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Development of Green Chili Sauce Modulated by Pea Pod Powder as a Functional Ingredient

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Abstract: Chilli sauce was produced in this study with fresh green chilli, pea pod powder for thickening, and a variety of other ingredients including spices, salt, sugar, and vinegar. The purpose of this research was to determine how adding varying amounts of pea pod powder (PPP) (15-35%) affected the final product. Chilli sauce's physical and chemical properties like pH, TSS, colour, and texture, as well as its physical and chemical properties like moisture, ash, crude protein, fat, crude fibre, carbohydrate, etc., were evaluated. Scanning electron microscopy was then used to characterize the product's morphology. In addition to its high nutritional and functional qualities, the created green chilli sauce regulated by pea pod powder exhibited good sensory and textural properties, as judged by comparison with a commercial green chilli sauce. This study found that the addition of 19% pea pod powder to the chilli sauce did not decrease its overall popularity. So, in future needs pea pod powder could be used to make foods that are high in nutrients.

Keywords: Peapod powder, green chilli sauce, functional food, SEM

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1. Introduction

The green and dried forms of Pea which is a leguminous crop are both widely used and appreciated. According to 2020-21 estimates, the world produced 11.2 million tons of peas, the vast majority of which was used for processing. Green peas are consumed at a rate of 2.3 kilograms per person worldwide, with India being the greatest consumer and the second largest producer (20.699,000 metric tons according to 2020 FAO data). Most peas today are preserved in some way, either by freezing, canning, or dehydrating (Rudra *et al.* 2020). Pea pods are incredibly beneficial to one's health due to their low calorie, low fat, and cholesterol-free composition as well as their high nutrient density (they are an excellent source of vitamins, minerals, and dietary fiber). Food waste from plants can be a rich source of bioactive substances like carotenoids, polyphenols, vitamins, fiber, and more. These phytochemicals have numerous uses, including in the creation of functional or enriched foods, in medicine, and in the production of dyes for the textile industry (Hanan *et al.* 2020a). The production of large amounts of pea waste in the form of pea pods during industrial processing is a major contributor to environmental problems and can result in the emission of harmful gases. Since unsustainable waste disposal practices have a direct influence on both production and profitability, these expenses may also translate into significant financial burdens. The pea peel wastes account for around 30–40% of the total pea weight and can be purchased at no additional cost in bulk quantities. Because of this, a variety of strategies are necessary to transform these wastes into products that are beneficial and have a high nutritional value (Mousa *et al.* 2021).

Recently, a few market surveys have shown that there has been a rise in the desire that consumers have for meals that are high in protein and fiber due to the positive benefits that these foods have on one's health. Because of this, the formulations of traditional foods need to be rethought so that they can produce foods that are rich in nutrients. When it comes to nutritional enrichment, the meals that are often targeted are ones that are easily accessible, acceptable, and affordable across a variety of socioeconomic strata (Pooja *et al.* 2022).

Green chilli is more popular than red. In season, green chilli costs Rs. 25-35 per kg, but off-season prices are Rs. 50-60 per kg. Due to its perishability, green chilli is difficult to store, transport, and sell. Lack of processing and preservation techniques causes huge amounts of green chilli to be wasted in the field. Hence, there is a need for proper utilization of green fresh chilli in the form of sauces (Singh *et al.* 2015). The food companies have been pushed to manufacture many different sorts of formulations of the chilli sauce as a result of the growing demand for a variety of different kinds of chilli sauces on the market. The researcher was motivated to create a chilli sauce with good nutritional and sensory quality by the fact that commercially available chilli sauce has minimal nutritious value (Mahmood *et al.* 2019).

Currently, there is no research available that looks at the addition of pea pod powder to Chilli sauce. Considering this, the present study aims to support waste utilization and waste to health concept by optimizing the ingredients of chilli sauce modulated with pea pod powder and analyzing its physical, chemical, microbiological, and morphological properties.

2. Materials and Methods

2.1. Material Procurement

In Winters, when pea pods are in season and plentiful in Varanasi, we shopped at the local market. Sigma-Aldrich and Merck were contacted to order analytical chemistry materials. There was no special care taken with the acquired raw materials; they were stored at normal room temperature (25°C). Sugar, salt, garlic, ginger, asafoetida, mustard seed, cumin, refined oil, and vinegar are also used in the production of chilli sauce.

