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SHORT COMMUNICATION

Effect of slice thickness and blanching time on different quality attributes of instant ginger candy

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Abstract Fresh ginger (*Zingiber officinale* Rosc.) suffers from weight loss, shrinkage, sprouting and rotting during storage after 3–4 weeks. This spoilage may be overcome by processing fresh produce to some value added products. An attempt was made to optimize the protocol for production of instant ginger candy. The experimental parameters considered were slice thickness (5.0–25.0 mm) and blanching duration (10–30 min) followed by dipping in 40°B and 75°B sugar solutions containing 2.0% citric acid respectively, for 1 and 2 h at 95 °C and dried at 60 °C for 1 h. RSM design was considered for this experiment and final products were evaluated for their textural properties, TSS, acidity, TSS: acid ratio, taste score and overall acceptability. The optimum product qualities in terms of hardness (2.08 kg), TSS (73.4%), acidity (1.31%), TSS: acid ratio (56.3), taste score (7.98) and overall acceptability (8.07) were obtained for slice thickness of 10.9 mm and blanching time of 24.9 min.

Keywords Instant · Ginger · Slice · Candy · Response surface methodology (RSM)

Introduction

Among all spices, ginger is the main cash crop supporting the livelihood and improving the economic level of many ginger growers of north eastern region. Ginger (*Zingiber officinale* Rosc.) is grown throughout the region but the leading states are Meghalaya, Mizoram, Arunachal Pradesh and Sikkim (Govind et al. 1998). The freshly harvested ginger is used for consumption as green ginger throughout the north eastern region. Due to marketing problem, farmers are not able to sell their produce since there is no local market big enough to absorb and handle green ginger in large quantities. Marketable surplus is sold outside the region through middlemen at a very low price. Therefore, it is essential to convert a part of produce into low volume high value ginger to make the crop remunerative. The dried ginger or ginger powder is generally used in manufacturing of ginger brandy, wine and beer in many western countries. Ginger oil is primarily used as a flavouring agent in confectionary and for soft drinks. The ginger is also used for several medicinal purposes (Yadav et al. 2004).

Meghalaya is a major producer of ginger in the region, which is also second largest producer in the country with total share of 19.59% after Kerala, which contributes 23.08% to the total production of the country. The production of ginger is highest in Meghalaya followed by Mizoram and Arunachal Pradesh (Anonymous 2004). Farmers are interested for the cultivation of ginger as soil, climate and other ecological factors favour the growth and development of the crop and there is a tremendous scope to increase the yield per unit area and thereby the total production of ginger in the North Eastern Region.

Ginger preserve/candy, a ready-to-eat (RTE) food product, is also in great demand for use in confectionery. Chocolate manufacturers utilize the preserve for enrobing. It is also used in jams, marmalades and ginger bread. The syrup in which ginger is preserved is valued for pickle and sauce making (Dubey and Tiwari 2009). The fresh ginger is perishable in nature and during storage it suffers from weight loss, shrinkage, rotting and sprouting. Due to lack of processing and value addition practices in ginger, during the harvesting season, a huge quantity of fresh produce becomes unmarketable. Very limited number of value added

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products from ginger are presently available in the market. Whatever, value added products are commercially available are of poor quality and less shelf life. Ginger candy, a traditional product, requires 5–7 days while with the present process it takes only 4–5 h. The present study was undertaken to develop and optimize the process parameters for production of this instant ginger candy.

