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Effect of Hydrocolloids Coating on Fat Uptake Reduction of Tapioca Sago Chips

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Abstract—*In this study the performance of different hydrocolloids (carboxy methyl cellulose, guar gum, gum tragacanth and methyl cellulose) during deep fat frying of tapioca sago chips were investigated. Maximum fat uptake reduction was observed 61.46 %, 58.65 % and 48.54 % in 1.5 % carboxy methyl cellulose, 2 % guar gum and 1.5 % guar gum containing tapioca sago chips, respectively. Texture analysis by penetration test showed that 2 % gum tragacanth coated chips was crisper among all other sample. Colour values (L, a and b) were investigated by Hunter color lab and best colour values were observed for all concentrations (1 %, 1.5%, 2%) of gum tragacanth coated chips. All gum tragacanth coated (1 %, 1.5%, 2%) chips were also found best in sensory scores.*

1. INTRODUCTION

Tapioca sago is commonly known as sabudana in Hindi or javvarishi in tamil, saggubiyyam in telugu in India. The word Tapioca and 'Tapioca Root (Cassava)'has different meanings. "Tapioca" is a product being extracted from cassava root. In India, the term "Tapioca-Root" is used to represent the tuber of cassava and word 'Tapioca' represents for derived starch from cassava roasted in a particular shape. This is a well known crop that is recognized by several names in the various regions where it is consumed. It is known as yuca, rumu or manioca in Latin America, manioc in French-speaking Africa and Madagascar, cassava in English-speaking Africa, mandioca or aipim in Brazil, tapioca in India and Malaysia, and bi ketella or kaspe in Indonesia. In the Indian culture Tapioca Sago is considered a non grain and hence consumed on fasting days. Indian traditional snacks are now being polular due to their unique taste, texture and color of the foods. Tapioca sago chips is good example of deep fat fried Indian traditional snacks.

Deep-fat frying is one of the oldest methods of food preparation for more than 3000 years [17].

Although deep fat frying looks very simple process but it involves very complex phenomenon. Food is fully immersed in hot cooking oil. Simultaneous heat and mass transfer takes place during deep fat frying. Hot oil (170-210° C) act as heat transfer medium. Product Moisture evaporation is takes place and pores are formed [4]. These pores are filled by oils. High moisture product losses their weight after deep fat frying. Deep fat frying gives flavor and texture to the final product. Deep fat frying changes nutritional, chemical and physical properties of food product. Protein denaturation, starch gelatinization, water vaporization and crust formation occurs due to deep fat frying [7, 9, 11].

Deep frying is classified as a dry cooking method because no water is used. Due to the high temperature involved and the high heat conduction of oil, it cooks food extremely quickly. The correct frying temperature depends on the thickness and type of food, but in most cases it lies between 175–190 °C (347–374 °F). Deep fat frying absorbs large amount of oil. High fat food products are cause of high blood cholesterol level and pressure, and as a consequence of the increased incidence of both obesity and coronary heart diseases [1, 3, 15]. Due to awareness of people towards healthier food product, this is need to reduced fat content in food. Hydrocolloids or food gums may play an important role in reducing fat.

Hydrocolloids may be defined as hydrophilic polymers. Hydrocolloids are water-soluble polymers, able to make viscosity and gelate aqueous system retaining water in food systems. Food hydrocolloids are able to form colloidal system. Hydrocolloids increase viscosity that is why they are widely used as gelling, thickening agents. Hydrocolloids play an important role in fried food by forming a fine coating, which is able to prevent excessive oil absorption during the frying process. They are developing interest also as food coatings for barrier properties to gas/moisture, and their satisfying mechanical feature [6]. Hydrocolloids are very hydrophilic in nature so they bind water or moisture. Hydrocolloids also extend shelf life to the fried food product and reduced fat uptake [8].

Texture is important parameter for the fried food. Texture is affected by frying time, oil temperature, moisture content, starch and most important by addition of hydrocolloids. Texture becomes a focal point for criticism and rejection of the food. The release of flavour is intimately related to the way in which the food structure breaks down in the mouth, and consequently to both the initial texture of the food and the change in texture throughout mastication.

The objectives of this study was to investigate the effect of coating with different hydrocolloids such as carboxy methyl cellulose (CMC), guar gum (GG), gum tragacanth (GT) and methyl cellulose (MC) on oil uptake, textural attributes and colour attributes of tapioca sago chips.