2.2. Preparation and Evaluation of Pea Pod Powder

After purchasing the fresh pea from a vendor in the Varanasi marketplace, the peas were peeled to separate the pea seed from the pods so that they could be further processed. This included sorting the pods to remove any that were not fresh, green, or disease-free; washing; drying; grinding; sieving; and packaging. The fine powder from the pods was tested using standard methods. The approximate amount of carbohydrate, protein, fiber, fat, and ash in pea pod powder was calculated using the methods set out by the AOAC (2016).

2.3. Chilli Sauce Preparation

Chilies were obtained from the market while they were still fresh and green, and then they were sorted before being processed. We made our chilli sauce in a manner similar to that described by Mahmood *et al.* (2019) but with a few tweaks here and there. On a per-100-gram basis, the following ingredients were included in the recipe: green chilli (0.1-2%), pea pod powder (PPP) 15-35%, sugar (0.1-2%), salt (1-2%), garlic (0.5-2%), ginger (0.1-2%), asafoetida (0.1-2%), cumin (0.1-2%), refined oil (1-10%), vinegar (20-30%), and mustard seed (0.1-2%). The experimental design for chilli sauce is shown in Table 1. The optimal amount of each component was determined by conducting a sensory analysis on the sauce before it was added. After being washed and drained of excess water, green chilies were sliced into little pieces. Finally, the ginger and garlic cloves were removed, peeled, and chopped. The oil was poured into a pan and heated over a flame. It was roasted until it was sputtering, then seasoned with cumin seeds, mustard seeds, and asafoetida. Green chilies, ginger, garlic, salt, and sugar were all diced and added to the pan. It was mixed thoroughly and let to sit for a couple of minutes. After the chilies had been thoroughly coated in the spices, the pea pod powder was added and the mixture was let to sit for 1-2 minutes before half a cup of water was stirred in. The mixture was stirred to ensure uniformity. The items were then covered and cooked for 5-10 minutes over a low flame before being served. When the samples were fully cooked and soft, another half cup of water was added, and they were cooked for another two to three minutes over high heat. After heating, vinegar was added, and the mixture was blended to a sauce-like consistency.

2.4. Sensory Evaluation

A semi-trained panel of 9 semi trained judges from the Centre of Food Science and Technology, Banaras Hindu University; Varanasi (India) carried out the descriptive sensory analysis. When rating the preferences, a hedonic scale with 9 points was provided, with 0 representing "not acceptable" and 9 representing "most acceptable." The ratings ranged from most acceptable to least acceptable.

2.5. Chilli Sauce Evaluation

Following the completion of making of the chilli sauce. The lyophilizer model used to lyophilize the sauce was an RP2V, Serail from France. The sauce was then freeze dried. The procedure consisted of three stages: external freezing (at -20°C for two hours), sublimation (at -20°C and 0.66 atmospheres for twelve hours), and desorption (at 25°C and 0.66 atmospheres for twelve hours). Afterward, once all the stages involved in lyophilization were finished, the powder was gathered, and the dried sample was examined (Kim *et al.* 2011).

2.5.1. Evaluation of physical properties

All of the physical characteristics were evaluated at room temperature, including the pH, acidity, total soluble solids, color, and texture. A pH meter (Eutech instrument) and a refractometer (Hand refractometer, Milwaukee, MA871) were used to determine the pH and total soluble solids levels, respectively. A Hunter lab colorimeter was used (manufactured by M/s Hunter associate laboratory Inc-USA to determine the exact hue of sauce. Texture was determined using texture analyzer model TA-TXT Plus, stable micro systems UK.

2.5.2. Proximate analysis of green chilli sauce

The proximate composition of the produced chilli sauce was analyzed using the method described by AOAC (2005). This analysis included the determination of the moisture, fat, protein, ash, carbohydrate, crude fiber, and reducing sugar contents.

