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Almond shell incorporated fibre rich biscuits

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ABSTRACT

The essence of the current study lies in the fact that almond shells are a cheap, widely accessible source of dietary fibre and bioactive compounds that have several positive health effects. The objective of the present study was to develop fibre-rich biscuits by incorporating almond shell powder in control biscuits formulation. The control biscuits were prepared in lab by using refined wheat flour, fat, water sugar, and sodium bicarbonate along with other ingredients. The almond shells were separated from almond fruits then defatted, dried and powdered for incorporation in control biscuits at various levels of 5%, 10%, 15%, 20%, 25%, and 30% by replacing refined wheat flour. The prepared almond shell powder was showing 45.2 % crude fibre. The prepared almond shell powder incorporated biscuits and control biscuits were analysed for different Physico-chemical and sensory parameters. The result revelled that as the level of incorporation of almond shell powder increased, the diameter, thickness, weight and volume of biscuit also increased and the density, spread ratio and spread factor decreased as compared to the control biscuit. The incorporation of almond shell powder found to elevate the crude fibre and ash of the control biscuits. The sensory evaluation of almond shell powder-fortified biscuits was done by 10 semi-trained panel members using 9 point hedonic scale. After control, the biscuits incorporated with 20% level of almond shell powder receive highest overall acceptability. The biscuit incorporated with 20 % almond shell powder found to contain 14.51 % fibre. The study thus concludes that it is possible to prepare acceptable quality fibre rich biscuits by incorporating maximum 20 % almond shell powder in the formulation of control biscuits.

Keywords : Almond shells, Fibres, Biscuits, Physico- Chemical Analysis

INTRODUCTION

The worldwide production of Almond in previous year 2021-22 was 1.68 Metric Tons [Shahbandeh M, 2022]. The major waste arising from almond fruit is almond shell. Almond shell contains a high amount of dietary fibres in the form of cellulose, hemicelluloses, and lignin (Ramos M, *et al*, and Barber T, *et al*, 2020). Recently Kalhaoui *et al*, 2022, prepared bread by incorporating 8% of almond shell powder into wheat flour and found that the prepared bread was acceptable, good in taste, safe for consumption and the good source of fibre at 26.66%. The intake of dietary fibres shows good health benefits in terms of microbial gut flora, colonic health, cardio-vascular diseases, and reducing severity of type-2 diabetes [Stephen, A, *et al*, 2017]. There should be daily intake of dietary fibre is 25–35 g/day (Prgomet, *et al*, 2017).

1.1 Almond Shell as a Source of Nutrients and Bioactive Compounds

The dried almond shell contains the highest amount of fibre that 25% along with a high sugar content from 18 -30% and Protein content around 8 % (Li X, *et al*, 2018). Mostly almond shells are used as livestock feed. Almond shells are found to be a good source of bioactive compounds and natural

antioxidants such as flavonol glycosides, phenolic acids (caffeine, ferulic, p-coumaric, and synaptic acids), triterpenoids (betulinic, urosolic, and oleanolic acids), catechin, vanillic acid, protocatechuic acid, and other polyphenolic compounds (Barral-Martinez, M, 2021, Wijeratne, S, *et al*, 2006 and Garcia-Perez, P, *et al*, 2021). The total polyphenolic content is comprised of between 35.9 and 166.7 mg GAE/g extract. The addition of almond shell powder reduces the risk of colon cancer in rats, reduces LDL cholesterol levels in humans, reduces DNA scission and metal ion chelation activities, and increases high-density lipoprotein cholesterol levels (Wijeratne, S, 2006, Barral-Martinez, M, 2021 and Manley, D. 2011).

