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Research Article

ANALYTICAL STUDY FOR EVALUATION OF EFFECT OF CONVENTIONAL PRIMARY PROCESSING TECHNIQUES ON *AMALAKI* (*Emblica officinalis* Gaertn)

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ABSTRACT

Primary processing techniques adopted play a crucial role in the determination of quality, safety and efficacy of therapeutic formulation. In Indian crude drug trade, standard protocols for primary processing of crude drugs are either not available or not followed by growers /collectors of crude drug. Still, most of the drugs are processed adopting conventional primary processing techniques which are area specific i.e., different method of primary processing is adopted in different areas. An analytical study was carried out with the aims of investigating the effect of two commonly used conventional processing methods on crude drug *Amalaki.* These methods are drying deseeded fruits without boiling (EWB) and drying deseeded fruits after boiling (EB). For the evaluation of effect of boiling on *Emblica* fruits, comparative pharmacognostical and phytochemical analysis of crude drug prepared by two different conventional methods was done. Study included High-Performance Thin Layer Chromatography (HPTLC) using gallic acid as a reference standard. The results of the study showed that boiling increased the leaching of water-soluble components like sugars, tannins, phenolics, oxalates, and ascorbic acid thus reducing the levels of some antinutritional components and also some beneficial biomolecules like ascorbic acid. Additionally, boiling enhanced extraction of flavonoids and free gallic acid probably due to hydrolytic degradation of bound tannins as confirmed by HPTLC fingerprinting. Both samples showed similar Rf values (0.451) which were very close to the gallic acid standard (0.454) indicating the preservation of the unique marker compound identity after processing. EB exhibited improved safety due to reduced oxalate content and improved bioavailability of some phenolic compounds whereas EWB preserved a wider range of phytoconstituents with high levels of ascorbic acid. The results of the study provide evidences necessitating need of standardized protocol for primary processing of crude drugs.

INTRODUCTION

The Post-harvest management and primary processing of medicinal herbs is the critical relationship between field cultivation and the production of high-quality, therapeutic grade botanical products. Unlike traditional agricultural crops, medicinal plants are appreciated solely for their complex spectrum of secondary metabolites, the active chemical constituents that give them their medicinal properties. The primary processing is the first line of defence against microbial contamination, enzymatic spoilage and chemical oxidation. Primary processing represents a critical stage in the post-harvest handling of medicinal plant materials, directly influencing their quality, stability, and therapeutic efficacy. It encompasses initial treatments such as cleaning, cutting, boiling, and drying, which are essential for preventing microbial degradation and ensuring safe storage. However, these processes can simultaneously induce significant physicochemical and biochemical changes within the plant matrix. At the end of the day, good post-harvest management ensures not only compliance with international safety standards such as Good Agricultural and Collection Practices (GACP), but it also preserves the bio-efficacy and market value of the herbs, transforming raw botanical biomass into premium, industry-ready raw materials.

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According to Charak Samhita, efficacy of a drug increase when it is collected in appropriate *Desh* i.e. *Sthana*, in appropriate season when it is fully grown-up and stored properly. One has to take utmost care from the collection of raw material to storage and distribution of prepared drugs in order to prepare standard quality of drug. Acharya Charak and Vagbhata has referred primary processing as *Samskara* in *Astha Aaharavidhi Visheshaytana* and *Sapta Aahar Kalpana*, through which the therapeutic potential, efficacy, shelf lives, taste etc. of a drug are enhanced. Processing is the making or refinement of the natural products which means imparting other properties[1]. These properties are infused by contact of water and fire, cleansing, churning, place, time, infusing, steeping etc. and also by long duration, utensil etc[1,2].

Amalaki is one of the most commonly utilized crude drugs used in Ayurveda. It is mainly processed through conventional methods which vary from place to place, depending on the traditional knowledge and availability of resources. Cultivation is the main source of *Amalaki* production that supports its wide use in nutraceutical and pharmaceutical industries. It is an important ingredient in many classical as well as exclusive formulations and is also widely consumed at the household level in the form of various value-added products. Its wide use underlines the necessity for critical evaluation of the methods of processing this material to ensure consistency in quality and therapeutic efficacy.