2.5.3. Bioactive compound in chilli sauce

Chilli Products have bioactive ingredients that are helpful to health, and the value-added products made from chilli could have a high demand in international markets (Kuna *et al.* 2018). Total phenolic content was measured using the method of Shaha *et al.* (2013) with a slight modification. In a conical flask, 0.2 gm of the sample was added to 100 ml of Methanol (80% w/w), shaken for 2 hours at room temperature, then centrifuged at 1500 rpm for 20 minutes at 25 ± 1°C. Then, 2 ml of the extract was mixed with 10 ml of Folin-Ciocalteu reagent, placed in a dark cabinet for 1–8 minutes, and 8 ml of 7.5% sodium carbonate was added. well-mixed Absorbance was measured at 765 nm after 2 hours at room temperature. All treatments had triplicate observations. Results were given in mg of gallic acid/100 g sample.

We used a modified version of the 2,2-diphenyl-1-picryl hydantoin (DPPH) assay established by (Alvarez-Parrilla *et al.* 2011) to estimate the antioxidant content of the sample. The sample was weighed out to be one gram, and then ethanol (80% w/w) was put in a conical flask to make up the remaining volume. Then, two milliliters of the material were placed in Eppendorf tubes. After that, we spun the samples for 5 minutes at 4000 rpm in an Eppendorf centrifuge. After diluting 3 ml of DPPH solution with water, 1 ml of supernatant was added to the test tube. After that, the material was left undisturbed for 30 minutes in the dark. The UV spectrophotometer detected absorbance at 517 nm. The concentration versus absorbance reading was recorded, and a graph was drawn.

2.6. Microstructure Analysis of Chilli Sauce by Scanning Electron Microscopy (SEM)

The green chilli sauce samples were analyzed using a ZEISS Supra-40 SEM, which requires 20 kV of acceleration voltage. Each sample was made according to the protocol laid out by Wang *et al.* (2013), with minor adjustments A 1% (w/v) suspension of green chilli powder was prepared by dispersing a tiny sample into anhydrous ethanol. A sputter gold coater was used to deposit a thin layer of gold (15 nm) onto a circular aluminum stub onto which a single drop of the suspension had been adhered using double-sided adhesive tape. The system was then put into operation.

3. Statistical Analysis

All analytical measurements were done in triplicates. The values of each parameter are given as the mean±S.D. Duncan's multiple range tests compared means with a statistical significance level of P< 0.05. SPSS for Windows was used to do statistical analyses (Version 17.0).

4. Results and Discussion

4.1. Evaluation of Pea Pod Powder

A detail of the findings from the chemical analysis of the pea pod powder can be found in Table 2. It was discovered that pea pod powder was an excellent source of proteins (13.68±0.31 g/100g). Carbohydrates made up of 63.12 g/100g, 0.05 g/100g of pea pod powder, followed by crude fiber (7.50 0.08 g/100g), fat (0.40 g/100g), ash (0.34 g/100g). The amount of protein found in pea pod powder was significantly higher than what was previously reported by (Hanan *et al.* 2020b), (Belghith-Fendri *et al.* 2016) and exhibited a level of protein content that was equivalent to that (Belghith Fendri *et al.* 2016). Our research showed that pea pods had a lower carbohydrate content than what was reported by (Hanan *et al.* 2020b), According to the findings of our research, the fat content of pea pods was significantly lower than that of (Hanan *et al.* 2020b) (Mateos-Aparicio *et al.* 2010). The amount of ash that was discovered in our research was greater than what was reported by (Hanan *et al.* 2020b) but it was less than what was observed by (Pooja *et al.* 2022).

4.2. Sensory Evaluation of Green Chilli Sauce

Table 3 shows that most chilli sauce sensory ratings differed significantly. The increase from 15% to 35% pea pod powder influenced the sauce's appeal. 19% pea pod powder (V7) had the best overall acceptability, scoring 7.999±0.802 in color and appearance, flavor and pungency, body and texture. As PPP concentrations rise, sensory ratings drop. This may be owing to the sauce's pale greenish color and increased viscosity when pea pod powder was added in large amounts compared to the other samples. This study found that adding up to 19% pea pod powder to chilli sauce was acceptable in terms of (colour and appearance, flavour and pungency, body and texture).

