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Optimization of the Level of Tapioca Starch in Chicken Meat Caruncles

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ABSTRACT

The present study was conducted to optimize the level of tapioca starch for the development of chicken meat caruncles (CMC). Three different levels of tapioca starch replacing - 50% (T-1), 60% (T-2) and 70% (T-3) of refined wheat flour, were undertaken along with control (100% refined wheat flour) for this study. All the variants were assayed for physico-chemical, proximate composition, texture profile, colour profile and sensory attributes. The cooking yield (%) was significantly higher ($P<0.05$) in T-2 than control group. Hydratability of T-3 sample was significantly lower ($P<0.05$) than control and T-1. Water absorption index of control samples was significantly lower ($P<0.05$) than the treated samples. The fat (%) of T-1 was significantly higher ($P<0.05$) than T-2 and T-3. Crude fiber (%) was found to be significantly lower ($P<0.05$) in T-1 than T-2 and T-3 samples. Hardness of T-2 was significantly higher ($P<0.05$) than control. There was no significant variation between adhesive force and stringiness of control, T-1, T-2 and T-3 samples. In colour profile, the L^* and a^* value of control was significantly lower ($P<0.05$) than T-1, T-2 and T-3 samples. Among the sensory attributes colour, flavour, crispiness, after-taste and meat flavour intensity were non-significant between control and treated batches. Overall acceptability was significantly higher ($P<0.01$) at 60% tapioca starch replacement level (T-2) as compared to others. On the basis of sensory quality, 60% incorporation of tapioca starch in place of refined wheat flour was adjudged as optimum in chicken meat caruncles.

***Key Words** : Chicken meat caruncles, Tapioca starch, Spent hen meat, Physico-chemical parameters, Sensory attributes*

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INTRODUCTION

Snacks have become a rapid food solution for consumers. Snack food industry is growing in a very fast pace from the last one decade. The key factors for this may be the higher standard of living and educational status, higher purchasing capacity of the employed community, increased awareness on requirement of nutritious food, increasing participation of women in the work force, lack of time due to job and recreational activities, growing number of single person family and small households, lack of skill, experience and facilities in preparing meals at home, migration of people to urban areas for job, students and other people at work taking packed meals and increasing catering establishments etc. The world's snack food market including semi-processed/cooked and ready to eat foods was valued at Rs 82.9 billion in 2004-05 and is increasing with a growth rate of 20%. However, in India snack food market has reached a value of Rs. 1530 crores and is expected to grow at 9 to 12% during the tenth five-year plan (Singh *et al*. 2013a). Cereal snacks usually lack some essential amino acids like threonine, lysine and tryptophan (Chaiyakul *et al*. 2009), so incorporation of spent hen meat enhances their nutritional value and improves sensory attributes (Singh *et al*. 2012). Moreover snacks are less perishable, more durable, more appealing and shelf-stable in nature (Singh *et al*. 2013b).

These days, consumers are more health conscious than before and they need healthy, natural, quality, safe and convenient food with pleasant appearance, texture, odour and taste (Tanuja *et al.* 2014). In meat based snacks, tapioca starch is used to improve the cooking yield, binding, hardness, expansion rate, bulk density, texture and sensory characteristics such as colour, flavour, taste and crispiness etc (Ibanoglu *et al.* 2006; Ravindran and Hardacre 2010). Tapioca starch is a white fluffy powder which is extracted from the roots of *Manihotesculenta*. It is used as a thickening and stabilizing agent in soups, puddings, breads, sauces, soy and meat products. It becomes clear and gel-like when cooked and dissolves when used as a thickener. Also it can withstand prolonged cooking times without breaking down affecting the sensory attributes (Singh 2011). In meats, tapioca starch added at the chopping stage swells during heating and binds in poultry rolls and meat loaves as well as other cooked meats. The final texture will be firm and retained for prolonged periods. Starch may reduce drip during smoking of meats and weeping of vacuum packed foods (Anonymous 2013). Tapioca starch can improve flavour and flavour release, increase moisture retention as well as reduce cooking losses (Knight and Perkin 1991; McAuley and Mawson 1994). There is limited availability of literature on the use of tapioca starch in chicken snacks. Kong *et al.* (2008) used 3% tapioca starch for the development of value-added jerky-style fish meat snacks from salmon. Suknark *et al.* (1999) also developed tapioca-fish snacks by twin screw extrusion. In lieu of that, the present study was envisaged to optimize the level

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of tapioca starch for the development of shelf-stable, ready-to-eat chicken meat caruncles (CMC).