Materials and methods

Uniform size ginger rhizomes cv. Nadia were harvested from the Horticulture Farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya and were washed thoroughly with clean water to remove dirt and other undesirable particles from the surface and also to reduce the microbial load causing contamination. After washing, rhizomes were air dried at room temperature (22±2 °C; 70±5% RH) for 2–3 h for removal of surface moisture. Dried rhizomes were peeled manually and slices were made with the help of stainless steel knife. The independent variables considered for this study were: slice thickness (ST, 5.0–25.0 mm) and blanching time (BT, 10–30 min) as per central composite rotatable design (CCRD). Blanched slices were dipped in 40°brix and 75°brix sugar solutions containing 2.0% citric acid respectively, for 1 and 2 h at 95 °C. As soon as the retention time reached the predetermined level, the materials were taken out from the syrup and kept in laboratory tray drier at 60 °C for 1 h. Dried materials were cooled at room temperature before being packed in air tight containers for further analyses. Flow chart for preparation of instant ginger candy is shown in Fig. 1. According to CCRD design, thirteen experiments were performed with two variables each at five levels and response surface methodology (RSM) was applied to the experimental data using a commercial statistical package (Design Expert 2002).

Freshly harvested uniform size ginger rhizomes
⇩
Washing with clean water
⇩
Peeling
⇩
Cutting into round shaped slices
⇩
Blanching in boiling water
(5-25 minutes with 2.0% citric acid)
⇩
Dipping in 40°Brix sugar syrup with 2.0% citric acid
(1 hr at 95ºC)
⇩
Dipping in 75°Brix sugar syrup with 2.0% citric acid
(2 hrs at 95ºC)
⇩
Draining and drying at 60 ºC for 1 hour
⇩
Cooling and packing

Fig. 1 Flow chart for preparation of instant ginger candy

The following second order polynomial response surface model (Eq. 1) was fitted to each of the response variable (Y_k) with the independent variables (X)

$$Y_k = b_{k0} + \sum_{i=1}^{2} b_{ki}X_i + \sum_{i=1}^{2} b_{kii}X_i^2 + \sum_{i\neq j=1}^{2} b_{kij}X_iX_j \quad (1)$$

where b_{k0}, b_{ki}, b_{kii}, and b_{kij} are the constant, linear, quadratic and cross-product regression coefficients respectively and X_i's are the coded independent variables of X_1 and X_2.

Regression analysis and analysis of variance (ANOVA) were conducted for fitting the models represented by Eq. 1 and to examine the statistical significance of the model terms. The adequacy of the models were determined using model analysis, lack of fit test and R^2 (coefficient of determination) analysis as outlined by Lee et al. (2000) and Weng et al. (2001). The numerical optimizations were also performed by the same software. In order to search a solution maximizing multiple responses, the goals were combined into an overall composite function, D(x), called the desirability function (Myers and Montgomery 2002), which is defined as:

$$D(x) = (d_1.d_2.......d_n)^{1/n} \quad (2)$$

where d_1, d_2....d_n are responses and n is the total number of responses in the measure.

Experimental product qualities in terms of total soluble solids (TSS, %), acidity (%), TSS: acid ratio, hardness (H), taste score and overall acceptability (OAA) were measured. TSS was measured with the help of digital refractrometer while acidity of the final product was analyzed by the method as described by Ranganna (1995). The texture characteristics of ginger candy in terms of hardness were measured using a Stable Micro System, TA-XT2 texture analyzer (Texture Technologies Corp., UK) fitted with a 35 mm cylindrical probe. Hardness value was considered as mean peak compression force and expressed in kg. The studies were conducted at a pre test speed of 1.0 mm/s, test speed of 0.5 mm/s, distance of 2 mm, and load cell of 50.0 kg (Cruzycelis et al. 1996).

The taste score and overall acceptability of the product was carried out by a panel of 10 judges using the standard method (BIS 1971). A nine point hedonic scale was used (score 1—extremely disliking and score 9—extremely liking).