In the classical Ayurvedic texts, *Amalaki* fruits are best to harvest in months of *Magha-Phalguna* when they are fully mature and replete with vital essence (*Purna Rasa*). and also describe the processing (*Samskara*) of *Amalaki* such as, in *Amalkayas Rasayana* cut the fruits and shade drying and 21 *Bhavana* (impregnation) with fresh juice[3], *Brahma Rasayana* (steaming over milk vapor)[4], *Amalaka Rasayana* (steam-cooking in *Palasha* (*Butea monosperma*) bark)[5]. According to Acharya Vaghbhat, *Amalaki* fruits filled in a hollow *Palasha* tree trunk then steamed[6], *Amalakavaleha* (soaking in alkaline *Palasha* water, shade drying and storing with honey and ghee)[7,8] and steam cooking in a closed *Palasha*-wood trough (shaped like a boat) and manual pulping.[9]

Field survey revealed that *Amalaki* fruits are processed by different conventional processing techniques based on local traditional knowledge from different places:

- Cutting fresh fruits into small pieces, manual removal of seeds, sun drying directly – a simple and popular method with minimal processing.
- Boiling before deseeding to soften the fruit to ease removal of seed, then sun or shade drying of pulp – said to improve storage stability.
- Drying of whole fruits without deseeding, and mechanical grinding with machine-based seed separation – typical of large-scale commercial handling.
- In certain place, oven drying (at controlled temperature), deseeding and drying of pulp.
- Preparation of value-added products like *Amalaki Murabba* – pricking and soaking in lime water for 24 hours, boiling, shade drying and treatment with sugar syrup to reduce bitterness and acidity.

Present study aimed to explore the impact of most commonly used conventional primary processing methods on the physicochemical and phytochemical properties of *Amalaki*. Study was planned to provide a comparative understanding of the effect of primary processing on the quality of the crude drug by analyzing physicochemical, phytochemical parameters and by High-Performance Thin Layer Chromatography (HPTLC) to provide scientific basis for standardization of traditional practices.

MATERIALS AND METHODS

Collection of Plant Material

Fruits of *Amalaki* (*Emblica officinalis* Gaertn.) were collected from Pilibhit district, Uttar Pradesh, India. The collection location was recorded with geo-coordinates of 28.641024° N latitude and 79.815934° E longitude. In its native environment, the fruits identified by its distinctive morphological characteristics, such as small, globose, yellow-green fruits on deciduous trees with delicate leaves. Only non-contaminated fresh fruits were carefully selected and collected in containers and then transported to laboratory for further processing. The collected material was subsequently verified by a department faculty member.

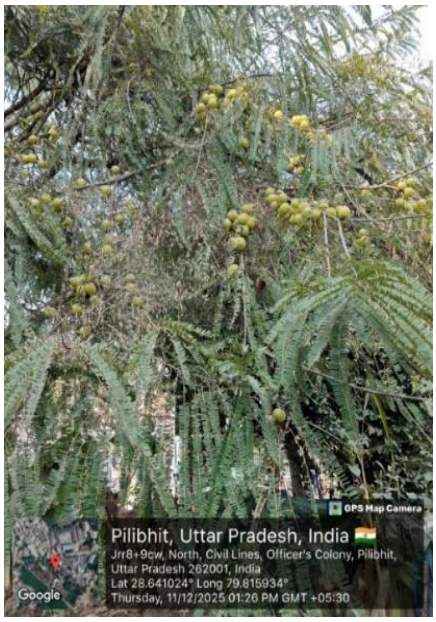


Figure 1.1: Collection of *Emblica officinalis* fruits from Pilibhit

Primary Processing of *Amalaki* Fruits Adopting Conventional Methods

Table 1: Conventional methods adopted for primary processing of *Amalaki* fruits

Labelling →	***Emblica* without boiling - EWB**	***Emblica* with boiling - EB**
Conventional Methods of processing	1. The *Amalaki* fruits are then thoroughly cleaned under running water. 2. *Amalaki* fruits were cut directly, and the pericarp and seeds of the fruit were separated. 3. Separated seeds are discarded and fruit pericarp is sun-dried. 4. Dried fruit were grinded using a standard grinder and filtered using a sieve. 5. Powder of the sample obtained.	1. The *Amalaki* fruits are then thoroughly cleaned under running water. 2. Boiling the fruits in water until they become soft. 3. Once softened, easily remove the seeds from the fruit. 4. Separated seeds are discarded and fruit pericarp is sun-dried. 5. Dried fruit were grinded using a standard grinder and filtered using a sieve. 6. Powder of the sample obtained

Organoleptic Assessment [10]

The organoleptic characteristics viz. colour, odour, taste, texture and shape of the processed samples were evaluated as per standard pharmacognostical procedures as described in Ayurvedic Pharmacopoeia of India.

Physicochemical Analysis [10]

Standard physicochemical parameters were evaluated as per the guidelines of the Ayurvedic Pharmacopoeia of India (API). Physicochemical parameters were determined for both samples in triplicate, including loss on drying (moisture content), total ash, acid-insoluble ash, water-soluble ash, alcohol-soluble extractive value, and water-soluble extractive value.

