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Extraction and Evaluation of Tamarind Kernel Mucilage powder for Hydrocolloidal Properties

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***Abstract*— *Hydrocolloids are commonly used as dietary fibers, thickeners, gelling agents, emulsifiers, stabilizer, fat replacers, clarifying agents, flocculating agents, clouding agents and whipping agents. The development of applicable hydrocolloids from crops and food disposals allow the recovery, recycling and sustainability of high value-added ingredients in the food chain.*

Tamarind seeds are subjected to various methods (soaking, drying, parching) for removal of seed coat. Finally parching at 80c for 20min resulted in 72% seed coat removal. The kernels were then milled through 355µm mesh using hammer mill. TKM is isolated from powder by hydrating TKP and dried with spray dryer which yielded 40% of TKMP. Physical and bio chemical parameters are studied for the kernel powder and mucilage powder. Functional properties such as solubility, water holding capacity, oil holding capacity, swelling index, emulsifying ability and foaming capacity were analyzed.

Solubility, WHC, OHC increased with increase in temperature, foaming and emulsifying capacity increased with increased weight to volume ratio of mucilage powder. The efficiency of using TKMP as coating agent was studied by dipping potato wedges in different aqueous 0.5% solutions of CMC, xanthan gum and TKMP. The percent coat pick up of TKMP was recorded as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

Keywords*— *Tamarind seeds, hydrocolloids, TKP, TKM, TKMP, emulsifying ability, foaming capacity.

I. INTRODUCTION

Mucilage is mainly water soluble polysaccharide. Plant mucilage are most widely used as thickening agent, binding agent, suspending agent, emulsifying agent, stabilizing agent, gelling agent. They also possess characteristics of sustainable release in to the product when added. (Gandhi *et al*, 2012)

Mucilages extracted from seeds are sources of natural hydrocolloids with low-cost offering a low-calorie intake turning it in an ideal product for the development/improvement of health products with beneficial properties to human consumption, making them a potential option for application in the food.

Tamarind seed polysaccharide is a natural polysaccharide. Tamarind seed polysaccharide contains monomers of galactose, xylose and glucose sugars with each other by covalent bonds. Polymers are used present in a molar ratio of 3:1:2, which constitutes 65% of the seed components. Xylose is very crucial sugar of tamarind seed, which can be used for xylitol production, Tamarind seed polysaccharide is mainly water soluble polysaccharide. (Malviya *et al*, 2012)

The tamarind seed mucilage dispersed in water has the ability of forming viscous solutions, with high thermal and chemical stability, edible, biodegradable, non-carcinogenic, biocompatible and nontoxic properties (Sharma *et al.*, 2014). Tamarind mucilage contains high amount of many essential amino acids, like isoleucine, leucine, lysine, methionine, phenylalanine and valine (Panigrahi *et al.*, 1989), making the mucilage affordable as food additive.

Due to high water activity of mucilage (a_w >0.90) and carbohydrate composition, the shelf life is limited to hours at room temperature, so it is necessary to use a conservation process to preserve most of the active ingredients and increasing its life span. One of the most common technologies for this purpose is drying; particularly spray drying which allows the properties of the product such as color, flavor and nutrients to be retained in high percentages (León-Martínez *et al.*, 2010).

As tamarind seed is a byproduct from pulp industry and the hydrocolloids which are in food uses are expensive. So, an attempt was made to extract the mucilage from tamarind kernel. As the mucilage doesn't possess any shelf life properties it is spray dried to evaluate for hydrocolloid properties.

Therefore, the aim of the present study was to extract and evaluate the functional properties and physicochemical characteristics of tamarind seed mucilage powder with the following objectives:

a. Extraction of tamarind seed mucilage and spray drying
b. Evaluation of spray dried mucilage for its functional and physico chemical properties.

