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Effect of processing on nutritional and antinutritional composition of *bathua* (*Chenopodium album*) leaves

Gaganpreet Kaur*
Junior Dietician, Hero DMC Heart Institute, Ludhiana (Punjab), India
Navjot Kaur
Department of Food and Nutrition, Punjab Agricultural University, Ludhiana-141004 (Punjab), India

*Corresponding author. E-mail: diljotbasra19@yahoo.in

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Abstract
Bathua (*Chenopodium album*) leaves were undertaken for different processing techniques and analyzed for their nutritional and anti-nutritional composition. Effect of processing on nutrient retention was assessed to attain the best processed form of leaves with maximum amount of nutrients. It was observed that the Cabinet dried processing improved the protein, fibre and ash content of leaves by 29.30, 5.74 and 16.42 percent respectively. Shade and cabinet dried technique improved the vitamin C and β-carotene by 34 and 14323 percent respectively. Maximum retention of calcium and iron was found in cabinet dried technique. It also improved magnesium by 254.50 percent. Amino acid retention was found maximum in cabinet dried technique. Cabinet dried technique improved *In vitro* protein digestibility by 27.75 percent with a decrease of 116.15 and 85.30 percent in phytates and oxalates respectively. Maximum retention of nutrients was observed in cabinet dried technique.

Keywords: Anti-nutrients, *Bathua* leaves, Nutritional composition, Nutrients, Processing

INTRODUCTION

Chenopodium album belongs to the family Chenopodiaceae, a fast-growing weedy annual plantand is largely cultivated in agricultural land and gardens and it is distributed all over South East Asia. It is mostly found around the areas of Sikkim, Mumbai, Kashmir and throughout Pakistan. It is commonly called 'white goose foot', whereas in Pakistan's local language, it is called*'bathua'*. It can be used in traditional recipes and consumed as a food product. The leaves of this plant are often used in cooking as they are extremely nutritious and also play a vital role in therapeutic nutrition (Ahmad *et al.,* 2012).

Due to its health promoting benefits*, C. album* has been considered as an important nutritional and medicinal plant in Ayurveda. It helps in diseases of blood, heart, spleen, eye and biliousness conditions, cough, abdominal pain, pulmonary obstruction and in nervous affections. Pharmacological studies on the plant reveals the proven activity of its as hypoglycemic, antibacterial, spasmolytic, antipruritic, anti-inflammatory, hepatoprotective, antioxidant and anticancer properties (Sikarwar*et al*., 2013).

The leaves of *bathua* contain various nutrients such as moisture (89.65%), protein (3.7%), fat (0.4%), other carbohydrates (2.9%). It is good source of thiamine (0.01mg), niacin (0.6 mg), vitamin C (35 mg), β-carotene (1.470 µg) per 100 gram along with traces of iodine, fluorine, and vitamin K. It is also a good source of calcium (15 mg /100g) and phosphorus (8 mg /100g) which helps in maintaining strong bones and has also role in cell signaling, blood clotting, muscle contraction and nerve function. Iron (4.2 mg/100g) in the leave soften helps to cure mild anemic conditions, especially in children. The leaves also contains essential amino acids like leucine, isoleucine, lysine, methionine, phenylalanine, threonine, valine and tryptophan (Pandey and Pathak 2009). The phytochemical content of *bathua* was analyzed and found to be very promising. On dry weight basis, the values of saponins (0.46g/100g) and crude alkaloids (9.7g/100g) were determined. Alkaloids acts as antispasmodic and analgesic agents while saponins help in promoting the immune system, in decreasing cholesterol levels in the blood. Various studies have revealed that phenolic compounds favours beneficial health effects. Phenolics scavenge the free radicals that provide the plants with defense mechanisms in order to prevent from harmful health effects by microorganisms and insects. Flavonoids show a wide range of biological activities such as inhibition of cell-proliferation, induction of apoptosis (cell death) and other antibacterial and antioxidant effects (Pandey and Gupta, 2014). It can be saidlike leaves can be used to combat calcium, iron and

vitamin A deficiency as they are good source of micronutrients.

