

## Effect Of Different Processing Methods On Functional And Physiochemical Properties Of Turmeric (*Curcuma Longa* Linn.) Rhizome Var. Kapurkot Haledo-1

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### ABSTRACT

A study was conducted from October to December 2022 to assess the impact of various processing methods on the functional and phytochemical properties of turmeric rhizomes. The experiment consisted of four treatments: Treatment 1: Oven-dried turmeric powder, Treatment 2: Blanching/Oven-dried turmeric powder, Treatment 3: Cooking/Oven-dried turmeric powder, and Treatment 4: Sun-dried turmeric powder. Each treatment was replicated four times. The findings indicated that sun drying (68.50%) and blanching/oven drying (66.50%) had a positive effect on dispersibility. Blanching/oven drying (0.32 g/ml) and cooking/oven drying (0.30 g/ml) significantly improved the bulk density of turmeric powder ( $p < 0.001$ ), with no significant difference between the two treatments. The water absorption capacity of the turmeric powders ranged from 3.35 to 5.35 g/ml, with the sun-dried sample exhibiting the lowest capacity and the cooked/oven-dried sample demonstrating the highest. Similarly, sun-dried powder had the lowest swelling power and solubility, whereas heat treatment resulted in a substantial increase in both of these parameters. Additionally, the curcumin content was highest in the cooked/oven-dried (3.11%) and sun-dried (2.99%) turmeric powder. Based on these results, it can be concluded that blanching and cooking are widely applicable in the food industry to enhance the bulkiness of turmeric powder for appropriate packaging and handling. Moreover, these methods contribute to the characteristic flavor and aroma of turmeric.

### 1. Introduction

Turmeric, scientifically known as *Curcuma longa*, is a perennial herbaceous plant from the ginger family (Zingiberaceae). Its tuberous rhizomes, found underground, have been used for various purposes throughout history, including as a condiment, textile dye, and medicinal aromatic stimulant. While turmeric is native to southern India and Indonesia, it is now extensively cultivated in both mainland and island regions of the Indian Ocean (Waseem K et al., 2012). Turmeric rhizomes have a tough brown skin and bright orange flesh, known for their pungent and bitter characteristics (Enemor et al., 2020). In Nepal, the National Ginger Research Programme (NGRP) has released two commercial turmeric varieties, namely Kapurkot haledo-1 and Kapurkot haledo-2, as reported by PIU Surkhet (2018).

The nutritional composition of turmeric, as investigated by Ikpeama et al. (2014), includes 8.92% moisture, 2.85% ash, 4.60% crude fiber, 6.85% fat, 9.40% crude protein, and 67.38% carbohydrates. Curcumin, a yellow-colored active ingredient, acts as a potent antioxidant and is responsible for the various biological activities of turmeric (Peter, 2000). Turmeric also contains essential compounds such as vitamin C, beta-carotene, polyphenols, fatty acids, and essential oils (Ikpeama et al., 2014). The dried and ground rhizomes of turmeric are commonly used as a spice in cooking, providing a distinct yellow color and flavor to food. Turmeric powder is also utilized in cosmetics and medicine. The quality of an agricultural product is influenced by both its inherent quality and the processing conditions it undergoes (Emelike et al., 2017). Similarly, the quality of turmeric powder is determined by the processing methods employed during the post-harvest phase. These methods may include boiling, drying, slicing, sun drying, and grinding. Sun drying, for instance, has been reported to affect the color and result in shrinkage, leading to an unappealing final product (Raji Abdul Ganiy et al., 2010). Blanching and the use of chemical treatments have been employed to minimize nutrient losses (Duarte et al., 2017). Cooking, on the other hand, can alter the physical, chemical, and

nutritional characteristics of food constituents. However, the functional and chemical properties of turmeric rhizomes from Nepal have not been thoroughly investigated before (Devkota & Rajbhandari, 2016).

