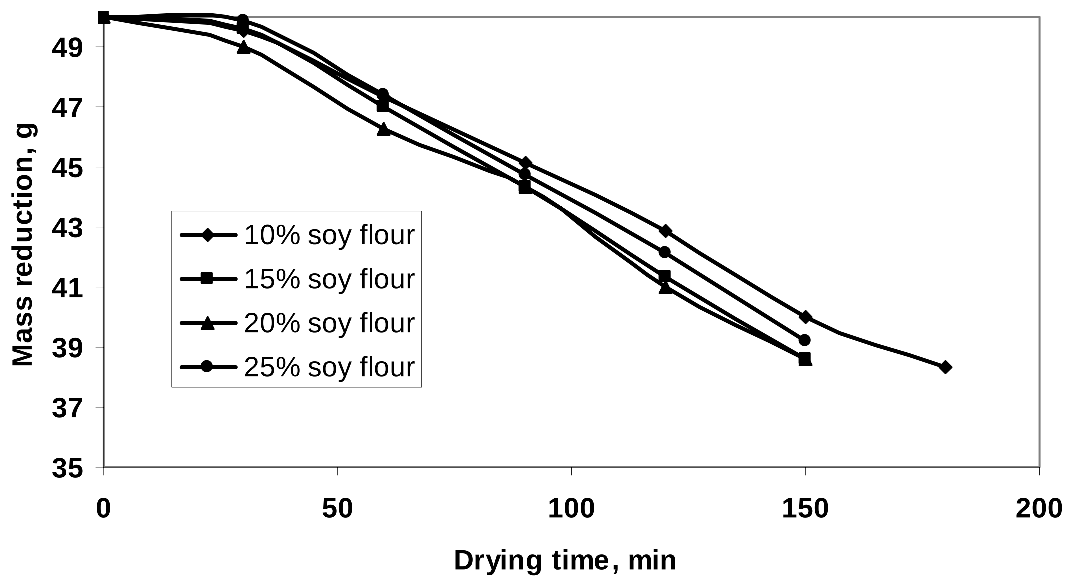


Figure 2. Microwave drying of mango fruit leather at 4 power level (8 W/g)

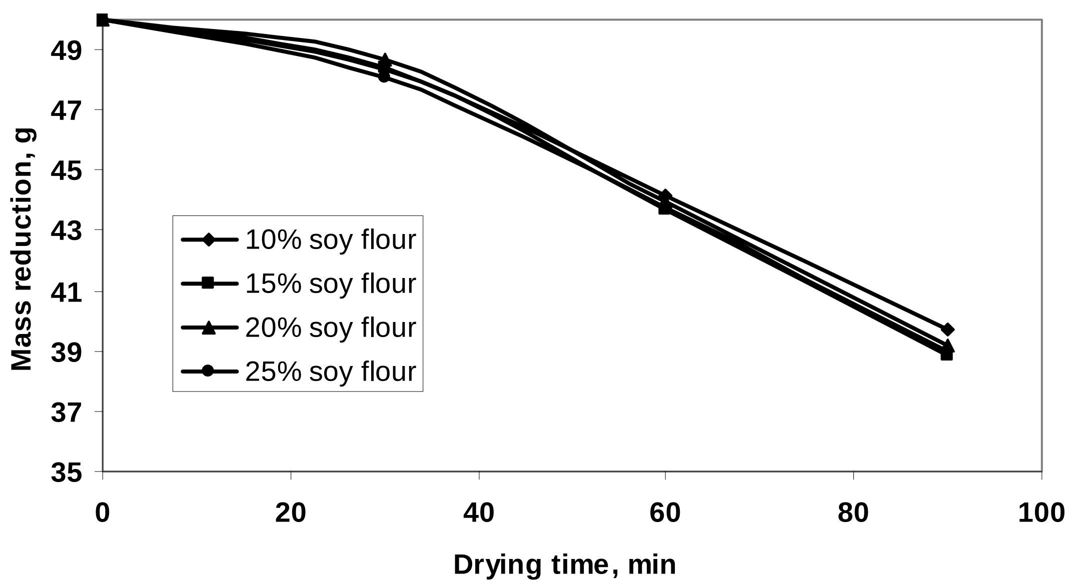


Figure 3. Microwave drying of mango fruit leather at 6 power level (12 W/g)