Quantitative Phytochemical Analysis

Quantitative analysis of preliminary phytochemical screening was carried out on methanolic extracts of both conventionally processed samples of *Amalaki* to compare the effect of processing methods on major phytoconstituents such as tannins, alkaloids, sugars, starch, total flavonoids, and phenolic compounds, using standard protocols. All estimations were performed in triplicate, and results were expressed as mean.

Estimation of Total Sugars [10]

Total sugar content was estimated by the phenol–sulfuric acid method. A 10% homogenate of the plant tissue was prepared in 80% ethanol and centrifuged at 2000 rpm for 15 minutes. The supernatant was collected and made up to a known volume. An aliquot of 0.1ml was taken, to which 0.1 ml of 80% phenol and 5ml of concentrated sulfuric acid were added. The mixture was incubated in an ice bath for 30 minutes, and the absorbance was recorded at 490nm using a UV–Visible spectrophotometer. All determinations were carried out in triplicate.

Estimation of Total Starch [10]

Total starch content was determined following ethanol extraction and acid hydrolysis. A 10% homogenate was prepared in 80% ethanol and centrifuged at 2000 rpm for 15 minutes. The residue obtained was treated with distilled water and heated on a water bath for 15 minutes, followed by maceration. Subsequently, 52% perchloric acid was added, and the mixture was centrifuged again at 2000 rpm for 15 minutes. The supernatant was collected and made up to a definite volume.

An aliquot of 0.1ml was taken, and 0.1ml of 80% phenol along with 5ml of concentrated sulfuric acid was added. The mixture was incubated in an ice bath for 90 minutes, and absorbance was measured at 490nm. All analyses were performed in triplicate.

Determination of Crude Alkaloid Content [10]

Crude alkaloid content was determined according to the method described by Harborne (1973). A known quantity (2gm) of powdered sample was extracted with 10% acetic acid in ethanol by continuous shaking for 4 hours. The mixture was filtered, and the filtrate was concentrated to one-quarter of its original volume.

Concentrated ammonium hydroxide was added dropwise to the concentrated extract to precipitate the alkaloids. The precipitate was collected using pre-weighed ashless filter paper and washed with dilute ammonium hydroxide solution. The filter paper containing the precipitate was dried in an oven at 60°C, cooled in a desiccator, and weighed until a constant weight was obtained.

Preparation of Methanolic Extract

First, 2gm powder was taken from each of the crude drug samples separately; 40ml of methanol was then added to each, and mixtures were shaken on a shaker for 6 hours. Subsequently, they were filtered using filter paper and concentrated in a water bath. Finally, collected and weighed the extracts. For the stock solutions, we dispersed 10mg of each extract in

1ml of methanol to create a primary stock concentration of 10mg/ml. We prepared a secondary stock solution of 1mg/ml by diluting a 100 µl sample of the primary stock with 900µl of methanol.

Estimation of Total flavonoids [11]

The total flavonoid contents were determined by following Chang et al. 2002 with slight modification for microplate reading. Briefly, stock solution of 10% AlCl3 and 1M potassium acetate were prepared separately. Various concentrations of test samples (20ml) were taken in 96 well plate. Quercetin 50, 25, 12.5, 6.25mg/ml final concentration was used as standard drug in separate wells of 96 well plate. To each test sample and standard drug, 10ml of $AlCl_3$ and 10ml potassium acetate were added. The volume of the reaction was made to 200ml by the addition of 160 ml distilled water. The plate was incubated for 30 min and read at 405nm wavelength on microplate ELISA reader. Standard curve was prepared using Excel trendline curve and the amount of total flavonoid was expressed as Quercetin equivalent mg/mg of extract (mgQE/g).

Estimation of Phenolic compounds [11]

Total phenolic contents were determined by Folin-Ciocalteu (FC) reagent assay with some modification for microplate analysis. Stock solution of FC reagent was prepared by diluting 10 times the FC reagent (density: 1.24g/cm3) with deionized distilled water. The assay was per formed in a 96 well plate by adding 20ml of the test sample and 90ml of FC reagent. The plate was incubated for 5 min and after incubation, 90ml of 6% sodium bicarbonate solution was added into it. The plate was further incubated at room temperature for 90 min. Gallic acid 40, 20, 10, 5 and 2.5mg/ml final concentration was used as standard drug in separate wells of 96 well plate. Readings were noted at 630nm wavelength on microplate ELISA reader. The TPC of samples was reported as milligrams of gallic acid equivalents (GAE) per gram extract (mgGAE/g).