2. MATERIAL AND METHODS

The study was carried out in the Department of Food Processing and Technology, School of Vocational Studies and Applied Sciences, Gautam Buddha University, Greater Noida. Tapioca sago used in the experiment was procured from local market of Greater Noida, U.P, India. Carboxymethyl cellulose was provided by Titan Biotech Ltd., Bhiwadi, Rajasthan India. Methyl cellulose was provided by Central Drug House (P) Ltd. Daryaganj, New Delhi, India. Guar gum and Gum tragacanth were provided by Himedia Laboratories Pvt. Ltd Mumbai India.

2.1 Preparation of Hydrocolloids solution

Different concentrations of CMC and GG (1%, 1.5%, 2%) were dissolved slowly in 100 ml slightly warm distill water. These solutions were placed on hot plate for 15 min at 55°C [18]. Tapioca sago chips were dipped in solution for 10 min and were dried at 40°C for 8 hours in tray dryer. Different concentration of MC (1%,1.5%,2%) were dissolved slowly in 33% hot water (>70 °C), then 65% cold water was added, MC solution was thickened with the addition of cold water and with time [18]. Tapioca sago chips were dipped in solutions for 10 minutes and were dried at 40°C for 8 hours in tray dryer. Different concentration of gum tragacanth (1%, 1.5%, 2%) were dissolved slowly in 100 ml hot water (> 65°C).Tapioca sago chips were dipped in solution for 10 min and was dried at 40°C for 8 hours in tray dryer.

2.2 Preparation of Tapioca sago chips for analysis

Tapioca sago balls
↓
Soaking (4 hours)
↓
Cooking (continuous stirring)
↓
Thick slurry
↓
Pouring mixture in round shape
↓
Drying (18 hours, 50-55°C)
↓
Dipping tapioca sago chips in different hydrocolloids Solution (10 min)
↓
Drying (8 hours, 40°C)
↓
Deep fat frying of tapioca sago chips
↓
Stored tapioca sago chips

Fig 3.3: Preparation of tapioca sago chips

2.3 Analytical methods

The moisture content of the tapioca sagochips was determined by drying the samples in a hot air oven at 105°C until constant mass weight. The moisture content was calculated from the difference in weight determined before and after drying. The fat content of the tapioca sago chips was determined by extraction with petroleum ether using a Soxhlet extraction unit [12].

Percentage oil reduction in tapioca sago chips was calculated as the weight difference between coated and non coated oven-dried samples before and after the extraction procedure. The texture of fried tapioca sago chips was determined using TA-XT plus texture analyzer, stable micro systems (U.K.).

Penetration test was done for measuring textural attributes. For the colour determination, a portable Hunter lab colorimeter (Hunter lab, Reston, USA) was used, which gave L, *a* and b values. All analyses were carried out in triplicate. The chroma, hue and total color difference (ΔE) was calculated from the Hunter L, *a*, b values.

Oil reduction due to coating (%)

$$= \frac{(\text{Oil, non coated sample}) - (\text{Oil, coated sample})}{(\text{Oil, non coated sample})} \times 100$$

$$Chroma = \sqrt{\left(a^2 + b^2\right)}$$

$$Hue\ \ angle = \tan^{-1}\left(\frac{b}{a}\right)$$

$$\Delta E = [(L - L\ \text{standard})^2 + (a - a\ \text{standard})^2 + (b - b\ \text{standard})^2]^{1/2}$$

2.4 Statistical analysis

All the experiments of the present study were performed in triplicate and mean values were calculated. Analysis of variance (ANOVA) was done. Differences between treatments at the 5% ($p \leq 0.05$) level were considered significant.

3. RESULTS AND DISCUSSION

3.1 Effect of hydrocolloids on oil uptake reduction of Tapioca sago chips

Product moisture, oil uptake and oil uptake reduction results are shown in Table 1, 2 & 3 respectively. The analysis of variance (ANOVA) results for each characteristic are also shown in same tables. All the concentrations of carboxymethyl cellulose were able to retain higher moisture than control and all other hydrocolloid coated samples. Crude fat of control tapioca sago chips was found about 35 %, while after coating, oil uptake in tapioca sago chips was found reduced to a significant extent in different hydrocolloids. Maximum oil uptake reduction of tapioca sago chips was found upto 61.46 %, 58.65 %, 47.74 % and 19.35% in 1.5 % CMC, 2% GG, 2% GT and 2% MC coated samples respectively. Sakhale (2011) also reported 48.85% & 43.72% reduction in oil uptake in casing of samosa with CMC and guar gum at 1.5% level, which is in agreement with our results [14]. This could have been due to formation of film of hydrocolloids on the product which might have decreased the tendency of the product to absorb the oil and lose moisture [2].