4.3. Evaluation of Physical Properties

Green chilli sauce with pea pod powder has a pH of 5.07±0.07, To a large extent, the acidic qualities of chilli sauce can be attributed to the vinegar that is commonly employed as an ingredient. In this investigation, the pH of the chilli sauce was just slightly higher than the range of 4.33±0.04 seen in commercial chilli sauce, which served as a control. While the acidity of the control sample was measured at 0.58±0.05, the optimized green chilli sauce measured only 0.26±0.02. Total Soluble Solid concentration in optimal green chilli sauce modified by pea pod powder is 11.60 ±0.10 versus 14.25 ±0.03 for the control. Results showed that optimal green chilli had a pH that was substantially higher and a TSS that was noticeably lower than findings of Mahmood *et al.* (2019) and Gamonpilas *et al.* (2011). The Hunter Lab Spectrophotometer was used to measure the color of green chilli sauce by showing L^*, a^*, and b^* values. The values that were found are shown in Table 4 below. The L^*, a^*, and b^* values for the control sample (T1) were 42.55, 4.30, and 26.98, while the values for the optimized sample (T2) were 32.52, 1.20, and 38.34. Using a texture analyser, we determined the firmness, cohesiveness, viscosity index, and consistency of the control and optimized green chilli sauce which is given in Table 5. Texture attributes of sauces are monitored and controlled to ensure that products are of the highest quality, acceptability.

4.4. Proximate Analysis of Green Chilli Sauce

Table 6 presents an approximation of an analysis of the control, which consists of commercial green chilli sauce, as well as an optimized version of green chilli sauce (V7). According to the findings, the presence of fiber-rich pea pod powder causes optimized (V7) green chilli sauce to have a greater crude fiber content (7.98±0.06) than the control, which is commercial green chilli sauce (0.72±0.49). This is because the control contains no pea pod powder. A further observation that can be made is that there has been an increase in the mineral content, as demonstrated by the fact that the ash content of optimized green chilli sauce was 4.533±0.306. It was discovered that the optimized sauce (16.96±0.54) had approximately twice the amount of carbohydrates as the control sauce (8.47±0.99), but it had slightly greater values of protein (0.47±0.06) and fat (0.13±0.03). When compared with the control sample of chilli sauce, which had a moisture content of 87.30±0.46 and a reducing sugar content of 24.30 ±0.03 respectively, it was discovered that the optimal chilli sauce had a moisture content of 88.28±0.29 and reducing sugar content of 28.51 ±0.04 respectively and both of these numbers were found to be significantly on the higher side. Higher moisture content was seen in optimized green chilli sauce because of the fiber's ability to bind and retain more water than other fibers. Our results were consistent with those of the Use of pea pod powder in instant pea soup

Table 1: Experimental design with actual variable level

	INGREDIENTS (g)											
	GC	PPP	SU	SA	GAR	GIN	AST	MS	CS	**RO**	**VIN**	**TW**
V1	28	34	1.5	02	0.5	0.5	0.5	01	01	06	25	100
V2	30	32	01	01	01	01	01	01	01	07	24	100
V3	35	28	0.5	0.75	1.25	1.25	0.25	0.75	1.25	08	23	100
V4	35	22	0.75	1.75	1.75	1.75	0.75	1.5	0.75	07	27	100
V5	38	23	1.25	1.25	0.75	0.75	0.75	1.25	01	04	28	100
V6	39	20	0.75	1.25	02	1.75	0.25	0.5	0.5	05	29	100
V7	40	19	0.5	01	1.5	1.5	0.25	0.5	0.75	05	30	100

+ GC-green chilli, PPP-pea pod powder, SU-sugar, SA-salt, GAR-garlic, GIN-ginger, AST-Asafoetida, MS-Matured seeds-cumin seed, RO-Refined oil, VIN-Vinegar, TW-total weight.
*each value is mean ±standard deviation (n=3), Different superscripts in each row were significantly different (P<0.05).