Since, it is uncommon, underutilized crop (Hernandez and Leon 1994) which is not used regularly in Indian homes because of the unawareness of people. In India the leaves are used either in raw or processed forms. Processing by different techniques (sun, shade, solar, cabinet drying) reduce the moisture content, enhance its shelf life, improve its quality, preserve and enhance its nutritional quality, makesit available throughout the year even in off season thus supplying the important nutrients in concentrated form (Gupta *et al*. 2011). In India, no study has been conducted which evaluated the effect of different processing techniques on the nutritional quality of leaves. So keeping all the points in view, a study has been carried out to evaluate the effect of different processing techniques on the nutritional and anti-nutritional quality of the leaves and to findout the best method to use leaves with maximum nutrients for its better utilization. The study will be helpful in popularizing the leaves and their nutritional benefits and prove a good choice for combating malnutrition in developing countries like India.

MATERIALS AND METHODS

Procurement and processing of leaves

Procurement of sample: Fresh (*Chenopodium album*) have been procured from the Department of Agronomy, Punjab Agricultural University Ludhiana. The fresh leaves were thoroughly washed, dried and used for the study.

Dehydration of leaves

Sorting and washing of leaves: *Bathua* leaves sorted with healthy leaves were washed thoroughly by dipping in water for one minute. The procedure was repeated till the leaves were devoid of dirt and soil.

Blanching and dehydration of fresh leaves: The leaves were blanched for 1-2 minutes and dried by various techniques such as sun drying, shade drying, solar drying and in cabinet drier (60°C for 10-12 hours) till moisture content reaches to 6-7%.

The dehydrated leaves were powdered and packed in low density polythene bags and stored in air tight containers until used for chemical analysis. Effect of processing leaves has been studied by comparing chemical composition of fresh and processed leaves.

Nutritional analysis

Proximate composition: Proximate composition viz. moisture, crude protein, crude fat, crude fibre, ash was analyzed by standard methods (AOAC,2000). The moisture content of raw and processed leaves were determined by drying the samples in cabinet drier at 105ºC. Protein (N × 5.30) (Swaminathan, 1974) was calculatedby determining total nitrogen employing Micro Kjeldahl method (Kel Plus Classic, Pelican Equipment Inc., India). Crude fat was extracted with petroleum ether, using Socs Plus and for fibre, acid alkali washing was given in Fibra Plus Apparatus (Pelican Equipment Inc., India). The available carbohydrates were calculated by adding the value of moisture, crude protein, crude fat, fibre and ash which was then subtracted from 100.. Gross energy was computed with the help of formula mentioned below

Gross Energy = (Crude protein× 4) + (Crude fat × 9) + (Carbohydrate × 4)

Vitamin content: The individual carotenoids were determined spectrophotometrically and separated on a column of calcium hydroxide of alumina (Rangana, 1995) and vitamin C was estimated through reduction of dye (AOVC,1996).

Total minerals: For minerals, the samples were wet digested in hot plate using nitric acid and perchloric acid mixture in 5:1 ratio (v/v) and used for the determination of total amount of calcium, iron, magnesium and zinc by atomic absorption spectrophotometry (AOAC, 2000).

Amino acids estimation: Extraction of sulphur amino acids was done by hydrolysing the samples in autoclave for 6 h at 15 lb pressure. After filtration, hydrolyzed samples were used for the determination of methionine (Horn, Jones and Blum, 1946), Lysine was assessed by method of Booth (1971) and estimation of tryptophan was done by Concon (1975).

***In vitro* protein digestibility:** *In vitro*protein digestibility was assessed by Akeson and Stachman (1964) method. The samples were digested with pepsin solution followed by pancreatin solution and incubated at 37ºC for 24 h. The residue was analysed for nitrogen content by MacroKjeldahl method. The digestibility co-efficient of the protein was determined by subtracting the residual protein from the initial protein on the basis of 100g of the sample.

Antinutritional factors: Oxalic acid was estimated by titring oxalates containing sulphuric acid against potassium permanganate as given by Abeza *et al* (1968) and extraction of phytin phosphorus was determined by employing hydrochloric acid and keeping the solution for 3 h. Amount of phytin phosphorus was calculated by using 2, 2 bipyridine solution on spectrophotometer (Haug and Lantzsch, 1983).

