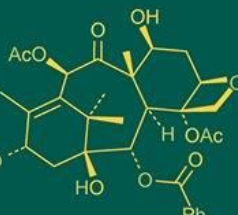
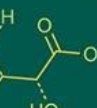
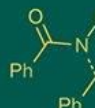


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Impact of grinding techniques and particle size on the functional attributes of turmeric (*Curcuma longa*) powder

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Abstract

This study explores how two grinding approaches; ambient and coolant-assisted and two particle sizes (300 and 500 microns) influence the functional properties of turmeric powder, derived from the Salem variety of rhizomes. Functional characteristics assessed include water solubility index (WSI), water absorption index (WAI), and oil absorption index (OAI). Results indicate that finer particle sizes (300 microns) improve solubility, while coarser sizes (500 microns) enhance water and oil absorption. Coolant-assisted grinding preserved these properties better than ambient grinding. The combination of coolant-assisted grinding and a 500-micron sieve produced optimal results for water and oil absorption, while the 300-micron sieve enhanced solubility. This study underscores the importance of optimizing grinding techniques and particle sizes to enhance the industrial utility of turmeric powder.

Keywords: Turmeric, *Curcuma longa*, grinding techniques, functional properties, particle size

1. Introduction

Turmeric (*Curcuma longa*), a perennial plant primarily cultivated in tropical and subtropical regions, holds significant importance in culinary, medicinal, and industrial applications due to its bioactive compound curcumin. Known for its anti-inflammatory, antioxidant, and antimicrobial properties, turmeric is widely used in the food, pharmaceutical, and cosmetic industries. As demand grows for turmeric-derived products, enhancing its functional properties becomes critical to meet industrial requirements.

The grinding process and resulting particle size significantly affect the functional attributes of turmeric powder. Grinding not only determines the particle size but also impacts the thermal and structural integrity of bioactive compounds. Ambient grinding generates heat through friction, potentially degrading sensitive compounds, while coolant-assisted grinding maintains low temperatures to preserve them.

This research focuses on evaluating the effects of two grinding methods; ambient and coolant-assisted and particle sizes (300 and 500 micron) on key functional properties: WSI, WAI, and OAI. The findings aim to guide the optimization of processing techniques for industrial applications of turmeric powder.

2. Materials and Methods

2.1 Raw Material

Salem variety turmeric rhizomes were sourced locally in Junagadh. The rhizomes were cleaned thoroughly before processing to remove impurities.

2.2 Grinding Techniques and Particle Size

Two grinding methods were employed

- Ambient Grinding (G₁):** Dried rhizomes were ground at room temperature using a grinding mill. Heat generated during grinding was not controlled.
- Coolant-Assisted Grinding (G₂):** Rhizomes were ground in a specially designed mill with a coolant circulation system (using propylene glycol) to maintain low temperatures, thereby preventing thermal degradation of bioactive compounds.

Each grinding method utilized two sieves for particle size separation

- 300 microns (S₁)
- 500 microns (S₂)

2.3 Measurement of Functional Properties

2.3.1 Water Solubility Index (WSI)

The WSI was determined following Anderson's method (1982). A 2.5 g sample was dispersed in 25 g distilled water, stirred for 30 minutes, and centrifuged at 4000 rpm for 15 minutes. The supernatant's solid content was measured, and WSI was calculated as:

$$\text{WSI}(\%) = \frac{\text{Weight of dissolved solids in supernatant (g)}}{\text{Initial weight of sample (g)}} \times 100$$

2.3.2 Water Absorption Index (WAI)

Using Anderson's method, 2.5 g of the sample was dispersed in distilled water, stirred for 30 minutes, and centrifuged. The sediment weight was recorded, and WAI was calculated as:

$$\text{WAI}(\frac{\text{g}}{\text{g}}) = \frac{\text{Weight of sediment (g)}}{\text{Initial weight of sample (g)}}$$

2.3.3 Oil Absorption Index (OAI)

OAI was assessed similarly to WAI, substituting oil for distilled water.

$$\text{OAI}(\%) = \frac{\text{Weight of sediment (g)}}{\text{Initial weight of sample (g)}} \times 100$$

2.4 Statistical Analysis

Data were analyzed using ANOVA, with significance determined at $p < 0.05$. Results were expressed as mean values with standard error. (Panse and Sukhatme, 1985) [5].