II. MATERIALS AND METHODS

Tamarind seeds were procured from the local markets of Bapatla. Physical properties like length, thickness are measured using vernier calipers. Density, Sphericity and number of seeds/100g were performed for both tamarind seeds and kernels. Tamarind seeds are subjected to various treatments for efficient seed coat removal (Fig 1)

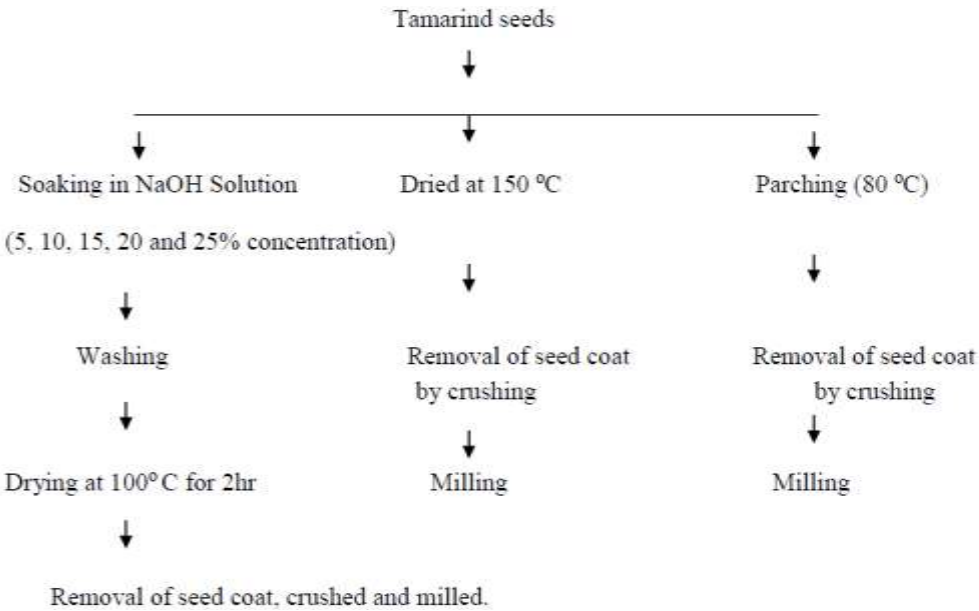

Fig 1: Flowchart of treatments for seed coat removal

Percent seed coat removal was calculated using the following formula

$$\%\ \text{removal of seed coat} = \frac{\text{Wt of the seeds taken} - \text{Wt of the seeds without seed coat}}{\text{Total weight of the seeds taken}} * 100$$

After every treatment tamarind seeds without seed coat were milled through 355 µm mesh by using hammer mill. The percentage of extraction yield of kernel powder was calculated by following equation,

$$\%\ \text{Extraction yield} = \frac{\text{Wt of the kernel powder}}{\text{Total weight of the seeds taken}} * 100$$

The moisture content of tamarind kernel seed powder was determined by air oven drying method by placing about 2 g of sample for 24 h in an air oven maintained at 103 ± 1 °C (AOAC, 2000). The moisture content (m.c.) on wet basis (w.b.) was calculated by using the following equation,

$$\text{Moisture content } (\%\text{w.b.}) = \frac{(w2 - w3)}{(w2 - w1)} * 100$$

where, w_1 = weight of empty box, g,
w_2 = weight of box + weight of sample, and
w_3 = weight of box + weight of bone dry material, g.

The protein content is measured by using Micro kjeldahl method, The Total Carbohydrate content can be measured by Phenol Sulphuric Acid method, The fat content of the samples is estimated by Soxhlet method. Swelling index of tamarind seed polysaccharide was determined by using the formula

$$\text{Swelling Index} = \frac{\text{Increase in the height of graduated cylinder}}{\text{Height at intial addition}}$$

Tamarind kernel Mucilage (TKM) extraction was done using the following procedure

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Tamarind Kernel Powder (TSP)

↓

TSP (20g) mixed with distilled water (1:10) and stirred (10min in hot plate stirrer)

↓

Constant stirring and addition of bi-distilled water (1:40) in relation with initial weight of seeds.

↓

Constant Heating (80°c for 60 min and kept for 24h at 20°c to assure release of mucilage)

↓

Centrifugation (for 8 min at 5500 rpm)

↓

Supernatant represents mucilage fraction which is decanted and stored at refrigeration temperature

Fig 2: Flowchart for extraction of TKM

Spray Drying: Spray drying of mucilage:

In general, fruits and vegetable juices are being spray dried after adjusting the total soluble solids (TSS) of the juices to 5% by incorporating maltodextrin. It increases the spray drying ability. It acts as an additive.