MATERIALS AND METHODS

Tapioca starch:Tapioca starch (TS) was procured from Shubham Starch Chemical Pvt. Limited, Faridabad, Haryana. The technical specifications and composition details of the tapioca starch are given in Table 1.

Spice mix:Spice mix was prepared by grinding dried (45±2ºC for 2 hours) ingredients as per the formulation - coriander 15%, cumin seeds 15%, caraway seeds 10%, aniseed 10%, black pepper 10%, red chilli powder 8%, dry ginger powder 8%, cinnamon 5%, clove 5%, cardamom large 5%, mace 5%, nutmeg 2% and cardamom small 2%, to a fine ground powder using Inalsa mixer (Inalsa Maxie plus, 07120219, Inalsa Technologies, New Delhi, India) and sieved through a fine mesh.

Preparation of minced chicken meat:The white Leghorn layer spent hens were slaughtered as per standard procedure in the experimental slaughter house of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana. After manual deboning, the meat chunks were tenderized by dipping in a solution containing 0.25% papain (w/w) and 0.15 M calcium chloride (w/v) for about 36-40 hours at 4±1°C *et al.* 2009). Thereafter the meat chunks were washed thoroughly 2-3 times with running water and then packed in low density polyethylene (LDPE) bags and kept at -18±1°C for subsequent use. Frozen tenderized chicken meat was taken out as per requirement and cut into smaller cubes after partial thawing in a refrigerator (4±1°C). The meat chunks were then double minced using 6 mm and 4 mm grinder plates (KL-32, Kalsi, Ludhiana, India) to get finely minced chicken meat.

Preparation of chicken meat caruncles:Preliminary trials were conducted for the selection of three levels of tapioca starch by replacing refined wheat flour and on the basis of physico-chemical and sensory attributes, it was found that three levels of tapioca starch viz. 50%, 60% and 70% of refined wheat flour were most suitable for development of chicken meat caruncles. In the present study, tenderized minced chicken meat was blended with common salt (TATA salt, Tata chemicals Ltd. Mumbai) and mixed in Inalsa mixer for 1 min, followed by mixing of sugar, baking powder (Ajanta Baking powder, Ajanta Food Products Co., Solan, India; Code No. 288668), carboxymethyl cellulose (S d fine-CHEM Ltd., Mumbai, India; Code No. 56095) and spice mix, up to 30 sec in the mixer. Then refined wheat flour (RWF) and tapioca starch were added and again mixed for 1-2 min. At last, refined oil (FORTUNE Soyabean oil) was added slowly by the side of the mixer and mixing was done for another 1 min. The chicken meat emulsion was prepared in four batches as per the formulation mentioned in Table 2. Finally four different variants were prepared viz. control (100% refined wheat flour), T-1 (50% tapioca starch), T-2 (60% tapioca starch) and T-3 (70% tapioca starch). Thereafter, with the help of a manually operated stainless steel extruder, the prepared chicken meat emulsion was extruded in the form of thin long chip like caruncles (7-8cm × 1 cm) in a microwave plate. Cooking was done in a microwave oven (Inalsa microwave ovens, New Delhi, India) for 4 min to get the cooked CMC. The cooked CMC were kept in Pearl Polyethylene Terepthalate (PET) jars and thereafter analyzed for different physico-chemical properties, texture, colour and sensory properties.