1.2 Fibre-Rich Biscuits

The word biscuit was derived from the *Latin* word *twice biscotus,* which means *"twice cooked bread.* Initially, the biscuits were used on long maritime journeys and were made up of only flour, water, and sugar (Parate, V, *et al*, 2019). Biscuits are loved by all aged group people because it is ready to eat, good in test and available in minimum price (Ranganna S, 1986). Now a day, the biscuits are made up of various ingredients such as refined wheat flour, fat, sugar, flavour, salt, liquid glucose, milk, chocolates, fruit, nuts, etc. as per the customer's requirement. Almond shells are a cheaply available source of Dietary fibres along with natural antioxidant and bio- active compounds which possess several health benefits. In the market survey it was found that the peoples are purchasing fibre rich biscuits of different brands, like oat bran, rice bran, wheat bran and corn bran, etc., to fulfil the requirement of Dietary fibres. Almond shells are cheap and easily available source of dietary fibres hence the aim of the said work was decided to develop fibre rich almond shell biscuit to minimize the bio degradable waste and to introduce new fibre rich biscuit in the market to satisfy the nutrient requirement. The addition of almond shell fibres in biscuits may help to treat several health issues like laxation, blood pressure, appendix, obesity and diabetes (Pawde S, *et al*, 2020 and J. W. Anderson, *et. al.*, 2009). The aim of the present work was to develop fibre-rich biscuits by incorporating almond shell powder in the formulation of control biscuits.

MATERIALS AND METHODS

The different raw materials and chemicals required for the preparation of almond shell biscuits are Almond Shells (Gurbandi Hard Shell Almonds, origin – Jammu and Kashmir, India), Refined Wheat Flour (Samrat), Liquid Glucose (Bake King), Inverted Sugar Syrup (Purix), Ammonium Bicarbonate (Bake King), sugar (Madhur), Distilled water, baking powder (Purix), skimmed milk powder (Nestle), fat (Amul Butter), salt (Tata), and flavour (Vanilla-Flying Bird). All the required materials were purchased from the local market in Jalgaon.

2.1 Preparation of Defatted Almond Shell Powder

The almond shells were defatted using petroleum ether in Soxhlet assembly (Remi- Soxhlet Assembly) for 16 to 18 hours. The defatted almond shell sample was collected and kept in a Hot air oven (Lab Hosp- Hot Air Oven) at 105 °C for 4 hours for the purpose of drying. The defatted, dried sample of almond shells was ground in a home grinder (Jyoti Mixer) and sieved with a 105-micron sieve to obtain a uniform particle size. The prepared almond shell powder was stored in HDPE bags for further use.

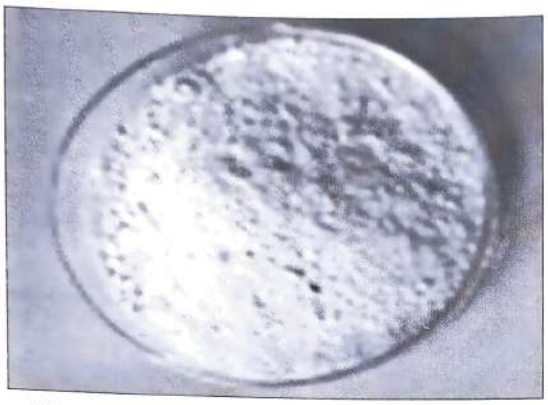

Fig 1: Almond Shell Powder

Figure 1, shows the image of prepared Almond Shell Powder at laboratory level which was light brown in colour.

2.2. Preparation of the Control Almond Shell Biscuit

The control biscuits were prepared in the laboratory using refined wheat flour. The ingredients and processing parameters used for the preparation of control biscuits are given in Tables 1. All the processing parameters were set by trial-and-error method and finalized as Pre-mixing time: 10 min, Finalize Mixing time: 10 min, Holding time: 10 min, Forming Dough Weight was 9.5 gm, Forming Dough Diameter was 55 mm, Forming Dough Thickness: 5.6 mm, Baking Temperature: 180°c and Baking Time: 13 min.

Table 1: Formulation of Control Biscuits

Ingredients	Quantity
Refined wheat flour (gm)	200
Fat (gm)	80
Sugar (gm)	120
Water (ml)	48
Invert Sugar Syrup (gm)	20
Flavour (ml)	0.8
Ammonium Bicarbonate (gm)	0.2
Salt (gm)	1
Liquid Glucose (gm)	20
Skimmed Milk Powder (gm)	16
Sodium Bicarbonate (gm)	6

Figure 2: Control Biscuits

The image of prepared Control Biscuit is shown in Figure 2. The control biscuit was made by using refined wheat flour that is without incorporating almond shell powder.

2.3. Preparation of Almond Shell Fortified Biscuits

In the preparation of almond shell fortified biscuit, the prepared almond shell powder was added in the formulation of control biscuits to the level of 5%, 10%, 15%, 20%, 25%, and 30% by replacing maida.