It was tried in the present study to decrease the addition of maltodextrin to increase the TSS level through trial and error experimentation and achieved spraying capability for tamarind kernel mucilage. The mucilage (100 mL) was spray dried with a laboratory scale spray dryer (LabPlant SD-05, England) with a concurrent air flow at different inlet drying air temperature 135 ± 5°c and the outlet temperature of 80 ± 5°c. The realistic values for spray dryer operational parameters were obtained from Lab Plant SD-05 manual.

Fig 3: Spray Dryer

The percentage of extraction yield of powder from mucilage after spray drying was calculated by following equation,

$$\%\ \text{Extraction yield} = \frac{\text{Wt of the mucilage powder}}{\text{Total weight of the mucilage taken}} * 100$$

Solubility:

Dispersions were prepared with 1.0 g of dry tamarind seed mucilage in 10 mL of bi distilled water at different conditions of temperature (15°, 25°, 45°, 55°, 65°, 75° and 85° C) for 30 min with continuous stirring at 400 rpm. The dispersions were then centrifuged with a cooling centrifuge for 15 min at 5500rpm. Supernatant were dried in a hot air oven at 100 C for 12 h.Percent solubility was calculated by following equation,

$$\%\ \text{solubility} = \frac{\text{Dried weight of supernatant}}{\text{Total weight of the sample taken}} * 100$$

Water holding capacity (WHC):

The WHC and OHC were evaluated at different conditions of temperature (15°, 25°, 45°, 55°, 65°, 75° and 85° C). For WHC, dispersions of 1% (w/v) of mucilage powder were prepared and placed in centrifuge tubes previously weighted containing a magnetic stirrer. Put in an agitation water bath for 30 min at the prescribed temperature. Then, the dispersions were centrifuged for 15 min at 5500 rpm. The supernatant was decanted, and the sample was reweighed.

$$\text{WHC g/g} = \frac{\text{Dried weight of supernatant}}{\text{Total weight of the sample taken}}$$

3.7.3. Oil holding capacity (OHC)

For the OHC at 15°, 25°, 45°, 55°, 65°, 75° and 85° C at 1% dilution of powder mucilage with corn oil (w/v) was prepared in a previously weighted centrifuge tube containing a magnetic stirrer. And put in an agitation water bath for 30 min at the prescribed temperature. The dilution was centrifuged the supernatant was decanted and the swollen granules were weighted.

$$\text{OHC g/g} = \frac{\text{Weight of oil absorbed sample}}{\text{Total weight of the sample taken}}$$

Emulsifying ability

Homogenized mixtures prepared (0.2, 0.4, 0.6, 0.8 and 1.0 %) from mucilage powder and 10 mL corn oil were homogenized at 6400 rpm. The homogenized mixture was centrifuged at 5500 rpm for 10 minutes.

$$\text{Emulsifying ability} = \frac{\text{Emulsion volume}}{\text{Total volume}} * 100$$

Foaming capacity

Mucilage powder dispersions (0.2, 0.4, 0.6, 0.8 and 1.0 %) were prepared and whipped. Foaming capacity of the powder was calculated by the following equation

$$\text{Emulsifying ability} = \frac{\text{Foam volume}}{\text{Total suspension volume}} * 100$$

Percent coat pick up and frying yield

The percent coat pick up was calculated after dipping the sample (Potato wedges) in various prepared hydro colloidal solutions for 1 minute. Percent coat pick by the sample was calculated by the following equation

$$\text{Percent coat pick up} = \frac{\text{Wt of sample after dipping} - \text{Wt before dipping}}{\text{Intial weight of the sample before dipping}} * 100$$

Frying yield

Frying yield of the sample treated with different hydrocolloids after tray drying at 80^0 C for 25min was calculated by deep fat frying the sample in edible oil at 180^0 C for 1 minute.

$$\text{Frying yield} = \frac{\text{Weight of the sample after frying}}{\text{Intial weight of the sampletaken for frying}} * 100$$

III. RESULTS AND DISCUSSION

Table.1: Physical properties of seeds and Kernel

Properties	Tamarind seeds	Tamarind kernel
Length	15.04mm	14.25mm
Thickness	6.41mm	5.26mm
Density	$1.43g/cc^3$	$1.12g/cc^3$
Sphericity	0.74	0.72
No of seeds/100g	32	25

As the seed coat is removed all the physical property values are less for kernel. The percentage of seed coat is 20% and the kernel which is also called as endosperm is about 80% weight of the total seed weight.