Table 1 :Technical and composition details of tapioca starch

Appearance	White Powder
Moisture (%)	13 to 14
Ash (%)	0.3 to 0.4
Soluble	0.7
pH of 10% solution	5 to 7
Acidity for 5gms using NaOH	1.00 ml.
Mesh size-pass through 100 Mesh %	99.80
Pass through 200 Mesh %	97.00
Protein %	0.3
Fibres	0.05 to 0.10
Iron ppm	30 to 40

Table 2 : Formulation used to prepare chicken meat caruncles

Ingredients (%)	Control	T-1	T-2	T-3
Chicken meat	65	65	65	65
Refined wheat flour (Maida)	35	17.50	14.00	10.50
Tapioca starch	0	17.50	21.00	24.50
Refined oil	5	5	5	5
Spice mix	2	2	2	2
Salt	1	1	1	1
Sugar	1	1	1	1
Carboxy methyl cellulose	0.7	0.7	0.7	0.7
Baking powder	0.5	0.5	0.5	0.5

Chemical analysis

Physico-chemical parameters

Emulsion stability: Emulsion stability was determined as per the procedure of Baliga and Madaiah (1970). About 20 gm of raw emulsion was weighed and taken into a LDPE bag and sealed tightly without any air pocket inside. The bag was placed in a thermostatically controlled water bath (Model: NSW 125) at 80±1°C for 20 min. It was then taken out, drained and weighed.

Emulsion stability (%) = (weight of cooked emulsion / weight of raw emulsion) × 100

Cooking yield: Cooking yield (%) was calculated by noting and dividing the weights of raw and cooked CMC before and after cooking respectively, multiplied by 100.

pH: ThepH was determined (Trout *et al.* 1992) with digital pH meter (SAB 5000, LABINDIA, New Delhi, India). For this, 10 gm of sample was homogenized with 50 ml of distilled water and the electrode was dipped into the suspension to note down the pH.

Water activity: Water activity (a_w) was determined using hand held portable digital water activity meter (Rotonix HYGRO Palm AW1 Set/40, 60146499). Finely ground CMC is filled up (80%) in a moisture free sample cup over which the sensor was placed for five min and reading was noted.

Hydratability: Hydratability of CMC was determined as per procedure of Mittal and Lawrie (1986). About 2.5 gm weighed sample of CMC was placed in a test tube with excess of boiled water in it. The tubes were immersed in a boiling water bath for 5 min to hydrate the sample. The hydrated sample was drained out for 5 min, with an intermittent blotting and then weighed carefully. Hydratability of CMC was determined as weight of water absorbed by the CMC (g) / weight of dry sample of CMC.

Water absorption index: The water absorption index (WAI) was determined as per the procedure given by Anderson *et al.* (1969). 2.5 gm of finely ground sample of CMC was weighed into 100ml centrifuge tubes. Then 30 ml of distilled water was added and the sample was left to equilibrate for 30 min with occasional stirring. After centrifugation at 5000 rpm for 10 min, the supernatant was collected in a petridish and the remaining gel was weighed. The water absorption index was calculated as the ratio of weight of gel obtained to that of initial weight of the sample (g/g).

Water solubility index: The water solubility index (WSI) was measured according to procedure described by Machado *et al.* (1998). The supernatant liquid obtained from WAI determination was used for determination of water solubility index. The supernatant liquid was kept in a hot air oven to evaporate to dryness. After drying, the petridishes were cooled and weighed. The water solubility index was determined as weight of solids to the initial weight of the sample (g/g).

Proximate composition: Proximate composition of CMC was determined as per the procedures of AOAC (1995). The moisture content was determined using automatic moisture analyzer (Essae, AND MX-50),fat by ether extraction method using Socs Plus (SCS-6-AS, Pelican Industries, Chennai, India),protein by using automatic digestion and distillation unit (Kel Plus-KES 12L, Pelican Industries, Chennai), crude fiber by using Fibra Plus, automatic unit, (FES-6, F-09014, Pelican Industries, Chennai). For ash estimation, moisture free sample was dried at 550°C in muffle furnace for about 7-8 hours. Percentage of carbohydrate in the CMC was simply calculated by subtracting moisture (%), fat (%), protein (%), fiber (%) and ash (%) from 100. Moisture: Protein ratio was determined by dividing moisture (%) with protein (%).

Texture profile: Texture profile analysis (TPA) was conducted using Texture Analyzer (TMS-PRO, Food Technology Corporation, USA). Each CMC was subjected to pretest speed (30 mm/sec), post test speed (100 mm/sec) and test speed (100 mm/sec) to a single Warner-Bratzler shear blade with a load cell of 2500 N. The TPA was performed as per the procedure outlined by Bourne (1978). Parameters like hardness (Newton; N), adhesiveness (milli Joules; mJ), adhesive force (-ve, Newton; N) and stringiness (millimeter; mm) were calculated automatically by the preloaded Texture Pro software in the equipment from the force-time plot.