There was no difference in the amount of other ingredients added to the formulation and process parameters compared to the control biscuit (almond shell). Since the surface of the biscuits with almond fibre in them was found to be drier than that of the control biscuits, hence the additional water was added in the formulations of almond shell incorporated biscuits. The amount of water in the control biscuit formulation was steadily increased as the level of fibre incorporation raised. The fortified biscuits then underwent physical, chemical, and sensory tests.

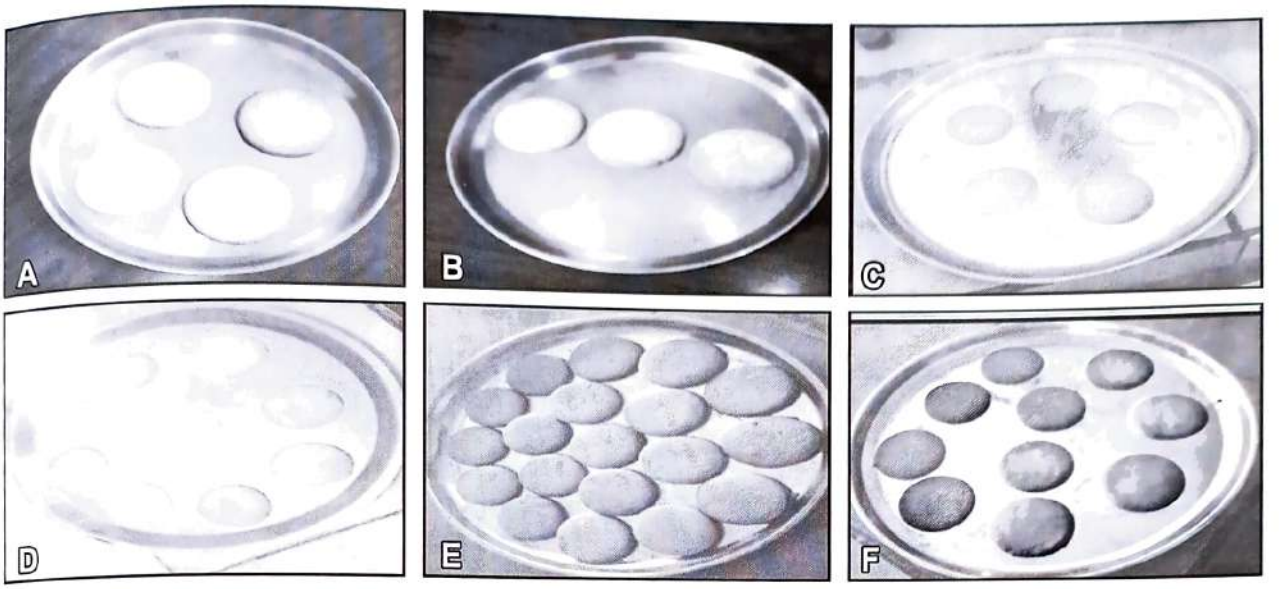

Figure 3: Almond Shell Powder Incorporated Biscuits

Figure 3, illustrates the biscuits incorporated with various levels of almond shell powder. Image A, B, C, D, E and F is representing biscuits incorporated with almond shell powder to the level of 5%, 10 %, 15 %, 20 %, 25 % and 30 % respectively

2.4. Evaluation of Prepared Biscuits

Using the standard testing protocols outlined in Ranganna 1986, the prepared almond shell biscuits were examined for various chemical parameters like, Moisture Content (Lap Hosp- Hot Air Oven), Ash (Muffle Furnace- Sisco India 220- 230 Volts), Fibre (Pelican Crude Fibre Analyzer FES04AS), Fat (Remi- Soxhlet Assembly), Protein (Pelican Protein Analyzer- KES04LVA), Energy, and Carbohydrates (By Difference Method). The sensory evaluation of prepared control and almond shell-incorporated biscuits was done by 10 semi-trained panel members. The analysis was done by judging taste, texture, colour, aroma, and overall acceptability, and ratings were given from 1 to 9 on the basis the hedonic scale.

2.5. Physical Analysis of Almond Shell Biscuits

According to the procedures outlined by *Parate et al. (2016)*, the physical analysis of the biscuits was carried out based on their weight, thickness, diameter, spread ratio, volume, density, etc.