Among all the combinations of the treatments parching for 22 min resulted in higher percentage of seed coat removal (72%) when compared with other treatments. 25% concentration of soaking in NaoH resulted higher percentage in seed coat removal (25%). 30% concentration of NaoH resulted in leaching of mucilage and also more absorption of moisture which resulted in higher drying time. Among drying samples, drying for 75 min resulted in 52% of removal of seed coat. More prolonged time of drying resulted in increase of volume of tamarind seeds and explosion of the seeds have been observed.

Parching for 25 min still resulted for higher percentage (76%), but the color of the kernel inside has been changed to dark brown due to the effect of temperature charring and dextrinisation. So, comparing between combinations of all the treatments parching for 22 min i.e., 72% removal of seed coat was considered as best option. After parching, tamarind seeds are crushed to remove the seed coat and were milled through 355 µm mesh by using hammer mill. 78.84% kernel powder was obtained after milling.

Fig.4: Tamarind Kernels and Powder

Table.2: Parameters of Tamarind Kernel Powder (TKP)

Properties/parameters	Readings
Bulk density	0.508g/cc
Tap density	0.526g/cc
Carr's index	3.422
Moisture content	2%
Protein	20.02g/100g
Total Carbohydrates	74.50g/100g
Fat	20g/100g

Protein content in kernel powder is about 20.02g/100g which is higher than the protein content of wheat flour. The protein content of the tamarind kernel powder has nutritional significance, and as such intake of the powder by substitution or replacement in different product formulations will greatly increase the total dietary intake of consumers. Total carbohydrates present in kernel powder (74.50g) are almost close to the carbohydrate values of other starchy grains/seeds. Due to its higher carbohydrate content and higher fat content

(20g/100g) it can be used as mucoadhesive and also as thickening agent in different food products.

The swelling index of the TKP is 2.75.Water retention capacity was found to be 5mL/g of the sample. This was attributed due to the presence of good protein content along with the polysaccharides.

Extraction of Tamarind Kernel Mucilage (TKM):

Table.3: Combination of kernel powder to water ratio for mucilage extraction

Seed powder water ratio used for stirring	Amount of water addition for heating	Total seed powder : water ratio	Mucilage remained after condensing, mL
20g:50mL (1:2.5)	800mL (1:40)	1:42.5	170 mL
20g:100mL (1:5)	800mL (1:40)	1:45	200 mL
20g:150mL (1:7.5)	800mL (1:40)	1:47.5	220 mL
20g:200mL (1:10)	800mL (1:40)	1:50	250. mL

Among all the combinations used for extraction of mucilage from TKP 1:50 (Total seed: Water) ration found to be effective and the mucilage leached into water is about 250mL after condensation. About 250 ml of TSM is subjected to spray drying by adding 1% of malto dextrin with an Inlet temperature: 135 ± 5°c, Outlet temperature: 80 ± 5°c and Pressure of compressed air: 4 bar. The extraction yield after spray drying is 40% (8g of TSMP).

Table.4: Physical and bio chemical Parameters of TKMP

Parameters	Readings
Bulk density	**0.367g/cc**
Tap density	**0.372g/cc**
Carr's index	**2.4**
Moisture content	**2%**
Protein	**14.78±0.45%**
Total CHO	**69.76±0.72%**
Fat	**4.76±0.36%**
Ash	**0.702±0.12%**

Results presented in table 4 of various parameters of Tamarind Seed Mucilage Powder. As the difference between bulk and tapped density values are close which indicates that the powder has lesser inter particle interactions. Carr index value of the TSMP is 2.4 indicates that the powder has good flow ability. The Carr's index of TSMP is lesser than TKP.