Table 1: Effect of carboxymethyl cellulose, methyl cellulose, guar gum and gum tragacanth on product moisture of tapioca sago chips

	Product Moisture* (wb) %			
Control Sample	5.9			
Experimental Samples	CMC	GG	GT	MC
Level of HC1%	6.67	6.29	4	2
Level of HC1.5%	10	7.4	2.55	3.3
Level of HC2%	7.47	8.63	2.6	4.33
ANOVA (Row)	Significant F(Calculated) = 5.29 > F (Critical) = 3.4, $p< 0.05$			
ANOVA (Column)	Significant F (Calculated) = 77.62 > F (Critical) = 3.0, $p< 0.05$			
ANOVA (Interaction)	Significant F (Calculated) = 5.99 > F (Critical) = 2.5, $p< 0.05$			

*Mean of three replications

Table 2: Effect of carboxymethyl cellulose, methyl cellulose, guar gum and gum tragacanth on oil uptake of tapioca sago chips

	Oil uptake* (Kg oil/kg dry solids)			
Control Sample	0.3638			
Experimental Samples	**CMC**	**GG**	**GT**	**MC**
Level of HC1%	0.1994	0.2292	0.2532	0.3262
Level of HC1.5%	0.1402	0.1872	0.2030	0.3050
Level of HC2%	0.1922	0.1504	0.1901	0.2934
ANOVA (Row)	Significant F (Calculated) = 30.99 >F (Critical) = 3.40, $p< 0.05$			
ANOVA (Column)	Significant F (Calculated) = 124.81 > F (Critical) = 3.008787, $p< 0.05$			
ANOVA (Interaction)	Significant F (Calculated) = 5.36 > F (Critical) = 2.50, $p< 0.05$			

*Mean of three replications

Table 3: Effect of carboxymethyl cellulose, methyl cellulose, guar gum and gum tragacanth on oil uptake reduction of tapioca sago chips

	Reduction in Oil Uptake (%)			
Experimental Samples	**CMC**	**GG**	**GT**	**MC**
1% HC	45.18	36.99	30.40	10.33
1.5% HC	61.46	48.54	44.20	16.16
2% HC	47.16	58.65	47.74	19.35

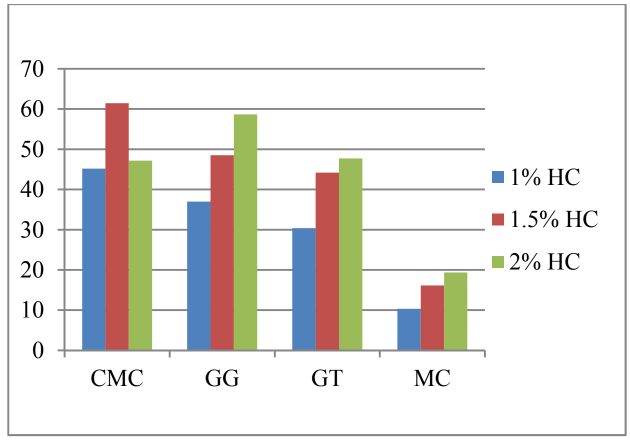

Fig. 1: Comparative analysis of oil uptake reduction in tapioca sago chips due to coating of hydrocolloids

3.2 Effect of hydrocolloids on textural attributes of tapioca sago chips

The effect of levels of various hydrocolloids on textural attribute of tapioca sago chips was investigated and the data obtained are also presented in Table 4. Hardness (Crispiness) of all hydrocolloid added samples were observed less than control sample except 1.5% GG (10449.28). Lowest hardness value of tapioca sago chips was found upto 4430.97, 4470.11, 2936.178 and 2479.87 in 1.5% CMC, 2% GG, 2% GT and 2% MC added samples. Thus 2% methylcellulose added tapioca sago chips was found the most fracturable and crispy among all hydrocolloid containing samples. The firm characteristics of the coated samples can be attributed to the formation of rigid cross-linked network that increases middle lamella cell wall rigidity and forms a resistant film on the surface of the sample [5]. Some studies have shown that the final texture of the fried product is slightly dependent on its composition [10, 13].