Estimation of Tannin [12]

In this the 96-well microplate method, 20 µl of sample or standard solution was added in each well followed by 100µl of Folin–Ciocalteu reagent. 5 min, 80µl of 7.5% sodium carbonate solution was added to each well. The plate was incubated at room temperature in dark for about 2 hours for full colour development. The absorbance was read in a microplate reader at 750nm. All samples were run in triplicate for accuracy. Tannic acid was used to prepare a standard curve and the results were calculated. Tannin content was expressed as mg tannic acid equivalents per g of dry sample (mg TAE/g).

Quantitative Estimation of Oxalic Acid/total oxalate ions by $KMnO_4$ Titration Method[13]

Principle: Oxalate ions are extracted from the plant parts by boiling them with dilute H_2SO_4 (0.5N). Then oxalate concentration estimated volumetrically by titrating the extract with standard KMnO4 solution.

$MnO4^- + 5C2O4^{2-} + 8H^+ \rightarrow Mn^{2+} + 10CO2 + 4H2O$

Preparation of 0.5 N H2SO4: (500ml): Concentrated H_2SO_4 was taken with purity of 98% (specific gravity= 1.84g/lit). So, 6.8 ml H_2SO_4 was added to distilled water to make 0.5 N H_2SO_4 by making the final volume 500 ml.

0.05 N $KMnO_4$ (100 ml): Molecular weight of $KMnO_4$ is 158 g. So, 0.158 g $KMnO_4$ was added to 100ml water for preparing 0.05 N $KMnO_4$.

Preparation of plant extract: 1gm of plant material was weighed in electric weighing balance and transferred to 30ml of 0.5 N H_2SO_4 and was boiled in a water bath for 15 minutes. Then the extract was filtered with Whatman's No. 1 filter paper. Equal volume of deionised water was added. Then 10ml of filtered extract was taken and 40ml 0.5 N H_2SO_4 was added. Final 50ml of mixture was heated to 60°C and was titrated against 0.05N $KMnO_4$. The end point was determined by permanent appearance of light pink colour.

HPTLC Analysis [14]

- Stationary phase: Pre-coated silica gel 60 F254 TLC plates.
- Mobile phase: Toluene: Ethyl acetate: Formic acid (5: 3.5: 0.5)
- Sample extract: Methanolic
- Application: The developed TLC plate densiometrically scanned by CAMAG HPTLC Scanner III with Wincats 3.2.1 software and photographs were taken under UV 254 &366 nm wavelength.
- Standard Marker: Gallic acid was used as a reference standard for comparison.
- The Rf values and peak densitometric profiles were recorded and compared between the two processing methods.

RESULT

Organoleptic Characteristics

The two conventional processing methods produced noticeable differences in the organoleptic properties of *Amalaki*. These variations indicate that the processing technique influences the sensory quality of the crude drug (Table 1.2).

Table 2: Comparison of Organoleptic Characteristics of processed samples of *Amalaki*

Sample/ Parameters	EWB	EB
Shape	Irregular small pieces of dried fruit pulp, fragmented, curved/flattened.	Irregular, shrinking and curled pieces of dried fruit pulp, relatively compact in appearance
Size	Pieces are variable in size, approximately 0.5–2cm in length and 0.2–0.8 cm in width.	Comparatively larger and thicker pieces due to swelling during boiling, approximately 1–2.5 cm in length
Colour	Outer surface: Dark brown to blackish brown; Inner surface: Light brown to yellowish brown.	Outer surface: Dark brown to blackish brown; inner surface: Brownish yellow to light brown.
Surface	Outer surface is rough, uneven, wrinkled and slightly fibrous; inner surface comparatively smoother.	More wrinkled, shriveled, and leathery surface. The texture is slightly harder.
Odour	Characteristic, slightly fruity and astringent odour of dried *Amalaki.*	Characteristic odour, slightly reduced fruity odour.
Taste	Slightly sour, then astringent taste.	Sour and astringent taste, comparatively mild.