2.5.1 Weight (gm):

The weight of 5 Biscuits were taken in grams and mean was calculated along with standard deviations. The Mettler Toledo (ME204/A04) weighing balance was used for weighing purpose.

2.5.2 Thickness and Diameter (mm)

The Vernier calliper (Aero Space) was used for measuring the thickness and diameter of prepared biscuits at laboratory level.

2.5.3 Spread Ratio (%)

The spread ratio of biscuits was calculated by dividing diameter of biscuit by the thickness of biscuit.

2.5.4 Spread Factor (%)

The spread factor of prepared biscuit was calculated as percentage with spread ratio of biscuit divided by the spread ration of control biscuit.

2.5.5 Volume (cm^3)

The volume of biscuit was determined by following given formula:

Volume of Biscuit $= \frac{Td^2\Pi}{4}$

Where,

d= Diameter of biscuit, T = Thickness of biscuit

2.5.6 Density (g/cm^3):

Density was calculated as the ratio of weight of biscuit to the volume of biscuit

RESULTS AND DISCUSSIONS

Table 2, displaying the powdered almond shell analytical results. The study of almond shell powder revealed that it included 5.02% of protein, 0.55% of pectin, 32.44% of hemicelluloses, 4.24% of lignin, and 28.22% of cellulose. The high amount of dietary fibres in almond shell powder was demonstrated by the analytical findings; as a result, it was appropriate to add it to the control biscuit to boost the level of fibres and their health benefits.

Table 2 : Analysis Results for Almond Shell Powder

Analysis	Almond Shell Powder
Moisture Content%	6.50± 2.73
Ash %	1.32± 0.024
Protein %	5.02± 0.091
Carbohydrate%	41.60± 5.06
Reducing Sugar %	1.29± 0.11
Non-reducing sugar%	4.90 ±0.21
Total Sugar%	6.19±0.019
Crude Fibre%	45.20±0.03
Cellulose %	28.22± 3.67
Hemicellulose %	32.44± 2.97
Lignin %	14.24± 0.06
Pectin %	0.55± 0.08

All values are means of three determination± standard deviation (±SD)

Table 3 is showing the impact on the physical aspect of control biscuits at various degrees of almond shell powder incorporation. Following addition of almond shell powder to the control biscuits, it was found that the diameter, thickness, volume and weight of all the almond shell powder incorporated biscuits were greater than the control biscuits. It was further observed that the diameter and weight of almond shell biscuits was increasing with increasing level of almond shell incorporation, whereas the volume was decreasing with increasing level of almond shell incorporation. The thickness was high with low level and less with high level of incorporation of almond shell powder in the formulation of control biscuits. Biscuits' spread ratio and spread factor were increases. The spread ratio, spread factor and density of all the almond shell incorporated biscuits were found to be less than the control biscuits. The similar results were observed by Huma Parvin, et al, 2017.After development of fibre rich biscuits by incorporating carrot and beetroot pomace powder. However the lowest spread ratio, spread factor and density were observed with low incorporation level (5 %) and highest spread ratio, spread factor and density was observed with high incorporation level (30 %). The physical results thus concluded that almond shell incorporated biscuits had greater diameter, thickness, volume and weight than control biscuits and less spread ratio, spread factor and density than control biscuits. However magnitude of increase and decrease in these physical parameters were the function of level of incorporation of almond shell in the formulation of control biscuits.

Table 3 : Effect of Different Levels of Almond Shell Powder Incorporation on the Physical Analysis of Control Biscuits