Results and discussion

Instant ginger candy was prepared considering slice thickness (5.0–25.0 mm) and blanching time (10–30 min) as

Table 1 Treatment combinations with their responses obtained during ginger candy preparation (with 2 variable 2nd order polynomial model)

Run No	Process variable		Responses					
	ST (mm)	BT (min)	Texture (kg)	TSS (%)	Acidity (%)	TSS: acid ratio	Taste score	OAA score
1	15.00	20.00	5.22	69.4	0.99	70.10	7.8	7.7
2	20.00	15.00	12.06	69.4	0.77	90.13	6.8	6.7
3	15.00	20.00	4.97	69.8	0.98	71.22	7.8	7.7
4	15.00	20.00	3.86	68.9	1.02	67.55	7.4	7.5
5	7.93	20.00	2.42	73.4	1.43	51.33	7.2	7.3
6	22.07	20.00	14.22	66.6	0.68	97.94	6.3	6.2
7	10.00	15.00	5.44	71.2	1.24	57.42	7.2	7.1
8	15.00	20.00	4.26	69.4	0.86	80.70	7.8	7.8
9	15.00	27.07	2.24	72.5	1.25	58.00	7.6	7.5
10	10.00	25.00	3.55	73.2	1.31	55.88	8.1	8.2
11	15.00	20.00	4.99	70.2	0.95	73.89	7.9	7.8
12	20.00	25.00	9.32	67.5	1.04	64.90	6.9	6.5
13	15.00	12.93	8.34	70.4	0.93	75.70	6.7	6.3

ST slice thickness; *BT* blanching time; *TSS* total soluble solids; *OAA* overall acceptability; *H* hardness

important process variables. RSM was applied to the experimental data and the values of various responses at different experimental combinations are given in Table 1. Regression analysis and ANOVA were conducted for fitting the model and to examine the statistical significance of the model terms. The lack of fit, coefficient of determination (R^2) and coefficient of variation (CV) values are given in Table 2. In this study, the lack of fit was found non significant indicating that these models are sufficiently accurate for predicting the responses.

The fresh ginger slices before processing recorded maximum hardness of 16.74 kg. During processing, hardness values varied from 2.24 kg to 14.22 kg within the combination of variables studied (Table 1). Close perusal of data presented in Table 2 indicates that slice thickness and blanching time are the most significant parameter affecting the hardness ($p \leq 0.001$ and $p \leq 0.01$ respectively) at linear level, while, quadratic terms of slice thickness was found highly significant ($p \leq 0.001$). Slice thickness was the main variable affecting the hardness as revealed by the respective regression coefficient and *F*-value. Figure 2 shows hardness of ginger candy as a function of slice thickness and blanching time which indicates hardness increases with increase in slice thickness while increase in blanching time showed decrease in hardness. Increase in blanching time caused decrease in hardness; this might be due to longer time heat treatment, which soften the ginger slices, and also due to extended exposure of slices into water. This is in accordance

Table 2 ANOVA and regression coefficients of the second-order polynomial model for the response variables (in coded units)

Variables	DF	Estimated coefficients						*F*-values					
		H (kg)	TSS (%)	Acidity (%)	TSS : acid ratio	Taste score	OAA score	H (kg)	TSS (%)	Acidity (%)	TSS: acid ratio	Taste score	OAA score
Model	5	4.67	69.54	0.96	72.69	7.74	7.70	31.86***	22.84***	25.2***	14.12**	12.86**	17.97***
X_1	1	3.63	−2.14	−0.23	13.46	−0.36	−0.46	107.3***	89.59***	94.4***	50.42***	20.36**	32.80***
X_2	1	−1.66	0.38	0.10	−6.47	0.28	0.32	22.33**	2.88	18.3**	11.67*	12.74**	16.56**
X_1X_2	1	−0.21	−0.98	0.05	−5.92	−0.20	−0.33	0.18	9.30*	2.3	4.88	3.16	8.30*
X_1^2	1	2.03	0.13	0.05	0.06	−0.42	−0.40	29.07***	0.29	4.4	0.00	24.22**	21.86**
X_2^2	1	0.51	0.86	0.07	−3.84	−0.22	−0.33	1.84	12.44**	7.8*	3.56	6.64*	14.43**
Lack of fit	3							5.56	2.67	1.3	1.33	1.78	6.59
R^2		0.958	0.942	0.947	0.910	0.902	0.928						
Adj R^2		0.928	0.901	0.910	0.845	0.832	0.876						
CV%		15.95	0.91	6.33	7.62	3.06	3.11						