Statistical analysis: The values were taken in triplicate and the results are given in mean ± standard deviation. Data were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 16.0. Tukey test was used to compare the significant differences in mean values obtained after processing of *bathua* leaves. Level of significance was expressed at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition of fresh and dehydrated *bathua* leaves has been in Table 1.

The protein content of fresh *bathua* leaves was found to be 3.20 percent while with dehydration this value was increased. Maximum protein was found in cabinet dried leaves i.e.31.20percent. Maximum decrease in protein content was analyzed with shade (26.50%), followed by solar (28.55%) and sun dried (29.30%). Significant difference was found among all treatments including fresh leaves($p \leq 0.05$). The value of protein content of fresh and dehydrated leaves was almost agreement with Singh *et al*. (2007) who reported 3.7 and 32.95 percent protein respectively.

Sun dried leaves were found to have maximum fat content of 1.62 percent whereas fresh leaves have 0.55 percent. Minimum fat content was found in shade dried leaves. The value of fat content of fresh and dehydrated was almost similar with the results of Singh *et al*. (2007) who reported 0.63 percent and 1.16 percent fat respectively.

Fibre content of fresh leaves was recorded lower (1.05%) than that of reported value (11%) by Vishwakarma and Dubey (2011). There was significantly ($p \leq 0.05$) increase in the fibre content of dehydrated leaves and maximum content of fibre was found in cabinet dried leaves (6.20%) followed by sun (5.74%), solar (5.05%) and shade (4.83%) dried leaves.

On dehydration, there was significant ($p \leq 0.05$) increase in ash content, however maximum increment was found in cabinet dried leaves i.e.17.45 percent as compared to fresh leaves i.e. 2.06 percent. The values agreewith the findings of Kowsalyaand Vidhya (2004) who reported 2.1 g/100g in fresh and 12 g/100g (Sun dried), 14 g/100g (Shade dried) and 15 g/100g (Cabinet dried)Arai kerrai leaves.

Carbohydrate content of fresh leaves was found to be 93.15 g while with sun, shade, solar and cabinet dried leaves, these values were estimated as 46.94, 54.43, 49.19, 44.26g respectively. The re-

Table 1. Effect of processing on the proximate composition of fresh and dried leaves of bathua by different techniques (DM basis).

Treatment	Moisture (%)	Crude protein(%)	Crude fat(%)	Crude fibre(%)	Total ash(%)	CHO* (g)	Energy** (Kcal)
Fresh leaves	86.7±0.71	3.20±0.14	0.55±0.7	1.05±0.7	2.06±0.04	93.15±0.18	390.33±0.78
Dehydrated leaves							
Sun dried	9.35±0.35	29.30±0.14	1.62±0.05	5.74±0.09	16.42±0.23	46.94±0.05	319.48±0.32
Solar dried	8.77±0.18	28.55±0.21	1.40±0.18	5.05±0.11	15.83±0.29	49.19±0.22	324.61±0.05
Shade dried	10.3±0.76	26.50±0.57	0.73±0.07	4.83±0.09	13.52±0.06	54.43±0.49	329.55±0.08
Cabinet dried	8.19±0.10	31.20±0.14	0.90±0.01	6.20±0.11	17.45±0.04	44.26±0.19	309.55±0.20
f value	8.657*	74.613*	35.287*	80.602*	154.234*	458.536*	3925.631*

Values are expressed as Mean ± SE, * Significant at 5% level, Samples were taken in triplicate, * Carbohydrate = 100 _ (Protein + Fat + Fibre + Ash), ** Energy = (Protein × 4) + (Carbohydrate × 4) + (Fat × 9).

Table 2. Effect of processing on vitamin content of fresh and dried leaves of bathua by different techniques (fresh weight basis).

Treatment	Vitamin C (mg/100g)	b-carotene (µg/100g)
Fresh leaves	37.00±1.41	1700.00±15.56
Dehydrated leaves		
Sun dried	26.00±2.83	12892.50±2.12
Solar dried	32.00±1.41	11604.50±9.19
Shade dried	34.00±2.83	13990.00±4.24
Cabinet dried	21.00±1.41	14323.50±3.54
f value	45.467*	160.54*

Values are expressed as Mean ± SE; * Significant at 5% level, Samples were taken in triplicate.