Colour profile: Colour profile was measured on a set of three cooked CMC (placed in a plate) using Lovibond Tintometer (Lovibond RT-300, Reflactance Tintometer, United Kingdom) set at 2° of cool white light (D_{65}) and known as L^*, a^*, and b^* values. The Hue (relative position of colour between redness and yellowness) and Chroma (Intensity, brightness or vividness of colour) were determined by using formula given by Little (1975).

$$\text{Hue} = (\tan^{-1})\ b/a; \text{Chroma} = [a^2 + b^2]^{0.5}$$

Sensory evaluation: Sensory analysis of CMC was conducted by seven trained and experienced panelists from the staffs at the Department of Livestock Products Technology, College of Veterinary Science, GADVASU using an eight point hedonic scale (Keeton 1983) with slight modifications, where 8=extremely desirable and 1=extremely undesirable.

Statistical analysis: Experiment was carried out thrice in duplicates (n=6) and data were analyzed on SPSS-16.0 software package (SPSS Inc. Chicago, IL, USA) as per standard procedures (Snedecor and Cochran 1994) for analysis of variance using Duncan's Multiple Range Tests and Homogeneity tests to test the significance of difference between means at 5% level (P<0.05) of significance.

RESULTS AND DISCUSSIONS

Physico-chemical parameters of chicken meat caruncles

Perusal of Table 3 revealed that there was no significant difference (P>0.05) of emulsion stability (%) between control and treated samples. The emulsion stability of treated CMC was comparable with control CMC. The cooking yield (%) was significantly higher (P<0.05) in T-2 than control but it was marginally higher than T-1 and T-3. There were less cooking losses in all the treated groups than the control group, because cooking losses got decreased on addition of tapioca starch in starch/meat complexes (Li and Yeh 2003). Similar results were reported by Hughes *et al.* (1998) by addition of 3%

tapioca starch in low-fat frankfurters. Knight and Perkin (1991), McAuley and Mawson (1994) also observed less cooking losses with dry addition of tapioca starch in restructured meat products. Berry (1997) also got similar results on addition of tapioca starch in low fat beef patties. These findings are in agreement with the present study.

The pH of T-3 was significantly lower ($P<0.05$) than control and T-1. Among the treated samples, pH did not vary significantly between T-1, T-2 and T-3, but it decreased continuously as the content of tapioca starch was increased. This is in contradiction with the study of Mittal and Usborne (1986) who reported decrease in pH of snacks with increase in level of meat and decrease in starch content. The a_w did not show significant variation among the different variants of CMC. For treated samples it ranged from 0.325-0.355. Hydratability of T-3 sample was significantly lower ($P<0.05$) than control and T-1. Among the treated batches, hydratability of T-1 was significantly higher than T-2 and T-3 and there was a continuous decrease in the value as the content of tapioca starch was increased in the formulation. WAI of control samples was significantly lower ($P<0.05$) than the treated samples. However, among the treated samples there was no significant variation of WAI. WAI of T-2 was marginally higher than T-1 and T-3 batches. The increase in WAI of treated samples may be due to increased gelatinization of tapioca starch as documented by Davidson *et al.* (1984) and Cheftel (1986). There was no significant variation between WSI of control and treated CMC. The WSI of treated samples were almost comparable with that of control sample.

Table 3: Effect of incorporation of tapioca starch on the physico-chemical parameters of chicken meat caruncles

	Treatments			
Parameters	**Control**	**T-1**	**T-2**	**T-3**
Emulsion stability (%)	98.03±0.16	97.09±0.37	97.93±0.36	96.71±0.64
Cooking yield (%)	53.50 ± 0.84^{a}	55.12 ± 0.56^{ab}	55.68 ± 0.58^{b}	54.90 ± 0.66^{ab}
Product pH	5.96 ± 0.06^{b}	5.91 ± 0.05^{b}	5.82 ± 0.05^{ab}	5.71 ± 0.03^{a}
Water activity (aw)	0.357±0.019	0.350±0.003	0.325±0.008	0.355±0.020
Hydratability	1.42 ± 0.07^{bc}	1.52 ± 0.04^{c}	1.30 ± 0.05^{ab}	1.19 ± 0.06^{a}
WAI	4.26 ± 0.07^{a}	4.78 ± 0.08^{b}	5.03 ± 0.18^{b}	4.93 ± 0.16^{b}
WSI	0.058±0.005	0.052±0.009	0.061±0.003	0.054±0.007