Table 2: Chemical analysis of Pea pod Powder

Nutrient Parameter	Content % (g/100g)
Carbohydrate	63.12±0.05^{a}
Protein	13.68±0.32^{a}
Ash	0.40±0.44^{b}
Fat	5.34±0.03^{a}
Crude Fiber	7.50±0.08^{ab}

Table 3: Comparative values for sensory attributes of green chilli sauce

Variants	Mean value for colour and appearance	Mean value for flavour and pungency	Mean value for body and texture	Mean value for overall acceptability
V1	6.57±0.79^{a}	6.29 ±0.95^{b}	5.86 ±0.69^{a}	6.24 ±0.86^{c}
V2	6.71±0.76^{a}	6.71±0.76^{b}	6.14±0.90^{ab}	6.52±0.80^{a}
V3	7.14±0.90^{b}	6.57±0.79^{ac}	6.71±0.76^{a}	6.81 ±0.81^{b}
V4	7.29 ±0.76^{c}	6.43 ±0.98^{a}	6.86 ±0.69^{a}	6.88 ±0.81^{ac}
V5	7.43 ±0.53^{ab}	7.14±0.69^{c}	7.14±0.69^{b}	7.24 ±0.53^{ab}
V6	7.01 ±0.82^{d}	7.29 ±0.76^{a}	7.29 ±0.76^{a}	7.19±0.77^{a}
V7	8.14±0.69^{e}	8.01 ±0.82^{ab}	7.86 ±0.89^{c}	8.00 ±0.80^{b}

Table 4: L*, a*, b* values of the green chilli sauce

Sample	L*	a*	b*
T1	42.55±3.26^{a}	4.30±0.02^{a}	26.98±0.02^{a}
T2	50.52± 4.26^{a}	1.20±0.01^{b}	38.34±1.23^{a}

Table 5: Comparative values for textural properties of green chilli sauce.

Textural properties	*Control*	*Optimized*
Firmness	178.51 ± 14.55[a]	179.31± 8.26[ab]
Consistency	959.16±58.98[a]	1606.08± 42.58[a]
Cohesiveness	-161.99±7.75[b]	-194.84± 16.24[a]
Viscosity Index	-414.72 ±22.29[a]	-427.077 ± 22.67[b]

Table 6: Proximate analysis of green chilli sauce

Constituents %	***Control***	***Optimized (V7)***
Protein	0.13 ±0.02	0.47 ±0.06
Fat	0.06 ±0.03	0.13±0.03
Moisture	87.30±0.46	88.28±0.29
Ash	3.33±0.15	4.53±0.31
Crude fibre	0.72±0.49	7.98±0.51
Net carbohydrate	8.47±0.98	16.96±0.54
Reducing Sugar	24.30 ±0.03	28.50 ±0.04

powder study (Hanan *et al.* 2020b). His analysis also revealed an increase in crude fiber (13.25%), a decrease in moisture (8.6%), a higher ash (7.5%) content, a higher carbohydrate (80.51%), a higher protein (1.50%), and a higher fat (1.90%) percentage. Pea seed use in soup preparation may account for the greater nutrient content seen in his study. There was a consistent pattern of similar findings in the studies of (Pooja *et al.* 2022).

4.5. Bioactive Compounds in Chilli Sauce

The ability to scavenge free radicals is quantified by measuring DPPH activity. Figure 1 shows Sample V7, which was optimized, has higher DPPH activity (91.59%) than the control sample (64.62%). This data suggests that, when compared to the control samples, the optimized samples exhibit the greatest free radical scavenging property. Total phenolic content is measured, and it is shown to be higher in the optimized sample (26±0.02 vs. 48±0.02 in the control sample).

4.6. Microstructure Analysis of Chilli Sauce by Scanning Electron Microscopy (SEM)

The morphology of the chilli powder was analyzed using scanning electron microscopy. Green chilli sauce powder samples were found to be broken