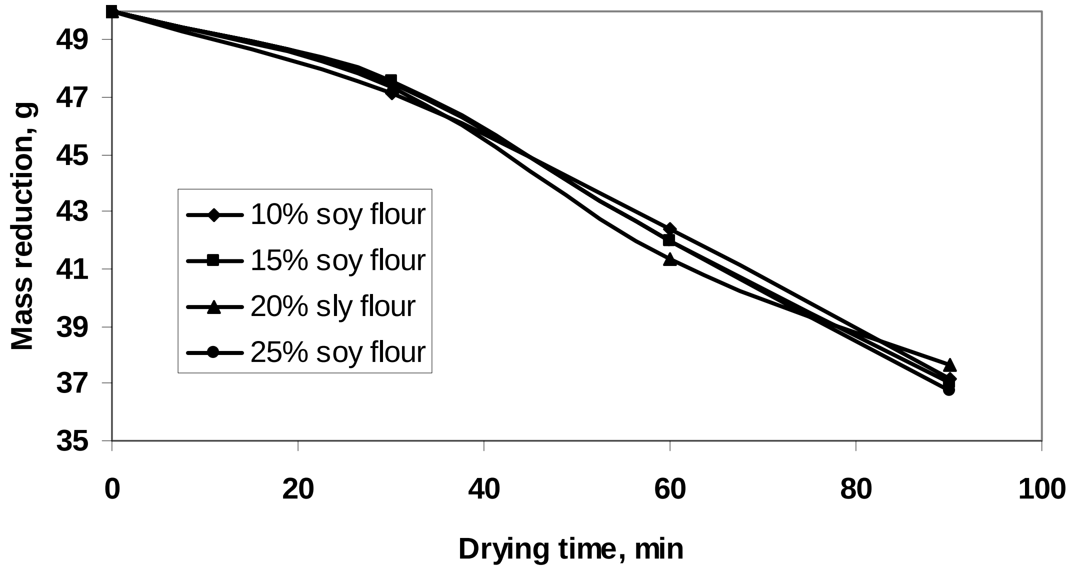


Figure 4. Microwave drying of mango fruit leather at 8 power level (16 W/g)

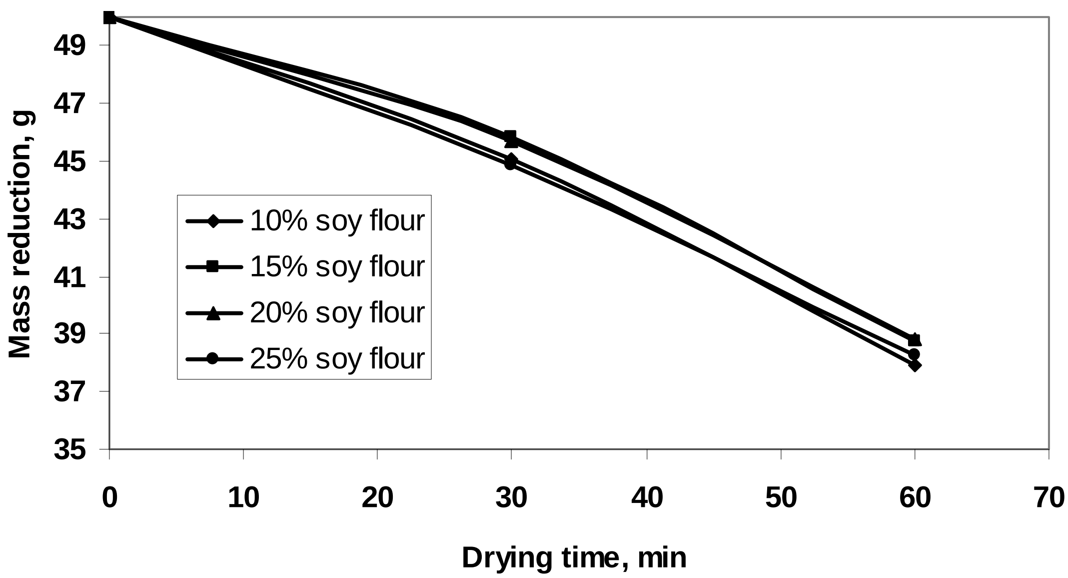


Figure 5. Microwave drying of mango fruit leather at 10 power level (20 W/g)

The relationship between mass reduction and microwave power density levels revealed that with increase in drying time a gradual reduction in mass at all levels of soy flour (10, 15, 20 and 25%) at 2 Wg^{-1} was observed. The time taken for reducing the moisture content to the range of 12- 15 % was 350, 300 and 200 sec, respectively for 10, 15, 20 and 25% soy flour.