* Significant at $p<0.05$, ** Significant at $p<0.01$, *** Significant at $p<0.001$, *H* hardness; *TSS* total soluble solids; *OAA* overall acceptability

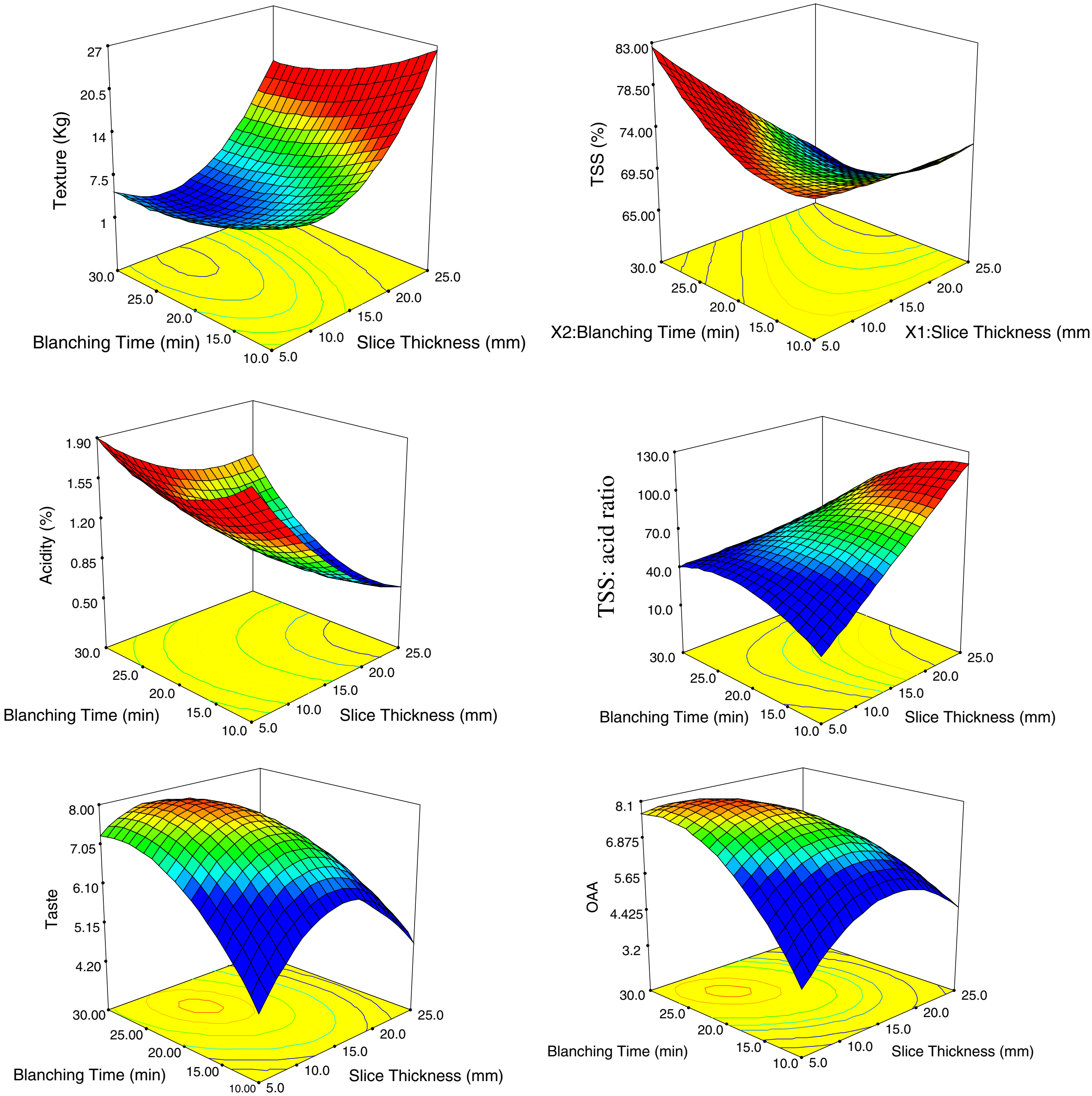

Fig. 2 Response surfaces plots for different quality parameters viz., texture(A), TSS(B), acidity(C), TSS: acid ratio(D), taste score(E) and OAA score(F) on the effect of slice thickness (mm) and blanching time (min) for instant ginger candy

to the findings of Guinard et al. (1997), Askari et al. (2006) and Aboubakar et al. (2009) on hardness of final products as affected by different pre-treatments.

During ginger candy processing, the maximum TSS was observed to be 73.4% at slice thickness of 7.93 mm and blanching time duration of 20.0 min while, the minimum was 66.6% at slice thickness of 22.07 mm and blanching time duration of 20.0 min, respectively (Table 1). Slice thickness is the most significant parameter affecting the TSS ($p \leq 0.001$) at linear level, while quadratic ($p \leq 0.01$) and interaction terms ($p \leq 0.05$) of blanching time as evident from Table 2. The maximum TSS (79.53%) was observed at slice thickness 5.0–8.0 mm; blanching time 27.5–30.0 min while minimum TSS (66.32%) was recorded with slice thickness 23.0–25.0 mm; blanching time 18.5–30.0 min (Fig. 2). With increase in slice thickness, the TSS decreased due to less penetration of sugar inside the deeper part through osmosis during the process of the ginger candy

Table 3 Software generated three optimum conditions of independent variables with the predicted values of responses

S. No	Process variables		Response variables						Desirability
	ST (mm)	BT (min)	Texture (kg)	TSS (%)	Acidity (%)	TSS: acid ratio	Taste score	OAA score	
1	10.85	24.93	2.08	73.4	1.31	56.3	7.98	8.07	0.97
2	10.25	24.05	2.08	73.4	1.31	56.3	7.98	8.07	0.92
3	10.10	22.97	2.07	73.4	1.31	56.3	7.98	8.07	0.85