Table 3. Effect of processing on the mineral content of fresh and dried leaves of bathua different techniques (DM basis).

Treatment	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)	Zinc (mg/100g)
Fresh leaves	142.50±2.12	4.15±0.35	53.50±2.12	0.50±0.14
Dehydrated leaves				
Sun dried	654.50±3.54	22.28±0.01	191.50±0.71	1.61±0.04
Solar dried	549.00±2.83	21.67±0.02	157.00±1.41	1.49±0.03
Shade dried	691.00±2.83	24.45±0.05	222.50±2.12	1.98±0.03
Cabinet dried	745.50±6.36	26.53±0.03	254.50±2.12	1.84±0.03
f value	797.005*	10063.556*	1213.957*	107.995*

Values are expressed as Mean ± SE; * Significant at 5% level; Samples were taken in triplicate.

Table 4. Effect of processing on the amino acid content of fresh and dried leaves of bathua by different techniques (DM basis).

Treatment	Methionine (mg/100g)	Tryptophan (mg/100g)	Available Lysine (mg/100g)
Fresh leaves	42.00±1.41	25.00±2.83	703.50±10.61
Dehydrated leaves			
Sun dried	297.00±1.41	154.00±4.24	810.00±1.41
Solar dried	271.50±2.12	141.00±2.83	826.50±4.95
Shade dried	262.50±2.12	73.50±2.12	796.50±0.71
Cabinet dried	341.50±3.54	169.50±3.54	853.50±4.95
f value	426.745**	332.930**	93.524**

Values are expressed as Mean ± SE;* Significant at 5% level; Samples were taken in triplicate.

Table 5. Effect of processing on the *in vitro* of fresh and dried leaves of bathua by different techniques (DM basis).

Treatment	*In vitro* protein digestibility (%)
Fresh leaves	10.51±0.40
Dehydrated leaves	
Sun dried	25.20±0.14
Solar dried	25.80±0.14
Shade dried	26.25±0.21
Cabinet dried	27.75±0.07
f value	105.333*

Values are expressed as Mean ± SE, * Significant at 5% level, Samples were taken in triplicate.

sults are in agreement with the work of other researchers (Vishwakarma and Dubey, 2011) who reported 54.04 g of carbohydrates in fresh leaves. On the other hand, Pandey and Pathak (2009) reported 4.9 g carbohydrate content in fresh leaves whereas Singh *et al*. (2007) reported the carbohydrate content of leaves to be 5.36 g /100g and for dehydrated leaves it was 34.36 g/100g.

A negligible difference was found between the calculated value of energy of raw (390.33 kcal) and processed samples i.e. sun (319.48 kcal/100 g), shade (329.55 kcal), solar (324.61 kcal) and cabinet (309.55 kcal)/100 g dried leaves. Vishwakarma and Dubey(2011) reported energy value of leaves as 271.4 kcal per 100 g of leaves.

Vitamin content: Vitamin C content (Table 2) of fresh leaves was estimated to be 37mg/100g. On dehydration, the amount of ascorbic acid was decreased in comparison to fresh leaves. This value was quite similar to the value given by Raghuvanshi *et al*. (2009) reported the nutritional composition of uncommon foods and found that ascorbic acid ranged between 3.26 to 173.13 mg/100g. The ascorbic acid ranged between 21 (cabinet dried) to 34 (shade dried) mg/100g in dehydrated leaves. Joshi and Mathur (2010) reported that fresh drumstick leaves had 220 mg/ 100 g of ascorbic acid. The leaf powder prepared by different methods of dehydration had ascorbic acid 92 mg/100g (sun dried), 140 mg/100g (shadow dried) and 56 mg/100g (oven dried) leaf powder. The amount of ascorbic acid was maximum in shadow dried sample as the leaves were not exposed to direct heat and air in this technique.

The β-carotene contentof fresh leaves was evaluated as 1700 µg /100g. Dehydrated leaves were more concentrated source of β-carotene than fresh leaves. This value was comparable to the value mentioned by Singh *et al*. (2007) who reported β-carotene content of dehydrated leaves as 14826 µg/100g which was 6-8 times greater than fresh values. The maximum retention of β-carotene was observed in cabinet drying technique i.e. 14323.50µgfollowed by shade (13990.00 µg), sun (12892.50 µg) and solar drying technique (11604.50) /100g. Dutta *et al*. (2005) reported that blanching increases the beta carotene content perhaps because of greater chemical extractability and loss of moisture and soluble solids which further concentrate the sample. Inactivation of certain oxidative enzymes takes place and it results in the breakdown of some structures leading to a higher net bioavailability of beta-carotene.