Table 4: Effect of hydrocolloids on textural attributes (Hardness) of Tapioca Sago Chips

	Hardness* (g)			
Control Sample	**8056.32**			
Experimental Samples	**CMC**	**GG**	**GT**	**MC**
Level of HC 1%	7535.21	5244.92	3964.01	4914.3
Level of HC 1.5%	4430.97	10449.28	3527.97	4312.26
Level of HC 2%	7089.55	4470.11	2936.17	2479.87
ANOVA (Row)	Significant F (Calculated) = 15.78 > F (Critical) = 3.40, $p < 0.05$			

ANOVA (Column)	Significant F (Calculated) = 55.87 > F (Critical) = 3.0, p < 0.05
ANOVA (Interaction)	Significant F (Calculated) = 29.12 > F(Critical) = 2.50, p< 0.05

*Mean of three replications

3.3 Effect of hydrocolloids on colour attributes of tapioca sago chips

The effect of hydrocolloids on colour quality of tapioca sago chips is given in Table 5. The L, a and b value of control sample was 90.10, 0.54 and 8.10. It was observed that Yellowness and lightness of all CMC coated samples were not significantly different but 1.5 % CMC coated samples was found significantly different in redness values of CMC coated samples. 1% methylcellulose coated sample had higher lightness and 1.5 % methylcellulose coated sample exhibited high redness and yellowness than other methylcellulose coated samples. It was also observed that higher yellowness and redness among all samples of gum tragacanth and guar gum were not significantly different.

4. CONCLUSION

In present study the effect of different hydrocolloids (carboxymethyl cellulose, guar gum, gum tragacanth and methylcellulose) were studied in terms of oil uptake reduction, textural attributes and color value of tapioca sago chips. Fat uptake reduction of tapioca sago chips was highest in 1.5 % carboxymethyl cellulose (61.46 %). 2 % guar gum also showed significant fat replacer property as it reduced fat uptake upto the 58.65%. 2 % gum tragacanth coated sample was concluded best based on their textural properties, as it provided highest crispness (lowest in hardness) among all other samples. Color analysis showed that gum tragacanth coated sample was very much similar to the control sample. All concentrations of gum tragacanth found to be best in sensory test due to high crispness and low hardness.

It was concluded that 2 % gum tragacanth coated tapioca sago chips was best in overall parameters because it provided lowest hardness, good color value and also reduced fat uptake upto the 47.74 %.

Table 5: Effect of hydrocolloids on colour value of Tapioca sago chips

	L Value*				a Value*				b Value*			
Control Sample	**90.10**				**0.54**				**8.10**			
Experimental Samples	**CMC**	**GG**	**GT**	**MC**	**CMC**	**GG**	**GT**	**MC**	**CMC**	**GG**	**GT**	**MC**
Level of HC1%	74.21	79.89	85.48	91.35	0.99	1.08	1.75	0.35	14.10	11.13	9.99	7.88
Level of HC1.5%	69.10	80.61	85.54	77.24	3.12	0.97	1.83	2.76	16.25	12.11	10.81	21.56
Level of HC2%	72.58	72.34	85.82	85.58	0.71	1.80	2.45	0.62	10.01	13.58	11.74	8.93
ANOVA (Row)	Significant F(Calculated) = 46.40 > F (Critical) = 3.40, p< 0.05				Significant F (Calculated) = 350.49 > F (Critical) = 3.40, p< 0.05				Significant F(Calculated) = 127.61 > F (Critical) = 3.4, p<0.05			
ANOVA (Column)	Significant F (Calculated) = 243.31 > F (Critical) = 3.0, p< 0.05				Significant F (Calculated) = 99.76 > F (Critical) = 3.0, p< 0.05				Significant F (Calculated) = 19.32 > F (Critical) = 3.0, p< 0.05			
ANOVA (Interaction)	Significant F (Calculated) = 35.62 > F (Critical) = 2.50, p< 0.05				Significant F (Calculated) = 219.89 > F (Critical) = 2.50, p< 0.05				Significant F (Calculated) = 80.54 > F (Critical) = 2.5, p< 0.05			

*Mean of three replications

Table 6: Effect of hydrocolloids on colour value (hue angle, chroma, total colour difference) of tapioca sago chips

	Hue angle Tan-1(b/a)				Chroma √a2+b2				Total colour Difference (ΔE)			
Control Sample	86.05				8.12				6.8920			
Experimental Samples	**CMC**	**GG**	**GT**	**MC**	**CMC**	**GG**	**GT**	**MC**	**CMC**	**GG**	**GT**	**MC**
Level of HC1%	86.00	84.45	80.06	87.46	14.17	11.18	10.14	7.89	23.74	17.49	11.89	5.60
Level of HC1.5%	78.83	85.42	80.39	82.70	16.56	12.14	10.96	21.73	29.41	17.03	12.06	24.50
Level of HC2%	85.94	82.45	78.21	86.02	10.03	13.70	11.99	8.95	24.49	25.44	12.22	11.47

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