3. Results and Discussion

3.1 Water Solubility Index (WSI)

WSI varied significantly based on grinding method and particle size (Table 1). Ambient grinding (G₁) achieved higher WSI values due to friction-induced heat, which partially gelatinized starch and denatured proteins, enhancing solubility. The 300-micron sieve (S₁) yielded higher solubility than the 500-micron sieve (S₂).

Effect of grinding methods and sieve size on functional properties of ground turmeric powder was given in table-1.

Table 1: Effect of grinding method and sieve size on functional properties of ground turmeric powder

Effect	WSI (%)	WAI (g/g)	OAI (%)
Grinding Methods			
Ambient grinding(G ₁)	24.58	4.05	215.64
Coolant grinding(G ₂)	21.02	4.43	222.33
S. Em±	0.2158	0.0276	1.7825
CD at 5%	0.6651	0.0851	5.4928
Sieve size			
300 micron(S ₁)	23.71	4.16	218.25
500 micron(S ₂)	21.89	4.32	219.72
S. Em±	0.2158	0.0276	1.7825
CD at 5%	0.6651	0.0851	NS
Interaction			
S. Em±	0.3052	0.039	2.5208
CD at 5%	NS	NS	NS
CV%	2.6774	1.8409	2.3022

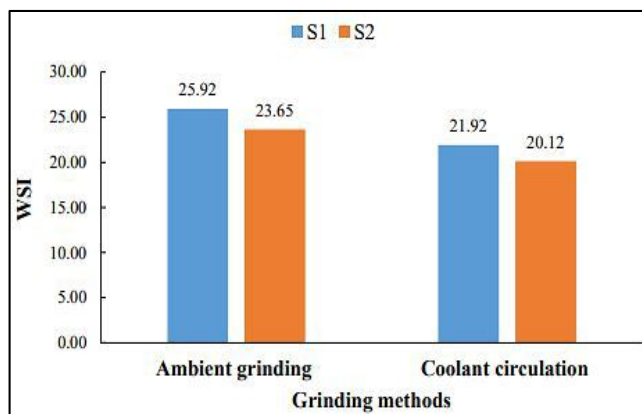


Fig 1: Effect of grinding methods and sieve size on WSI of ground powder of turmeric

Figure 1 illustrates that the Water Solubility Index (WSI) of ground powder is higher in ambient grinding treatments compared to coolant-assisted grinding treatments. The highest WSI value (25.92%) was observed for ambient grinding with 300-micron particles, while the lowest (20.12%) was recorded for coolant-assisted grinding with 500-micron particles. The significant heat generated during ambient grinding, due to friction, leads to partial gelatinization of starch and denaturation of proteins in turmeric, disrupting the native structure of its components. This alteration in the macromolecular structure enhances the solubility of these components in water, resulting in higher WSI values.

In contrast, coolant-assisted grinding methods, which operate at lower temperatures, preserve the native structure of food components and reduce solubility. Bhattacharya *et al.* (2014) [2] reported that low-temperature grinding retains the structural integrity of food materials, thereby lowering their solubility in water. Similarly, Misra and Brooker (2009) [3] found that cryogenic grinding prevents the breakdown of starch granules, leading to reduced WSI values compared to ambient grinding methods. These findings underscore the influence of grinding conditions on the solubility characteristics of turmeric powder.

3.2 Water Absorption Index (WAI)

WAI was significantly higher for coolant-assisted grinding (G₂) than ambient grinding (G₁), with 500-micron particles (S₂) showing the best results. Coolant-assisted grinding preserved the structural integrity of starch granules, enhancing their water-binding capacity.

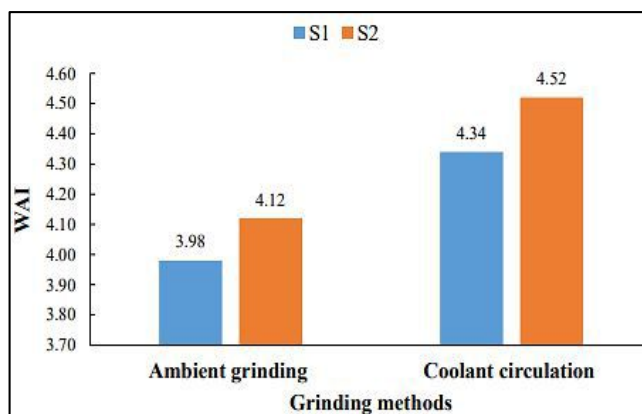


Fig 2: Effect of grinding methods and sieve size on WAI of ground powder of turmeric

Figure 2 shows that the Water Absorption Index (WAI) of ground powder is lower in ambient grinding treatments compared to coolant-assisted grinding treatments. WAI values ranged from 3.98 g/g for ambient grinding with 300-micron particles to 4.52 g/g for coolant-assisted grinding with 500-micron particles. The lowest WAI (3.98 g/g) was observed in ambient grinding with a 300-micron sieve, while the highest WAI (4.52 g/g) was recorded for coolant-assisted grinding with a 500-micron sieve.