Mineral content: Fresh leaves showed 142.50 mg calcium (Table 3) which was found close to the value mentioned by Uusiku*et al*. (2011) and Kowsalya and Vidhya (2004) for calcium. Post processing enhanced calcium contentof leaves significantly ($p \leq 0.05$). Dehydration of leavesleads to concentration of calcium by 4 to 5 folds. Maximum increment was observed by cabinet, followed by shade (691.00 mg), sun(654.50 mg) and solar (549.00 mg) /100g dried technique.

Fresh leaves have an iron content of 4.15 mg/100g where as the iron content (Table 3) of the leaf powder prepared by different methods of dehydration (Sun, Shade, solar and cabinet) was estimated to be 22.28 mg/100g (Sun dried), 24.45 mg/100g (Shade dried), 21.67 mg/100g (solar dried) and 26.53 mg/100g (cabinet dried) which was 95 to 96% more than their fresh counter parts. Laxmi and Kohila (2007) reported the results similar to analysed values. The iron content of fresh Agathi was 3.9 mg/100g. On dehydration, the iron content raised to 22.7 mg/100g (Sun dried), 25.3 mg/100g (Shade dried) and 24.6 mg/100g (Cabinet dried). On the other side, Singh *et al*. (2007) reported 5.76 mg/100g of iron in fresh leaves.

Table 6. Effect of processing on the anti nutritional factors of fresh and dried leaves of bathua by different techniques (DM basis).

Treatment	Phytates	Total phenols	Oxalates
Fresh leaves	250.00±2.83	214.00±4.24	162.50±2.12
Dehydrated leaves			
Sun dried	143.49±0.07	179.50±2.12	115.35±0.21
Solar dried	138.27±2.05	165.75±1.77	126.20±0.28
Shade dried	178.73±1.06	138.27±1.41	131.50±0.42
Cabinet dried	116.15±1.48	153.40±0.57	85.30±0.42
f value	832.6*	2583.755*	72506.787*

Values are expressed as Mean ± SE, * Significant at 5% level, Samples were taken in triplicate.

Magnesium content of fresh leaves was found to be53.50 mg per 100 g which coincides with the value (54.7 mg to 146 mg/100 g) reported by Schonfeld and Pretorius (2011) while contradicts with the values (3.14 and 160.60 mg/100 g) reported by Zhang *et al*.(2011) and Hassan *et al*. (2011). Maximum and significant (p ≤0.05) result was estimated after cabinet drying (253.50mg/100 g) where as minimum and significant result was recorded after solar drying (157.00 mg/100 g).

Processing affected the zinc value of *bathua*leaves(Table 3). It was found 0.50 mg/100g in fresh leaves while itincreased maximum after shade (1.98 mg), followed by cabinet (1.84 mg), sun (1.61 mg) and solar (1.49 mg) /100g drying. Zhang *et al*. (2011) reported that *bathua* leaves contained 3.14 mg/100g of zinc. The results are in line with Schonfeld and Pretorius (2011) who reported that dark green leafy vegetables of South Africa contained 0.5 mg to 1.0 mg/100 g of zinc.

Amino acid analysis: Fresh leaves had 42 mg methionine per 100 g of protein which helps to maintain proper nitrogen balance of body (Table 4). It was increased with the application of processing. The maximum and significant value (341.50 mg/100g) was observed on cabinet drying, followed by sun drying with significant difference as compared to fresh leaves. Sood (2007) reported 49 mg/100gof protein in *bathua* leaves which is comparable with the present result. The analysed value coincides with the value (50mg/100g) reported by Gopalan *et al*. (2004) but contradicts the value (1.17mg/100g) reported by Aremu *et al*. (2011).