ST slice thickness; *BT* blanching time; *TSS* total soluble solids; *OAA* overall acceptability

preparation. Similarly, increase in blanching time caused an increase in TSS through softening of the tissues and permitting faster penetration of sugar through osmosis. Similar results were reported by Alam et al. (2010) for aonla slices.

Acidity of ginger candy varied from 0.68% to 1.43% within the combination of variables studied (Table 1). From Table 2, it can be seen that slice thickness and blanching time are the most significant parameter affecting the acidity ($p \leq 0.001$ and $p \leq 0.01$ respectively) at linear level, while, quadratic terms of blanching time was found significant ($p \leq 0.05$), however, there was no significant contribution at quadratic and interaction terms of slice thickness. The maximum acidity (1.68%) was observed at slice thickness 5.0–7.2 mm; blanching time 24.8–30.0 min while, the minimum (0.67%) was at slice thickness 22.5–25.0 mm; blanching time 10.0–18.0 min (Fig. 2). Increase in blanching time caused increase in acidity; this might be due to longer time heat treatment and also due to extended exposure of slices into water, which soften the ginger slices for more penetration of acid into the product. Similar results were reported by Alam et al. (2010) for aonla slices.

TSS: acid ratio varied from 51.33 to 97.94 within the combination of variables studied (Table 1). From Table 2, it can be seen that slice thickness and blanching time are the significant parameter affecting the TSS: acid ratio ($p \leq 0.001$ and $p \leq 0.05$ respectively) at linear level. The maximum TSS: acid ratio (101.4) was observed at slice thickness 21.5–25 mm; blanching time 10.0–18.5 min while, the minimum (36.8) was at slice thickness 5.0–7.5 mm; blanching time 10.0–15.0 min (Fig. 2).