Parameters	Level of Almond Shell Fortification						
	0%	5%	10%	15%	20%	25%	30%
Diameter (mm)	55.23 ± 0.23^{a}	55.51 ± 0.20^{a}	55.54 ± 0.13^{a}	55.62 ± 0.22^{b}	55.65 ± 0.21^{b}	55.91 ± 0.21^{c}	55.96 ± 0.20^{c}
Thickness (mm)	5.20 ± 0.24^{a}	5.94 ± 0.2^{b}	5.89 ± 0.15^{b}	5.78 ± 0.22^{c}	5.56 ± 0.16^{d}	5.53 ± 0.12^{d}	5.51 ± 0.28^{d}
Spread Ratio (%)	10.62 ± 0.12^{a}	9.34 ± 0.03^{b}	9.42 ± 0.21^{b}	9.62 ± 0.33^{c}	10.00 ± 0.81^{d}	10.11 ± 0.74^{d}	10.15 ± 0.93^{d}
Spread factor (%)	100 ± 0.02^{a}	87.94 ± 0.04^{b}	88.70 ± 0.08^{c}	90.58 ± 1.2^{d}	94.16 ± 0.45^{e}	95.19 ± 0.33^{f}	95.57 ± 1.02^{f}
Volume (cm^3)	4.50 ± 0.13^{a}	5.14 ± 0.38^{b}	5.05 ± 1.20^{b,c}	4.97 ± 0.38^{c}	4.80 ± 1.84^{d}	4.82 ± 1.28^{d}	4.82 ± 0.43^{d}
Density (g/cm^3)	1.85 ± 0.10^{a}	1.63 ± 0.2^{a,b}	1.68 ± 0.11^{b,c}	1.72 ± 0.15^{c,d}	1.79 ± 0.11^{d}	1.80 ± 0.24^{d,e}	1.82 ± 0.17^{e}
Weight (g)	8.34 ± 0.06^{a}	8.41 ± 0.13^{a,b}	8.49 ± 0.15^{b,c}	8.57 ± 0.02^{c,d}	8.62 ± 0.15^{d,e}	8.71 ± 0.41^{e}	8.80 ± 0.22^{g}

All values are the means of ten biscuits determination ±standard deviation (SD) Means not sharing a common superscript letter in a row are significantly different at $p<0.05$ as assessed by t-Test.

Table 4 shows the effect of different levels of almond shell powder incorporation on the chemical parameters of control biscuits. The moisture content of all almond shell incorporated biscuits was slightly greater than control biscuits but as the level of incorporation of almond shell powder increased the moisture content of biscuits was decreasing. The level of fat content, protein content, carbohydrate and Energy of almond shell incorporated biscuits were slightly decreasing as compared to control biscuits due to increased in the level of almond shell incorporation. The level of fibre content and ash content was increasing in almond shell incorporated biscuits as compared to the control biscuits because the almond shell contained a high level of fibre. While no significant changes were observed in acid insoluble ash or acidity of extracted fat. Similar result was also observed in Study of Whey Protein Concentrate Fortification in Cookies Variety Biscuits by Parate et al, 2011.

Table 4: Effect of Different Levels of Almond Shell Powder Incorporation on the Chemical Analysis of Control Biscuits

Parameters	Level of Almond Shell Fortification						
	0%	5%	10%	15%	20%	25%	30%
Moisture Content (%)	3.2 ± 2.12^{a}	3.62 ± 1.21^{b}	3.59 ± 1.38^{b}	3.44 ± 2.35^{b}	3.3 ± 0.7^{a,b}	2.97 ± 0.56^{c}	2.56 ± 3.47^{d}
Ash (%)	0.36 ± 0.01^{a}	0.38 ± 0.02^{a}	0.38 ± 0.02^{a}	0.39 ± 0.01^{a,b}	0.44 ± 0.02^{b}	0.52 ± 0.0^{b}	0.61 ± 0.01^{c}
Fat (%)	21.41 ± 0.72^{a}	19.9 ± 0.27^{a}	19.85 ± 0.70^{a}	19.78 ± 0.05^{b}	19.65 ± 0.01^{b}	19.56 ± 0.01^{b}	19.47 ± 0.06^{b}