Tryptophan (Table 4) which is required for vitamin synthesis such as niacin and is used to make important brain chemicals was found to be 25 mg/100g of protein in fresh leaves. On dehydration, the tryptophan content was increased. Among all the dehydration techniques, maximum retention of tryptophan was seen in cabinet drying technique i.e. 169.50±3.54 mg/100g. Gopalan *et al*. (2004) observedtyptophan content of fresh *bathua*leavesas 20 mg per 100 g protein. Sood (2007) reported tryptophan content in *Chenopodium album* leaves as 39 mg/100g.

Lysine content in fresh *bathua* leaves was found to be 703.50 mg/100g. On dehydration, the lysine content was increased however, maximum increment was observed in cabinet drying technique (853.50mg/100g) and minimum increment was observed in shade drying technique (796.50mg/100g). The lysine content of the study agrees with the results of lysine of fresh *bathua* leaves reported by Gopalan *et al*. (2004).

It may be concluded from the data that methionine, tryptophan and lysine content was observed maximum in cabinet drying technique followed by sun drying technique.

***In vitro* protein digestibility:** *In vitro* protein digestibility of fresh *bathua* leaves was analyzed as 10.51 percent (Table 5). Processing improved protein digestibility of leaves. *In vitro* protein digestibility content of the dehydrated *bathua* leaves prepared by different methods of dehydration was 25.20 percent (sun dried), 26.25 percent (shade dried), 27.75 percent (cabinet dried) and 25.80 percent (solar dried). The results obtained were similar to values (9.78 to 14.48%) reported by Raghuvanshi *et al*. (2009) in underutilized foods.

Anti nutritional factors (Phytates, oxalates and total phenols: Antinutritional components are known to reduce the bioavailability of nutrients in the body.

Phytates (Table 6) can bind to certain minerals such as calcium, iron, zinc and magnesium and decrease their absorption (Nduagu *et al*. 2008). Phytate content of fresh leaves was evaluated as 250 mg per 100 g which is similar to the value (238.3 to 268.33) reported byAli (2015). The value was found to be decreased by processing methods applied on it. The level of phytate was reduced significantly (p ≤ 0.05) by cabinet followed by solar, sun and shade drying technique. Ilelaboye*et al*.(2013) studied the effect of cooking methods on mineral and anti nutrient content of green leafy vegetables. The phytate content of fresh leaves was 210.54 mg/100g (*Taliumtriangulae*), 155 mg/100g (*Amaranthus hydrides*) which was reduced to 106.20 mg/100g (*Taliumtriangulae*), 78.31 mg/100g (*Amaranthus hydrides*) after processing.

The oxalates content of fresh *bathua* leaves was estimated as 162.50mg/100g. On dehydration, the oxalates content of *bathua* was reduced, minimum and maximum amount was observed in cabinet

(85.30mg/100g) and shade drying technique (131.50 mg/100g) respectively. Ilelaboye*et al*. (2013) analysed the oxalate content of fresh leaves i.e. *Taliumtriangulae* (28.93 mg/100g), *Amaranthus hydrides*(47.35mg/100g). On processing it was reduced to 15.84 mg/100g (*Taliumtriangulae*), 32.55 mg/100g (*Amaranthus hydrides*). On the other hand, Paul *et al*. (2012) revealed that oxalic content of fresh spinach and *bathua* leaves were 88.8 mg/100g and 174.5 mg/100g respectively which were reduced to 48.4 mg/100g (spinach) and 58.6 mg/100g (*bathua* leaves) after processing.

The dehydrated *bathua* leaves contain significantly ($p \leq 0.05$) lower amount of total phenols than that of fresh *bathua* leaves. However, minimum amount of total phenols was observed in shade (138.27 mg/100g) drying technique.

Conclusion

Bathua (*Chenopodium album*) leaves are loaded with appreciable amounts of amino acids, calcium and iron which are beneficial for adequate growth and development. The results of the study revealed that processing has improved the nutrient content and reduced the anti nutritional factors of *bathua* (*Chenopodium album*) leaves significantly. Improvement in proximate composition, mineral content and *In vitro* protein digestibility was observed with processing. Maximum retention of nutrients was found with cabinet drying technique as compared to others such as sun, shade and solar drying techniques. Being economical and tremendously rich in nutrients, dehydrated *bathua* (*Chenopodium album*) can be an alternative to overcome micro-nutrient deficiencies among the vulnerable sections of the society.

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