The processing of turmeric rhizomes involves postharvest treatments such as boiling and drying. Various methods were used to determine the functional properties of the samples. Dispersibility, which measures the tendency of flour to separate from water molecules, is indicative of its hydrophobic action (Eke-Ejiofor & Kin-Kabari, 2010). Higher dispersibility indicates better reconstitution properties. Bulk density, also known as volumetric density or apparent density, is the mass of flour particles divided by the total volume they occupy. It is a functional property relevant to flours, powders, fine particles, granules, and other divided solids in foods or food ingredients. Water absorption capacity (WAC) refers to the amount of water (moisture) taken up by food or flour to achieve the desired consistency and create a high-quality food product. Oil absorption capacity (OAC) refers to the binding of fat by the non-polar side chains of proteins. OAC is an important functional property that the oil absorption capacity is a critical functional property that enhances the mouthfeel and preserves the flavour of food products (Iwe et al., 2016). The swelling index (SI), also referred to as swelling capacity (SC), quantifies the volume in millilitres absorbed by one gram (1g) of food material during swelling under specific conditions. Solubility in a food system refers to the ability of a solute, whether it be a solid, liquid, or gaseous substance, to dissolve in a liquid, gaseous, or solid solvent.

The main objective of this study was to assess the impact of different processing methods on the functional and phytochemical composition of turmeric rhizomes. Specifically, the study aimed to examine the relationship between functional and physicochemical properties. Furthermore, the study sought to investigate the relationship among various processing and extraction methods based on phytochemical composition.

### 3. Methodology

#### 2.1 Site and time of the experiment :

The study was conducted between October and December 2022 at two different locations: the laboratories of the Centre for Biotechnology, Agriculture, and Forestry University in Chitwan, and the Department of Food Technology and Quality Control in Kathmandu.

#### 2.2 Experimental materials:

The materials used in the experiment were turmeric rhizomes of variety Kapurkot haledo-1. Four treatments and four replications were used in the CRD method to conduct the experiment.

#### 2.3 Treatments details:

Treatment 1 : Peeled, grated and oven-dried (60° C for 24 hrs) rhizomes

Treatment 2 : Peeled, blanched (10 mins), grated and oven-dried (60° C for 24 hrs) rhizomes

Treatment 3 : Peeled, cooked (1 hr), grated and oven-dried (60° C for 24 hrs) rhizomes

Treatment 4 : Peeled, grated and sun-dried (5 days)