During ambient grinding, the friction-induced heat can significantly damage starch granules in turmeric, compromising their structural integrity and reducing their ability to absorb water. In contrast, coolant-assisted grinding, conducted at low temperatures, minimizes heat-induced damage, preserving the native structure of starch granules and proteins. This structural preservation allows the granules to retain their integrity, enhancing their water absorption capacity and resulting in higher WAI values.

These observations align with previous studies. Yadav *et al.* (2013) [8] reported that elevated temperatures during grinding disrupt starch granules, diminishing their water absorption capacity. Similarly, Singh and Nath (2012) [6] found that cryogenic grinding, a form of coolant-assisted grinding, effectively preserves the structural integrity of starch and proteins, leading to improved WAI. Murthy *et al.* (2014) [4] also noted that low-temperature grinding methods help maintain the water absorption properties of ground powders. These findings highlight the critical role of temperature control during grinding in influencing WAI.

3.3 Oil Absorption Index (OAI)

OAI followed a similar trend, with coolant-assisted grinding outperforming ambient grinding. Although sieve size had no significant effect, the preservation of lipophilic compounds during coolant-assisted grinding resulted in higher oil absorption.

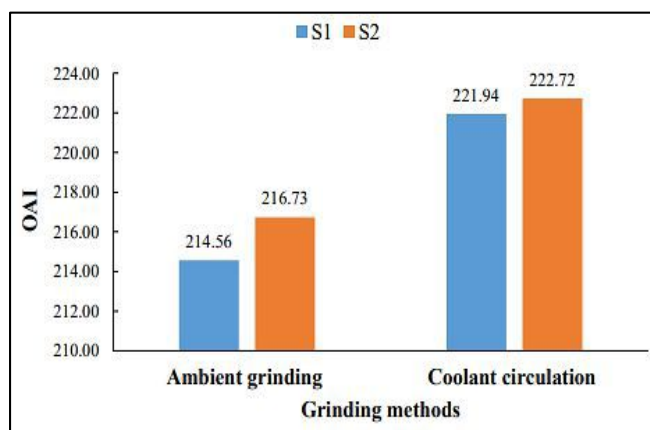


Fig 3: Effect of grinding methods and sieve size on OAI of ground powder of turmeric

Figure 3 shows that the Oil Absorption Index (OAI) of ground powder is lower in ambient grinding treatments compared to coolant-assisted grinding treatments. OAI values ranged from 214.56% for ambient grinding with 300-micron particles to 222.72% for coolant-assisted grinding with 500-micron particles. The lowest OAI (214.56%) was observed in ambient grinding with a 300-micron sieve, while the highest OAI (222.72%) was recorded for coolant-assisted grinding with a 500-micron sieve.

Coolant-assisted grinding effectively minimizes the thermal degradation of lipophilic components, preserving the oil-binding sites within turmeric powder. This preservation enhances the powder's natural oil-absorbing capacity, resulting in higher OAI values. In contrast, the heat generated during ambient grinding can degrade these lipophilic components, reducing the powder's oil absorption capacity.

These findings are supported by previous studies. Suryanarayana *et al.* (2011) [7] observed that grinding under low-temperature conditions helps maintain the integrity of lipophilic compounds, leading to higher OAI values. Similarly, Bhattacharya *et al.* (2014) [2] reported that cryogenic grinding effectively retains the natural oil-binding components of turmeric, further enhancing its OAI. These results highlight the importance of low-temperature grinding techniques in preserving the functional properties of turmeric powder.

4. Conclusion

This study highlights the significant impact of grinding methods and particle size on the functional properties of turmeric powder. Coolant-assisted grinding with a 500-micron sieve achieved the best results for Water Absorption Index (WAI) and Oil Absorption Index (OAI), while the 300-micron sieve demonstrated superior performance for Water Solubility Index (WSI). These findings suggest that low-temperature grinding methods are highly effective in preserving the structural and functional integrity of turmeric powder. Such methods are recommended for industrial applications to enhance the quality and versatility of turmeric powder, making it more suitable for use in the food, pharmaceutical, and cosmetic industries.

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