Parameters	Level of Almond Shell Fortification						
	0%	5%	10%	15%	20%	25%	30%
Acidity of Extracted Fat (%)	0.27 ± 0.5 [a]	0.29 ± 0.04 [a]	0.30 ± 0.04 [a]	0.28 ± 0.08 [a]	0.32 ± 0.04 [a]	0.30 ± 0.06 [a]	0.28 ± 0.03 [a]
Crude Fibre (%)	1.28 ± 0.02 [a]	4.56 ± 0.2 [b]	7.89 ± 0.15 [c]	11.23 ± 0.004 [d]	14.51 ± 0.04 [e]	17.60 ± 0.17 [f]	20.87 ± 0.25 [g]
Protein (%)	8 ± 0.25 [a]	7.88 ± 0.01 [a]	7.62 ± 0.05 [a, b]	7.44 ± 0.21 [b]	7.06 ± 0.08 [b, c]	6.88 ± 0.06 [c]	6.72 ± 0.11 [c]
Carbohydrates (By differ.) (%)	65.67 ± 5.02 [a]	63.66 ± 5.00 [a]	60.67 ± 4.87 [b]	57.72 ± 2.23 [c]	55.04 ± 0.11 [d]	52.47 ± 4.32 [e]	50.22 ± 1.22 [f]
Acid Insoluble ash (%)	0.031 ± 0.21 [a]	0.023 ± 0.01 [a]	0.026 ± 0.24 [a]	0.029 ± 0.31 [a]	0.024 ± 0.12 [a]	0.030 ± 0.12 [a]	0.026 ± 0.10 [a]
Energy Kcal/ 100 gm	477.62 [a]	468.74 [b]	459.73 [c]	450.90 [d]	443.29 [d]	433.20 [e]	417.15 [e]

All values are the means of ten biscuits determination ±standard deviation (SD) Means not sharing a common superscript letter in a row are significantly different at $p<0.05$ as assessed by t-Test.

The sensory analysis, of almond shell incorporated biscuits is shown in Table 5. The highest overall acceptability score was received by the biscuits incorporated with 20% almond shell- next to control biscuits. Afterward, the sensory score declined up to the 30% almond shell incorporated biscuit. It was observed that as the level of incorporation of almond shell powder increased, it lead to the formation of roughage on the surface of the biscuit due high amount of fibres. Also there developed slight inferior taste and darkening of colour biscuits with increasing level of almond shell incorporation. This roughness of surface, inferior taste and darkening in colour was the cause for less sensory score received by biscuits incorporated with high level of almond shell Lebesi, D.M. and Tzia, C. 2011

Table 5: Effect of Different Levels of Almond Shell Powder Incorporation on the Sensory Analysis of Control Biscuits

Parameters	Control	5%	10%	15%	20%	25%	30%
Aroma	8.5±0.20	8.5±0.02	8.3±0.10	8.2±0.07	8.4±0.05	7.6±0.91	7.4±0.44
Colour	8.9±0.41	8.4±0.21	8.3±0.32	8.4±0.40	8.4±0.11	8.2±0.25	7.9±0.04
Texture	8.6±0.5	8.8±0.45	8.7±0.41	8.6±053	8.6±0.22	8.3±0.11	8.1±0.17
Taste	8.7±0.23	8.2±0.61	8.2±0.13	7.8±0.55	8.3±0. 8	7.2±0.12	7±0.03
Appearance	8.8±0.06	8.5±0.30	8.2±0.24	7.7±0.20	8.4±0.12	7.7±0.21	7.4±0.04
Overall Acceptability	8.9±0.5	8.2±0.22	8±0.0	8.1±0.00	8.4±0.17	7.2±0.50	7.1±0.2

All values are means of ten determination± standard deviation (SD)

CONCLUSION

Followings are the conclusions drawn from the said study:

1. The powder made from defatted almond shells was a rich source of fibre and it is possible to prepare acceptable quality fibre rich biscuits by its incorporation in the formulation of control biscuits.
2. Incorporation of almond shell powder however brings changes in the various

parameters (physical, chemical and sensory) of control biscuits depending on the level of incorporation.

3. The incorporation of almond shell powder from 5% to 30% level in control biscuits brings an increase in diameter, thickness, volume and weight and decrease in spread ratio, spread factor and density of the control biscuits from 30% to 5% level.
4. Almond shell incorporation however doesn't bring much deviation in chemical parameters except increase in fibre content from 1.28 to 20.87% from in control biscuits.
5. When incorporated at high level that is more than 25% addition of almond shell powder brings unacceptable impact on sensory measures such as hardness, colour darkening and inferior taste.
6. The maximum level of almond shell powder that can be incorporated in the given formulation of control biscuits is 20%.

The further study on Almond Shells should be done to evaluate the presence of vitamins and minerals content and to develop various bakery products, snacks and fermented products and beverages, etc. The potential application towards the utilization of Almond shells can be helpful for almond industries to build up the successful economy by re-utilizing almond shell as a by- products for the production system.

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