Figure 1.2: Comparative appearance of *Emblica officinalis* fruits after primary processing: without boiling (EWB) and with boiling (EB)

Physicochemical Parameters

Table 3: Comparative analysis of physicochemical parameters of *E. officinalis*

S.N.	Parameters	Values in percentage (%)		Standard as per API
		EWB	EB	
1.	Foreign matter	0.00000	0.00000	≤ 3%
2.	Moisture content	5.19330	6.16550	NA
3.	Total ash	3.60170	4.06420	≤ 7%
4.	Acid insoluble ash	0.40330	0.43320	≤ 2%
5.	Water soluble ash	0.46500	0.45400	NA
6.	Alcohol soluble extractive	32.5066	32.3422	≤ 40%
7.	Water soluble extractive	38.8911	32.3422	≤ 50%
8.	N-Hexane soluble extractive	0.22000	0.20660	NA

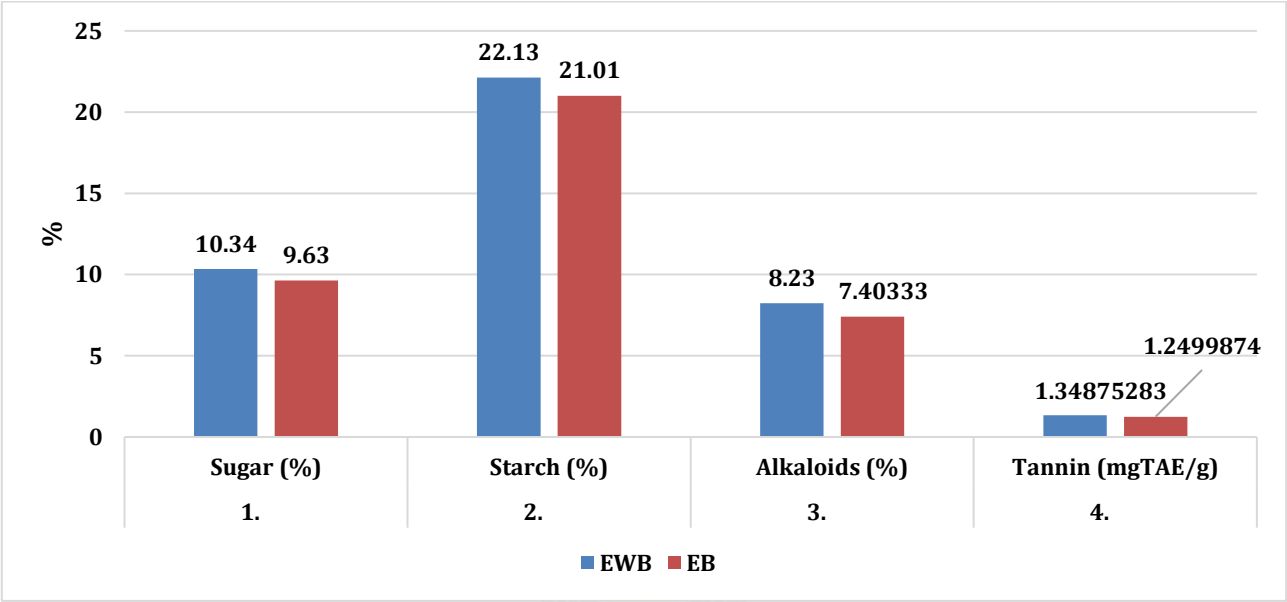
Quantitative Estimation of Phytoconstituents in *Amalaki*

Preliminary phytochemical screening of methanolic extracts showed presence of different phytoconstituents including sugar, starch, phenols, flavonoids, tannins, alkaloids.

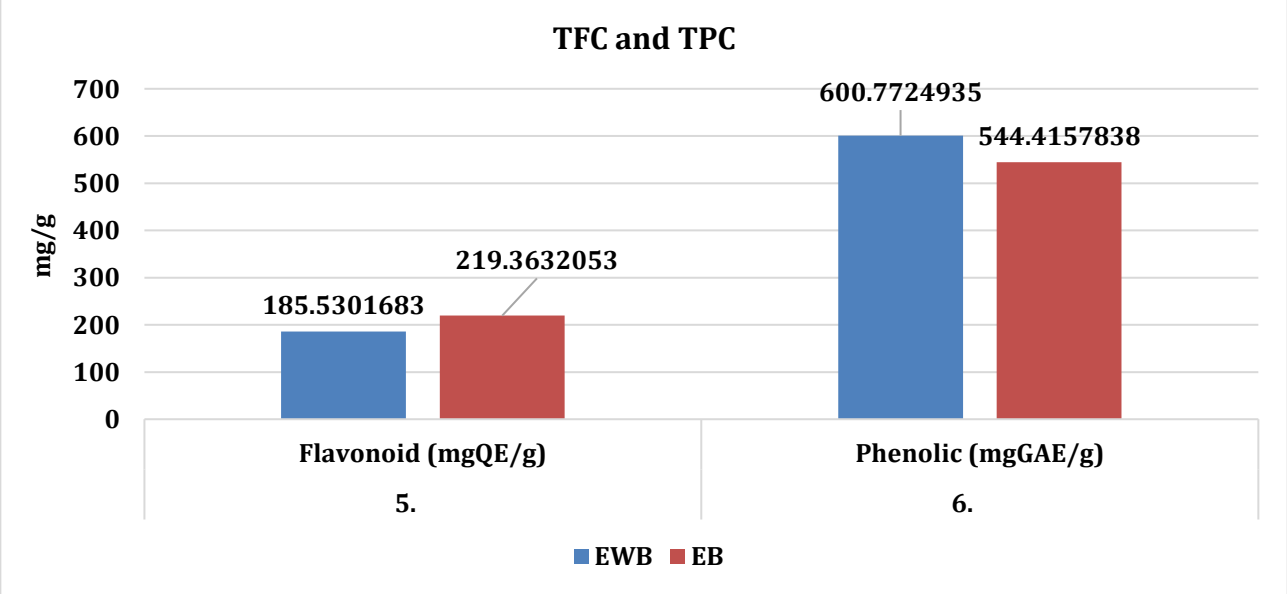
Table 4: Comparative analysis of phytochemical parameters of *E. officinalis*