#### 2.4 Preparation of treatments:

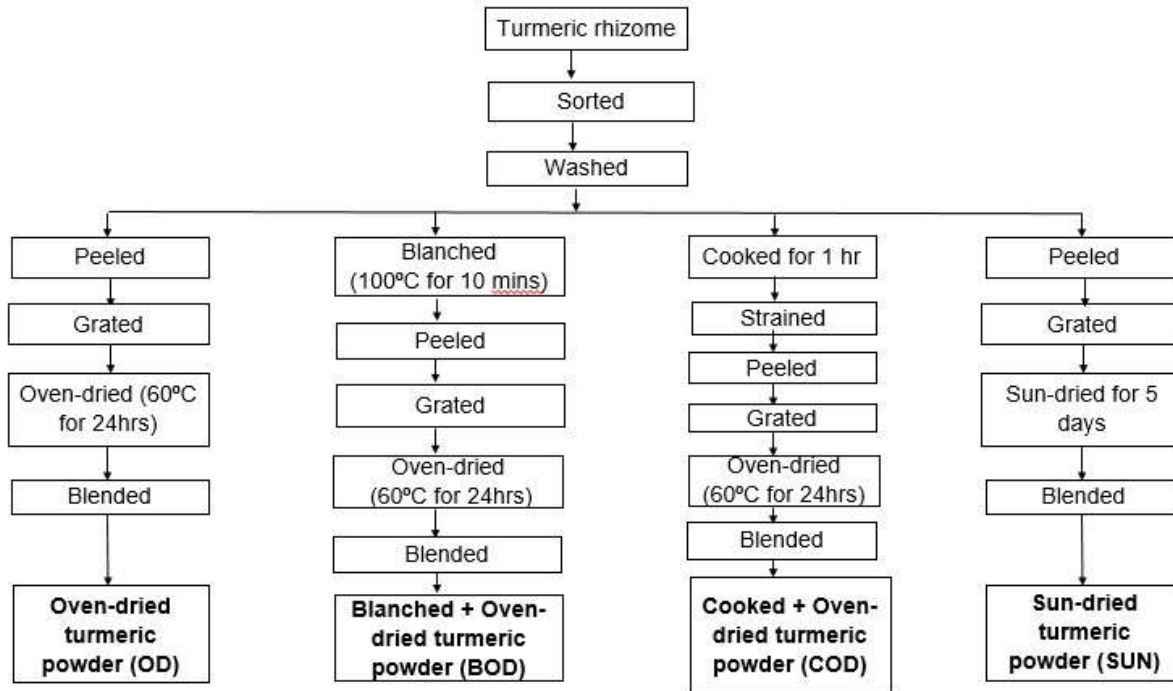


Figure 1. Schematic diagram of treatment preparation (Tamuno, 2020)

## 2.5 Functional properties :

### 2.5.1 Dispersibility :

Dispersibility was determined by the method of Kulkarni et al. (1991). The turmeric sample of 10g was weighed into 100 ml measuring cylinder and distilled water was added to a volume of 100 ml. The set up was stirred vigorously and allowed to settle for three hours. The volume of the settled sediment was recorded as shown on the measuring cylinder and the obtained value subtracted from 100. The difference was reported as percentage dispersibility.

$$\text{Dispersibility (\%)} = 100 - \text{Volume of settled sediment}$$

### 2.5.2 Bulk density:

Bulk density was determined by the method described by Narayana & Rao (1984). The sample was poured into a calibrated sample tube. The sample was added till it gets to the 5 ml mark on the tube and then it was weighed again. The tube with the sample was tapped while more samples were added. This continued till the sample was steady at the 5 ml mark of the tube and then the final weight was taken.

$$\text{Bulk density (g/ml)} = \frac{\text{Sample weight after tapping} - \text{Sample weight before tapping}}{5 \text{ ml of centrifuge tube}} \times 100$$

### 2.5.3 Water absorption capacity:

The water oil absorption capacity was determined using the method by Sosulski(1962). One gram of sample was added to 15 ml of distilled water in a pre-weighed centrifuge tube. The centrifuge tube was agitated and centrifuged for 30 minutes at 3000rpm. The clear supernatant was discarded and the volume taken and the tube absorbed water was weighed. The retained water was computed as water absorbed per gram of the sample.

$$\text{Water absorption capacity (g/ml)} = \frac{\text{Initial volume water added} - \text{volume of water decant}}{\text{Sample weight}}$$

#### 2.5.4 Oil absorption capacity:

The oil absorption capacity was determined using the method by Sosulski (1962). One gram of sample was added to 15 ml of canola oil in a pre-weighed centrifuge tube. The centrifuge tube was agitated and centrifuged for 30 minutes at 3000rpm. The clear supernatant was discarded and the volume taken and the tube absorbed oil was weighed. The retained oil was computed as oil absorbed per gram of the sample.

$$\text{Oil absorption capacity (g/ml)} = \frac{\text{Initial volume oil added} - \text{volume of oil decant}}{\text{Sample weight}}$$

#### 2.5.5 Swelling power and Solubility:

The swelling Power and Solubility was determined using the method by Takahashi & Seib(1988). One gram of the sample was weighed and transferred into a flask and 15 ml of distilled water was added to the sample in the conical flask and shake thoroughly, it was sent to the water bath at a set temperature of 95°C for 1 hour. After heating, it was cooled under running water; it was transferred into a previously dried and weighed centrifuge tube and centrifuge for 30 minutes at 2000 rpm. After centrifuge, the swollen volume was read directly from the tube. The clear portion was transferred into a previously ignited weighed metal can, it was dried in the oven at 105°C for 1 hour after which it was cooled in the dessicator and weighed.

$$\text{Solubility (\%)} = \frac{\text{weight of solute}}{\text{sample weight}} \times 100$$

$$\text{Swelling power} = \frac{\text{Weight of tube + sediment} - \text{weight of empty tube}}{\text{Sample weight}}$$

#### 2.6 Statistical analysis:

The collected data were compiled and entered into Ms- excel 2010. Data analysis was done using R version 4.0.1. Analysis of variance for all the observed parameters was carried out as per the procedures given in Agricolae package of R. Duncan's Multiple Range Test (DMRT) for mean separations was done. Correlogram and dendrogram were prepared using corplot and factoextra packages of R respectively.