Among the soy flour concentrations, the time required to dry the mango leather was lower in 25% soy flour incorporation. This may be due to lower initial moisture content of the leather. There was no significant difference in the drying time of 15 and 20% soy flour incorporated mango leather dried at $2Wg^{-1}$ power level.

Fig. 2 showed that the drying time was reduced to 150 sec when the soy enriched mango leather was dried with the microwave power level of 4 Wg^{-1}. There was a 50 % reduction in drying time when compared to the drying of mango leather at 2 Wg^{-1} power levels. Among the soy flour concentrations, there was no significant variation in drying time.

The drying time was reduced to 90 and 60 seconds when the microwave power levels were increased from 6 to 10 Wg^{-1} (Figs. 3-5). From the drying curves (Figs. 1-5), it was observed that the drying time progressively reduced with increase in microwave power levels form 2 to $10Wg^{-1}$. This might be due to higher heat generation within the sample at higher microwave power leading to rapid moisture removal (Wang et al., 2004). Generally the experimental results showed that in all the samples, the microwave power levels reduced the drying time with slightly varying ratios. Also the percent reduction in drying time was not exactly proportional to power levels except 2 and 4 Wg^{-1}. At lower power levels, due to lower heat generation, the drying time was longer. Similar results were reported by Beaudry et al., (2003). The moisture content of the mango leather was reduced from 30-35% to 10-15% (w.b.).

Drying rate of enriched mango fruit leather

The drying rate was calculated as the quantity of moisture removed per unit time per unit dry matter. The drying rate was increased with increase in microwave power level from 2 to 10 Wg^{-1}. The drying rate of mango leather was lower at 2 Wg^{-1} due to lower heat generation in the product. At $2Wg^{-1}$, the mass reduction was nearly constant from initial to final. But at 10 W/g, there was a steep reduction in the mass of the mango leather. This might be due to higher microwave power, which helped in rapid removal of moisture. There was no significant variation of drying rates by increasing the soy flour level from 15 to 25%. The study showed that the drying rate variations were mainly due to microwave power levels. Similar observations were reported by Yongsawatdigul and Gunasekaran, (1996) for cranberries.

Texture analysis of enriched mango fruit leather

The texture analysis of the enriched mango fruit leather with various concentrations of defatted soy flour showed that 15 and 20 % soy enriched mango leather retained significantly better texture (29.6 and 27.8) when compared to 10 and 25 % (22.7 and 24.1), respectively. Texture quality of the mango leather dried at various power levels was found to be 26.6, 26.1, 31.4, 24.2 and 21.9, respectively for 2, 4, 6, 8 and 10 power levels. Among the power levels, level 6 had retained significantly better texture when compared to the products dried at other power levels. The final dried mango leather had the TSS range of 75-80^{o} Brix.

Measurement of Colour

Mean colour values of enriched mango fruit leather with variations of defatted soy flour dried at different micro wave power levels were compared. The data obtained for lightness (L), redness (a) and yellowness (b) are shown in Table 1&2. There was a significant difference in the dried mango leather due to soy flour concentrations and MW power levels.

Table 1. Effect of variation of soy flour on surface colour mango fruit leather

S.No	Soy concentration (%)	L	a	b
1	10	52.487^{B}	9.849^{B}	20.947^{C}
2	15	52.474^{B}	9.976^{B}	23.707^{B}
3	20	52.316^{B}	11.071^{A}	25.687^{A}
4	25	53.338^{A}	9.931^{B}	26.554^{A}