S.N.	Phytochemicals	EWB	EB
1.	Sugar (%)	10.34000000	9.630000000
2.	Starch (%)	22.13000000	21.01000000
3.	Alkaloids (%)	8.230000000	7.403330000
4.	Flavonoid (mgQE/g)	185.5301683	219.3632053
5.	Phenolic (mgGAE/g)	600.7724935	544.4157838
6.	Tannin (mgTAE/g)	1.348752830	1.249987400

- Sugar, starch and alkaloids present in higher concentration in EWB sample.
- Total phenolic content and tannin were reported to be in higher concentration in EWB compared to EB.
- Concentration of total flavonoid was found to be more in EB sample.



Graph 1: Comparison of phytochemical parameters in *E. officinalis* samples



Graph 2: Comparison of TFC and TPC in methanolic extract of *E. officinalis* samples

Estimation of Oxalic Acid/Total Oxalate

Table 5: Concentration of oxalic acid /total oxalate (%) in *Amalaki* Powders

S.No.	Samples	EWB	EB
1.	Percentage of oxalic acid/ total oxalate	5.8700	3.2307

HPTLC

HPTLC of *Amalaki* samples showed bands corresponding to gallic acid marker. EWB and EB showed similar Rf values (0.451) matching with gallic acid standard (Rf 0.454), confirming the presence of marker compound.

EWB & EB → Rf = 0.451, showing the closest match to gallic acid.

Table 6: Rf. Values in HPTLC Chromatogram of methanolic extract of *E. officinalis*

S.N.	Scan Wavelength	Sample (10 µl)		Standard (Gallic acid)
		EWB	EB	5 µl
1.	250 nm	0.033	0.033	-
2.		**0.451**	**0.451**	**0.454**
3.	350 nm	0.001	0.000	-
4.		0.017	0.018	-
5.			0.049	-
6.		-	-	0.400
7.		0.411	0.411	-

Table 7: Number of peaks at 250 nm, Area under the curve in HPTLC Chromatogram of *E. officinalis* with gallic acid