Mean ± SE with different superscripts in the same row differ significantly ($P<0.05$). Control= 35.00%RWF; T-1=17.50% RWF+ 17.50% TS, T-2 = 14.00% RWF+ 21.00% TS and T-3 = 10.50% RWF+ 24.50% TS

Proximate composition of chicken meat caruncles

Data pertaining to proximate composition of CMC are presented in Table 4. There was no significant variation of moisture (%) and protein (%) between control and treated samples. However, the highest value of both moisture (%) and protein (%) was found in control samples. Among the treated samples the values for both the parameters were comparable with control. The fat (%) of T-1 was significantly higher ($P<0.05$) than T-2 and T-3. There was no significant variation of fat (%) between control, T-1 and T-3 samples. There was no significant difference between crude fiber (%) of control and T-1 as well asT-2 and T-3 samples. However, among the treated CMC, crude fiber (%) was found to be significantly lower ($P<0.05$) in T-1 than T-2 and T-3 samples. There was a

Table 4: Effect of incorporation of tapioca starch on the proximate composition of chicken meat caruncles

	Treatments			
Parameters	**Control**	**T-1**	**T-2**	**T-3**
Moisture (%)	5.71±0.25	5.55±0.08	5.49±0.11	5.56±0.25
Protein (%)	28.51±1.14	25.52±2.74	24.45±1.27	25.38±0.73
Fat (%)	11.58 ± 0.45^{bc}	12.08 ± 0.81^{c}	9.17 ± 0.44^{a}	9.83 ± 0.84^{ab}
Crude Fiber (%)	2.30 ± 0.34^{a}	2.33 ± 0.61^{a}	4.83 ± 0.60^{b}	5.83 ± 1.14^{b}
Ash (%)	4.85±0.08	4.43±0.66	3.91±0.15	3.72±0.40
Carbohydrates (%)	47.06±1.28	50.09±2.91	52.15±1.93	49.69±2.38
Moisture: Protein ratio	0.20±0.02	0.23±0.02	0.23±0.01	0.22±0.01

Mean ± SE with different superscripts in the same row differ significantly ($P<0.05$). Control= 35.00%RWF; T-1=17.50% RWF+ 17.50% TS, T-2 = 14.00% RWF+ 21.00% TS and T-3 = 10.50% RWF+ 24.50% TS.

continuous increase in crude fiber (%) of the samples as the content of tapioca starch increased in the formulation. This might be due to crude fiber content of tapioca starch. There was no significant variation of ash (%) among the control and treated samples of CMC. However, there was a marginal decrease in ash (%) as the content of tapioca starch increased in the formulation. Carbohydrates (%) did not vary significantly among control and treated batches. Among treated groups the carbohydrates (%) was marginally higher in T-2 than T-1 and T-3. There was no significant variation of moisture: protein ratio among control and treated samples.

Texture and colour profile of chicken meat caruncles

Data pertaining to texture and colour profile of CMC are presented in Table 5. In texture profile, there was no significant variation between hardness of control, T-1 and T-3 samples. However, the hardness of control sample was lower than all the treated groups. This is in agreement with the study of Hachmeister and Herald (1998) who also observed increase in value of hardness in tapioca starch added turkey meat batters as compared to control samples. Tapioca flour incorporation in meat products gives firmness to the product (Ahamed *et al.* 2007). The adhesiveness of control was significantly higher than T-1 and T-2. However, among the treated groups there was no significant variation between T-1, T-2 and T-3 samples but there was a continuous increase in the adhesiveness as the content of tapioca starch increased in the formulation. There was no significant variation between adhesive force and stringiness of control, T-1, T-2 and T-3 samples. However, the literature does not address the effect of tapioca starch on adhesiveness, adhesive force and stringiness of meat based snacks. Sajilata and Singhal (2004) documented that incorporation of modified starches into snacks can have a high degree of mouth melt, less waxiness, improved texture and increased crispiness.