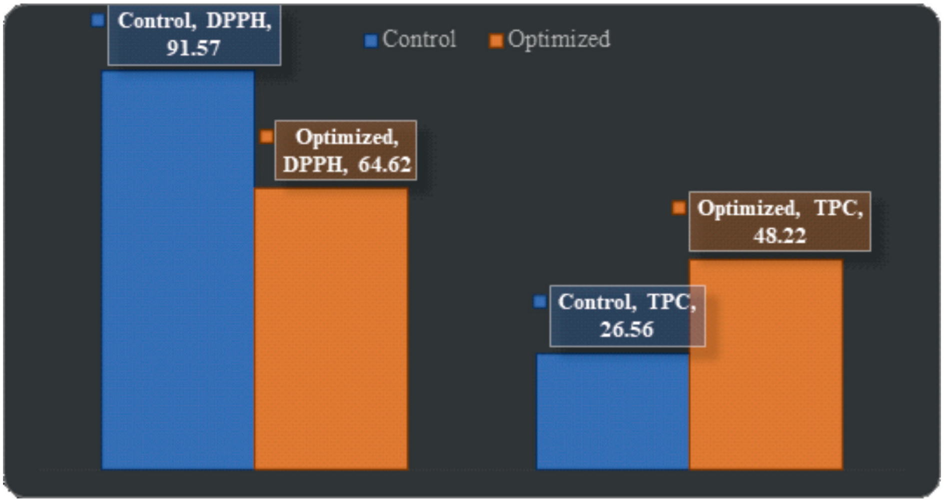

Figure 1: Graphical representations for Bioactive compounds present in Peapod green chili sauce

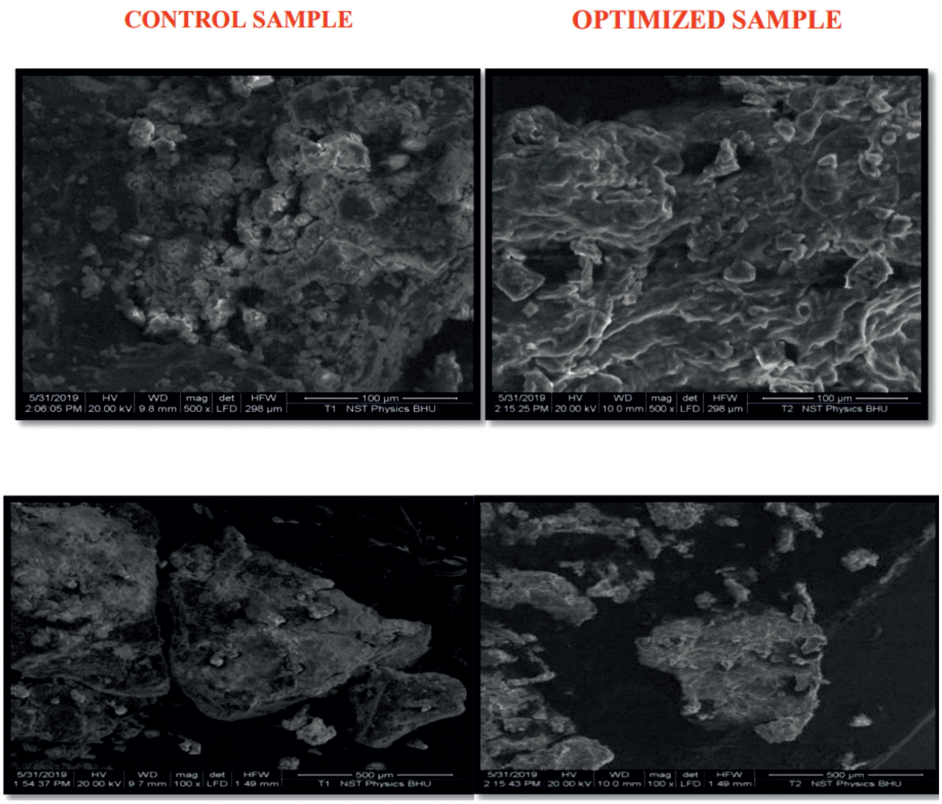

Figure 2: The morphology of both control and optimized green chilli sauce sample mag.100x and 500x

down into a fine powder and destroyed in the amorphous area. The optimized green chilli sauce powder almost matches the morphology of the control green chilli sauce powder, according to the comparative analysis. Our SEM images contradicted those of (Rudra *et al.* 2020) in "Manufacturing of mayonnaise with pea pod powder as a beneficial ingredient."

5. Conclusion

Based on the findings of this research, it is possible to draw the conclusion that the production of green chilli sauce that was regulated by pea pod powder possessed high sensory and textural features in addition to good functional capabilities. This study investigated the potential for additional research on pea pods to regulate green chilli sauce by isolating the starches in pea pods that can be used as a thickening agent in place of entire pea pod powder. The findings of this investigation have opened the door for further investigation. Although pea pods are typically regarded as waste material, they can be included for the production of items that are fortified with nutrients. The green chilli sauce that has been modified by Pea Pod Powder is a more affordable alternative to commercial sauce and has the potential to be rich in both nutrients and antioxidants, making it a nutritious option.

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