S.N.	Samples	No. of Peaks in Chromatogram	Area
1.	EWB	2	0.0006
2.	EB	2	0.0010

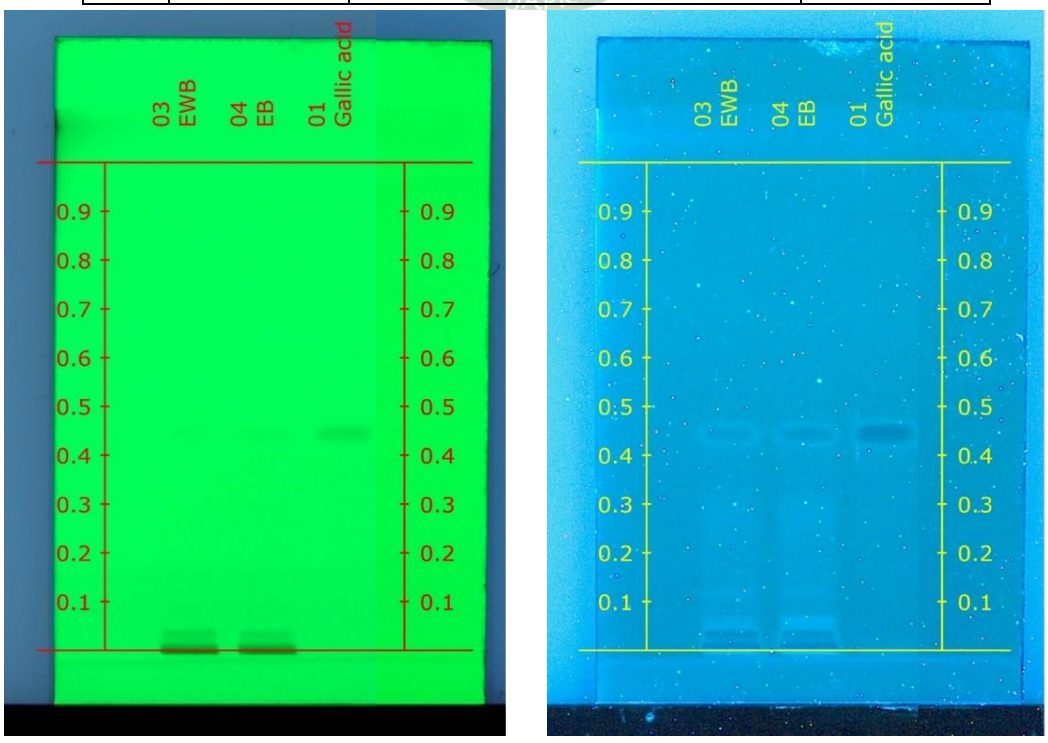


Figure 1.3 & 1.4: Comparative HPTLC chromatogram of processed *Emblica officinalis* samples (EWB and EB) at 254 and 366 nm.

DISCUSSION

In Pilibhit district of Uttar Pradesh, *Amalaki* is found growing both naturally and under cultivation, indicating its adaptability to diverse ecological conditions. Wild *Amalaki* from forest habitats generally showed larger tree size and smaller, more fibrous fruits, whereas cultivated varieties produced fruits with higher pulp content, likely reflecting differences in soil fertility, cultivation practice and genetic variability.

The EB sample showed comparatively more compact and shrunken pieces with slight darkening and reduction in fruity odour than EWB. These changes may be attributed to the combined effect of boiling and subsequent drying, which can cause structural modification of fruit tissues and loss of some volatile and water-soluble components. Heat treatment may also promote changes in natural pigments and cellular organization, resulting in variation in colour and texture. However, the EB sample showed darker and more irregular granular particles, suggesting alteration of cellular structures due to thermal processing. The relatively clearer cellular arrangement in EWB indicates lesser structural modification compared to boiled material.

The complete absence of foreign matter in both samples indicates proper collection, cleaning and processing. EWB showed 5.1933% moisture compared with 6.1655% in EB; the higher moisture retention in EB may result from boiling-induced hydration of fruit tissue prior to drying. Total ash was 3.6017% (EWB) and 4.0642% (EB), the slight increase in EB possibly reflecting concentration of inorganic constituents after boiling and drying. Acid-insoluble ash (0.4033% EWB; 0.4332% EB) indicates minimal contamination with silica and inorganic matter, and water-soluble ash values (0.465% EWB; 0.454% EB) suggest little impact of boiling on this parameter.

Extractive value reflects the quantity of active constituents soluble in a given solvent, evaluated here in water (polar), alcohol (semi-polar) and n-hexane (non-polar). Alcohol-soluble extractive values were almost identical (32.51% EWB vs. 32.34% EB), suggesting that ethanol-soluble phytoconstituents remained largely stable during processing, with only a marginal reduction attributable to thermal treatment. EWB showed a higher water-soluble extractive value (38.89%) than EB (32.34%), indicating possible loss of sugars, tannins, glycosides and other polar constituents during boiling. Both samples showed very low n-hexane-soluble extractive values (0.22% EWB; 0.2066% EB), confirming that *Amalaki* contains only small amounts of non-polar constituents such as lipids, waxes and volatile compounds, with negligible influence of boiling on this fraction.

Quantitative phytochemical analysis showed that boiling differentially affected individual phytochemical groups. EWB showed higher sugar (10.34%), starch (22.13%) and alkaloid (8.23%) content than EB, likely reflecting leaching of water-soluble constituents into the boiling medium, to which sugars and certain alkaloidal components are particularly sensitive. Total phenolic content was likewise higher in EWB (600.77 mg GAE/g) than EB (544.41 mg GAE/g), consistent with leaching and thermal degradation of phenolics during boiling; tannin content followed the same trend (1.349 vs. 1.250mg TAE/g EWB vs. EB), tannins being water-soluble and prone to leaching on boiling. In contrast, total flavonoid content was higher in EB (219.36 mg QE/g) than EWB (185.53 mg QE/g), possibly reflecting enhanced extractability of bound flavonoid fractions following heat-induced disruption of cellular structures.