In colour profile, the L^* and a^* value of control was significantly lower ($P<0.05$) than T-1, T-2 and T-3 samples. Among the treated groups there was no significant variation in both L^* and a^* values and all the values were comparable to each other. There was no significant variation of b^* value among the control and treated batches. Both control and T-1 were having the same b^* value i.e. 26.43. Hue angle was significantly higher ($P<0.05$) in control than the treated batches. There was no significant variation of hue angle among the treated groups. Chroma did not differ significantly among the control and treated batches.

Table 5: Effect of incorporation of tapioca starch on the texture and colour profile of chicken meat caruncles

	Treatments			
Parameters	**Control**	**T-1**	**T-2**	**T-3**
Hardness (N)	58.37±4.46^{a}	66.98±5.09^{ab}	73.84±4.36^{b}	72.14±5.39^{ab}
Adhesiveness (mJ)	57.15±6.14^{c}	28.96±2.74^{a}	40.93±5.98^{ab}	49.12±5.96^{bc}
Adhesives force (-ve, N)	16.79±2.14	14.31±1.24	15.78±1.48	14.34±0.95
Stringiness (mm)	2.43± 1.16^{b}	0.50±0.19^{a}	0.98±0.33^{ab}	1.02±0.24^{ab}
Colour profile				
L*	38.32±0.61^{a}	43.00±1.12^{b}	43.11±0.72^{b}	42.32±1.08^{b}
a*	11.20±0.63^{a}	13.64±0.30^{b}	13.47±0.41^{b}	13.69±0.46^{b}
b*	26.43±0.71	26.43±0.49	27.50±0.62	25.86±0.51
Hue angle	67.06±1.18^{b}	62.68±0.58^{a}	63.86±0.88^{a}	62.14±0.63^{a}
Chroma	28.75±0.74	29.76±0.49	30.65±0.57	29.28±0.61

Mean ± SE with different superscripts in the same row differ significantly ($P<0.05$). Control= 35.00%RWF;
T-1=17.50% RWF+ 17.50% TS, T-2 = 14.00% RWF+ 21.00% TS and T-3 = 10.50% RWF+ 24.50% TS

Sensory quality of chicken meat caruncles

Data pertaining to various sensory attributes of CMC incorporated with tapioca starch are presented in Table 6. All the sensory attributes namely colour, flavour, crispiness, after-taste and meat flavour intensity were non-significant between control and treated batches. However, overall acceptability of T-2 was significantly higher ($P<0.05$) than T-3, but it was marginally higher than control and T-1. For all the sensory attributes, T-2 got marginally higher scores than T-1 and T-3 groups, so it was considered most acceptable.

CONCLUSION

The present study revealed that replacing 60% of refined wheat flour with tapioca starch improved the physico-chemical and sensory attributes of shelf-stable, ready-to-eat chicken meat caruncles. Also it imparted desirable colour to product in addition to increase in cooking yield, moisture, hardness and crispiness. Therefore, snack food industry can effectively develop good quality meat snacks by replacing 60% of refined wheat flour with tapioca starch in 65% spent hen meat based CMC formulation.

Table 6: Effect of incorporation of tapioca starch on the sensory attributes of chicken meat caruncles

	Treatments			
Parameters	**Control**	**T-1**	**T-2**	**T-3**
Colour/Appearance	7.00±0.12	6.89±0.20	7.11±0.23	6.89±0.18
Flavour	6.89±0.11	6.89±0.14	6.89±0.16	6.78±0.12
Crispiness	7.22±0.25	6.83±0.08	7.22±0.09	6.94±0.06
After-taste	6.89±0.16	6.67±0.14	6.89±0.22	6.44±0.18
Meat flavour intensity	6.56±0.18	6.72±0.15	6.83±0.14	6.56±0.15
Overall acceptability	6.89±0.23[ab]	6.72±0.12[ab]	7.17±0.19[b]	6.56±0.13[a]

Mean ± SE with different superscripts in the same row differ significantly (P<0.05). Control= 35.00%RWF; T-1=17.50% RWF+ 17.50% TS, T-2 = 14.00% RWF+ 21.00% TS and T-3 = 10.50% RWF+ 24.50% TS.

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