Taste score during ginger candy processing at different combinations of slice thickness and blanching time are presented in Table 1. The maximum taste score (8.1) was observed at slice thickness of 10.0 mm and blanching time duration of 25.0 min while minimum was 6.3 at slice thickness of 22.07 mm and blanching time duration of 20.0 min, respectively. Slice thickness and blanching time were the main variables affecting the taste score as revealed by the respective regression coefficient and *F*-value (Table 2). The maximum taste score (7.95) was observed at slice thickness 9.5–12.5 mm; blanching time 23.0–27.0 min while, the minimum (5.48) was at slice thickness 5.0–8.0 mm; blanching time 10–13.5 min (Fig. 2). Similarly, the maximum OAA score (8.2) was recorded at slice thickness of 10.0 mm and blanching time of 25.0 min while, the minimum (6.2) was at slice thickness of 22.07 mm and blanching time of 20.0 min, respectively. The maximum OAA score (8.04) was at slice thickness 6.0–12.0 mm; blanching time 23.0–26.5 min while, the minimum (4.85) was at slice thickness 5.0–8.0 mm; blanching time 10.0–12.5 min (Fig. 2). This finding was in accordance with the study reported by Maharaj and Badrie (2006) and Skierkowski et al. (1990). They carried out instrumental and sensory evaluation of textural properties of extrudates from blends of high starch/high protein fractions of dry beans. They reported that sensory score for final products were significantly ($p \leq 0.001$) affected by different process parameters.

Numerical optimization was carried out for the process parameters for production of instant ginger candy for obtaining the best product. The desired goals for each variable and response were chosen and different weights were assigned to each goal to adjust the shape of its particular desirability function. Table 3 shows software generated three optimum conditions of independent variables with the predicted values of responses. Solution no.1, having the maximum desirability value (0.97) and desirability graph (Fig. 3) was

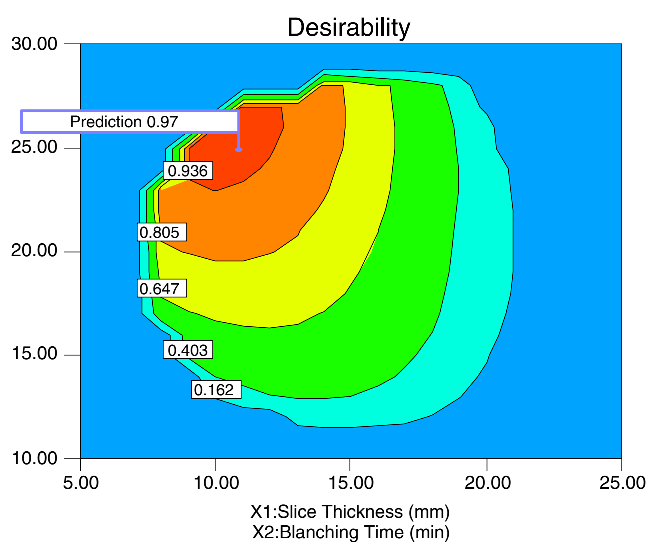

Fig. 3 Desirability graph for the effect of slice thickness (mm) and blanching time (min) for the production of instant ginger candy

selected as the optimum process conditions for developing instant ginger candy. The product qualities in terms of hardness (2.08 kg), TSS (73.4%), acidity (1.31%), TSS: acid ratio (56.3), taste score (7.98) and overall acceptability (8.07) were obtained at optimum process condition of slice thickness (10.9 mm) and blanching time (24.9 min.).

Conclusion

RSM design was found suitable for the process optimization for developing instant ginger candy. Hardness, TSS, acidity, TSS: acid ratio, taste score and overall acceptability score of instant ginger candy by candying process were dependent significantly on the process variables namely, slice thickness and blanching time. Slice thickness had the greatest influence, whereas the effects of blanching time was comparatively less on the quality attributes of instant ginger candy.

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