Oxalate is a significant anti-nutritional constituent in plant-based crude drugs; elevated levels can reduce mineral (particularly calcium) bioavailability and increase the risk of kidney stone formation. Traditional processing steps such as soaking, boiling and drying are known to reduce oxalate levels through leaching of soluble oxalates into water. Oxalic acid/total oxalate content was 5.87% in EWB and 3.2307% in EB- a marked reduction attributable to leaching of water-soluble oxalate together with heat-induced modification of plant tissue. Oxalate content in plant material is known to vary with climatic conditions, soil composition, maturity stage and the plant part analysed.

The HPTLC profiles of both EWB and EB showed a characteristic band corresponding to the gallic acid marker, confirming retention of the phenolic marker constituent despite processing-induced changes in other parameters. Rf values for EWB and EB (0.451) closely matched the gallic acid standard (0.454), and both samples showed two detectable chromatographic peaks, though peak area differed between samples, indicating quantitative variation in marker compound concentration. EB showed relatively higher band intensity, sharper peak profiles and greater peak area, indicating a higher concentration of free gallic acid, plausibly resulting from hydrolytic breakdown of Gallo tannins during boiling.

This is consistent with reports that gallic and ellagic acid concentrations increase with heat treatment (e.g., 80–120°C), while ascorbic acid, a heat-sensitive water-soluble vitamin, is known to decline significantly under thermal treatment. Notably, antioxidant activity of *Amla* has been reported to persist even after prolonged heat treatment, indicating that this activity is not solely dependent on ascorbic

acid but also on hydrolysable tannoids such as gallic and ellagic acid [15].

Thermal processing is a widely used, cost-effective method for processing fruits and vegetables that reduces microbial and enzymatic activity and can improve nutrient bioavailability, taste and texture, albeit with some loss of nutritional, functional and sensory quality. In the present study, boiling reduced anti-nutritional oxalate content while apparently enhancing the availability of free gallic acid through hydrolytic conversion of bound tannins- illustrating that processing can simultaneously reduce anti-nutritional factors and improve the bioavailability of certain beneficial phytoconstituents.

In light of the Charaka Samhita principle, which emphasizes the importance of selecting specific therapeutic formulations and procedures based on individualized conditions keeping in mind *Desh* (place) and *Kala* (time).[16] *Amalaki* processed by boiling fresh fruits has relatively lower oxalate content. Conversely *Amalaki* processed by directly cutting and drying of fruits (un-boiled) retains a wider range of phytoconstituents, such as ascorbic acid. These compounds are well known for their potent antioxidant, antidiabetic potential and may be more appropriate for *Rasayana* (rejuvenative) purposes, where overall nutritive and antioxidant potential is desired.

CONCLUSIONS

In *Amalaki*, primary processing, particularly boiling followed by drying, produced significant alterations in both pharmaceutical and nutraceutical attributes. Boiling resulted in leaching of water-soluble constituents such as sugars, tannins, phenolics, and oxalates, thereby reducing anti-nutritional factors and enhancing safety. Notably, the oxalate content was lower in boiled samples compared to directly cut and dried sample. At the same time, thermal processing increased the extractability of flavonoids and free phenolic compounds, particularly gallic acid, as confirmed by HPTLC analysis. Ascorbic acid content was reduced due to its heat-sensitive nature. Despite this reduction, the antioxidant potential of *Amalaki* was maintained, as it is not solely dependent on ascorbic acid but also on phenolic compounds such as gallic and ellagic acids. In contrast, directly dried (un-boiled) samples retained a broader spectrum of phytoconstituents, including higher ascorbic acid content, making them more suitable for *Rasayana* (rejuvenative) applications.

Study shows that primary processing has a limiting effect on concentration of secondary metabolites in finished crude drugs. This effect needs to be analysed in multiple stages like quantification of different metabolites, therapeutic efficacy of crude drugs processed adopting different conventional methods in pre-clinical and clinical studies to determine standardized protocol for the primary processing of crude drugs.

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Abbreviations

API– Ayurvedic Pharmacopoeia of India; AH.– Astanga Hridaya; Ci.– Chikitsa Sthana; CS.- Charak Samhita; EWB– Dried Deseeded Emblica fruits without boiling; EB– Dried Deseeded Emblica fruits after boiling; GAE– Gallic Acid Equivalent; NA- Not available; QE– Quercetin Equivalent; Rf– Retention factor; Su.- Sutra Sthana; TAE– Tannic Acid Equivalent; TFC- Total Flavonoid Content; TPC– Total Phenolic Content; U.- Uttar Sthana/ Uttar Tantra;

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