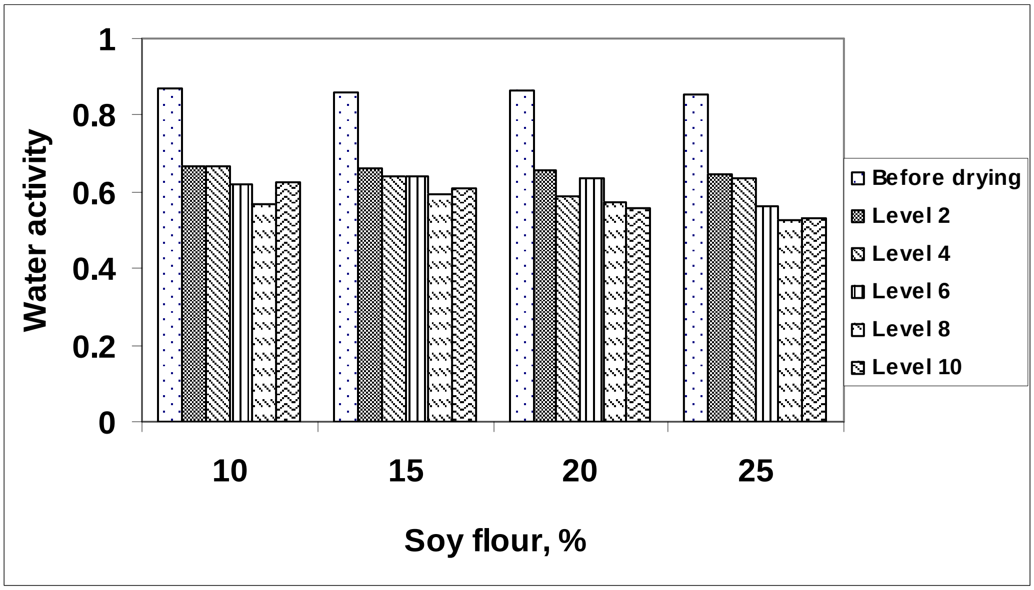
Table 2. Effect of different micro wave power level wave power level on surface colour mango fruit leather

S.No	MW power level	L	a	b
1	2	49.535^{D}	9.583^{C}	19.339^{D}
2	4	51.350^{C}	9.899^{BC}	22.923^{C}
3	6	51.866^{C}	10.318^{B}	24.217^{CB}
4	8	53.969^{B}	9.915^{BC}	24.370^{B}
5	10	56.549^{A}	11.320^{A}	30.270^{A}

From the Tables, It was observed that by increasing the soy flour concentration and microwave power level, the values for lightness and yellowness were increased. The increase in yellowness was due to the addition of soy flour and the increase in lightness was due to the microwave power level. Also at higher power level, the drying time was shorter and the change in colour was lower. Similar results were reported by Gujral and Khanna, (2002) for mango leather.

Water activity of the enriched fruit leather

Mean values of water activity of different concentration of soy flour enriched mango leather dried under different MW power levels are shown in Fig. 6. The mean values of water activity for 20 samples showed that the water activity of all the dried mango leather were within the safer limit (0.667-0.529). Because of the lower water activity, the dried mango leather is not readily prone to microbial spoilage and undesirable enzymatic reactions as reported by Yongsawatdigul and Gunasekaran, (1996).



Sensory evaluation

Statistical analysis for sensory evaluation revealed that there was no significant variation in the mango leather enriched with 10 and 15%. Also these samples scored significantly higher values in terms of colour, texture, flavour and taste when compared to the mango leather enriched with 20 and 25% soy flour. Also at the increased microwave power levels of 8 and 10, the sensory score was significantly lower (Tables 3 and 4). Similar results were reported by Nieto et al., (2001).

Table 3. Mean Value of Sensory Score of Enriched Mango Fruit Leather with DF Soy Flour

S.No	Soy concentration (%)	Mean
1	10	6.925^{A}
2	15	6.824^{A}
3	20	6.649^{B}
4	25	6.385^{C}

Table 4. Mean Value of Sensory Score of Enriched Mango Fruit Leather at Different MW

Power Level

S.No	MW power level	Mean
1	2	7.006 [A]
2	4	6.874 [AB]
3	6	6.750 [B]
4	8	6.372 [C]
5	10	6.477 [C]

Conclusion

The study revealed that the drying time was reduced from 200sec to 60 sec when the microwave power levels were increased from 2 to 10, corresponding to 4 to 20 W/g, respectively. The colour retention was higher at 20 and 25% soy flour enriched mango leather, dried at the higher microwave power levels of 8 and 10, respectively. The texture of the mango leather was significantly higher at 10 and 15%. Also the sensory evaluation showed that the soy flour enriched mango leather of 10 and 15%, dried at the microwave power level of 2 and 4 scored significantly higher values in terms of colour, texture, flavour and taste when compared to higher levels. Further studies are required at lower microwave power levels to determine the quality of the dried enriched mango fruit leather. Unfortunately decreasing the microwave power level may increase the drying time to unacceptable levels.

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