Functional properties of mucilage powder

Solubility of tamarind seed mucilage particles showed that the solubility increased with increase in temperature. There was a drastic increase in the solubility percent till a temperature of 45^0 C (76.4 ± 0.31%), from this point for every 10^0 C raise in the temperature the increase in the solubility percent was minimum. Heating above 75^0 C (88.14 ± 0.50%) showed solidifying effect due to high temperature and this type of insolubility might be due to the removal of water of imbibitions from the protein particles, since such an explanation would account for the effect of hot water in restoring the solubility of the protein.

Water holding capacity (WHC) is an important property in food technology from a viewpoint of stability, yield, texture and sensory evaluation. WHC represents the amount of water held and absorbed by the hydrated sample afterward an external force is applied. WHC for tamarind seed mucilage particles is showed in Table 4.7, this value increased as temperature was increased. This may be explained because an increment on temperature results in an increment on molecular mobility of molecules promoting the water absorption till 65^0 C (0.6 ± 0.024g/g). Decreasing trend was observed after increasing of temperature above 65^0 C. At the temperature of 75^0 C the WHC recorded was 0.54 ± 0.056g/g.

As the temperature increased OHC of the TSMP has increased till 65^0 C (4.0 ± 0.04g/g) and OHC showed a decline trend when further heated to 75^0 C (3.33 ± 0.07g/g). Similar values of OHC were observed in durian seed gum (Amid and Mirhosseini, 2012) in guar and xanthan gum (Segura-Campos et al., 2014). These values of OHC shows that tamarind seed mucilage powder could play an important role in food processing, since fat acts on flavor retainers and increases the mouth feel of foods.

Emulsifying ability increased when the weight of spray dried tamarind seed mucilage/volume of oil ratio was increased. This fact can be explained from the increase in the fraction of mucilage and a subsequent increase of the chains of the branched structure among the surface active to absorb oil molecules that lower the surface tension. TSMP's emulsifying ability was done using 0.2, 0.4, 0.6, 0.8 and 1% concentrations of powder.

Highest emulsifying ability was recorded at 1% concentration (92.4±0.005%).

Good foaming properties are linked with flexible mucilage structure that can reduce surface tension. This effect is attributed to the increased amount of mucilage, which is transported to the interface to form visco elastic films that improve the foam formation. As the concentration increased foaming capacity also increased. Highest foaming capacity was recorded at 1% concentration (3.70±0.04%).

Among all the treatments sample treated with xanthan gum has the highest coat pick up (34%), this is due to the viscosity of the xanthan gum is more among the three treatments at particular concentration. The percent coat pick up of TKMP was recorder as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). Highest yield was observed in potato wedges dipped in xanthan gum solution (75.6%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

IV. SUMMARY AND CONCLUSIONS

Carr index value of the TSMP is 2.4 indicates that the powder has good flowability. The Carr's index of TSMP is lesser than TKP.

There was a drastic increase in the solubility percent till a temperature of 45^0 C (76.4 ± 0.31%), from this point for every 10^0 C raise in the temperature the increase in the solubility percent was minimum. Decreasing trend was observed after increasing of temperature above 65^0 C. At the temperature of 75^0 C the WHC recorded was 0.54 ± 0.056g/g. As the temperature increased OHC of the TSMP has increased till 65^0 C (4.0 ± 0.04g/g) TSMP's emulsifying ability was done using 0.2, 0.4, 0.6, 0.8 and 1% concentrations of powder. Highest emulsifying ability was recorded at 1% concentration (92.4±0.005%). Highest foaming capacity was recorded at 1% concentration (3.70±0.04%).The percent coat pick up of TKMP was recorder as 6% which is higher than CMC. The percent frying yield of potato wedges dipped in TKMP solutions recorded 68.4% which is higher than the potato wedge dipped in CMC solution (60.97%). These results show that TKMP can be effectively used as coating material for increasing frying yield of the samples.

Apart from coating agent TKMP can also be considered as effective stabilizing, emulsifying and foaming agents in food formulations instead of artificial (synthetic) extracted sources.

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