### 4. Results and Discussion

Data obtained from the experiment were analysed and described here under the different headings and sub-headings with appropriate tables and figures wherever necessary.

#### 3.1 Effect of Processing Methods on the Functional Properties of Turmeric Powder

##### 3.1.1 Functional Properties

Treatments	Dispersibility (%)	Bulk density (g/ml)	Water absorption capacity	Oil absorption capacity	Swelling power (g/g)	Solubility (%)
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		(ml/g)	(ml/g)	(ml/g)	(ml/g)	(ml/g)
OD	64.00b	0.21c	4.13b	1.54b	6.64bc	21.11a
BOD	66.50a	0.32a	3.92b	1.43bc	6.92b	19.38b
COD	62.50b	0.30ab	5.35a	2.00a	7.89a	16.75c
SUN	68.50a	0.29b	3.35c	1.40c	6.29c	17.29c
LSD	2.22	0.02	0.33	0.13	0.36	1.24
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F-test	***	***	***	***	***	***
SEm (±)	0.68	0.01	0.19	0.06	0.16	0.48
CV (%)	2.21	6.49	5.15	5.19	3.39	4.35
Grand mean	65.38	0.28	4.18	1.59	6.93	18.63

\*\*\* indicates significant at  $p < 0.001$ . Means followed by the same letter(s) in the column are not significantly different at 5% by DMRT. OD = Oven Dried turmeric powder; BOD = Blanched + Oven Dried turmeric powder; SUN = Sun Dried turmeric powder; COD = Cooked + Oven Dried turmeric powder.

Table 1. Effects of different processing methods on functional properties of turmeric rhizome var. Kapurkot haledo-1

#### 3.1.1.1 Dispersibility (%):

Table 3 presents the dispersibility of turmeric powder influenced by different processing methods. The results indicated that the processing methods had a significant impact on dispersibility ( $p < 0.001$ ). Dispersibility values ranged from 62.50% in the cooked/oven-dried sample to 68.50% in the sun-dried sample. Sun drying (68.50%) and blanching/oven drying (66.50%) were found to have an improved effect on dispersibility, and these treatments were not significantly different from each other. Similarly, oven drying (64.00%) and cooking/oven drying (62.50%) treatments showed no significant difference between them, and they had a comparatively lesser effect on dispersibility.

Dispersibility refers to the ability of flour to disperse and separate from water molecules, indicating its hydrophobic action (Eke-Ejiofor & Kin-Kabari, 2010). Higher dispersibility values are associated with better reconstitution properties (Elkhalifa & Bernhardt, 2013). Based on the present investigation, sun drying has been identified as an effective processing method for enhancing the reconstitution properties of turmeric powder.

#### 3.1.1.2 Bulk density (g/ml):

The bulk density of turmeric powder, influenced by different processing methods, is presented in Table 3. The results indicate that the processing methods had a significant effect ( $p < 0.001$ ) on the bulk density. The bulk density of turmeric powders varied from 0.21 g/ml in the oven-dried sample to 0.32 g/ml in the blanched/oven-dried sample. Both blanching/oven drying (0.32 g/ml) and cooking/oven drying (0.30 g/ml) demonstrated a significant ( $p < 0.001$ ) improvement in the bulk density of turmeric powder, with no notable difference between these treatments. On the other hand, sun drying (0.29 g/ml) and oven drying (0.21 g/ml) significantly differed ( $p < 0.001$ ) and had a relatively lower impact on bulk density.

The bulk density of flour primarily relies on the particle size and initial moisture content (Tsegaye & Duguma, 2020). The absorption of moisture during the cooking and blanching processes could explain the increased bulk density observed in turmeric powders. This is consistent with findings by Igbokwe et al. (2016) in their study on blanched *Dioscorea bulbifera*

flour, which reported a similar increase in bulk density. The high bulk density observed in turmeric powders processed with cooking/oven drying and blanching/oven drying indicates their heaviness and suggests their suitability for use in food preparations. Higher bulk densities in flours are desirable as they facilitate ease of dispersibility and reduce paste thickness, as noted by Udense & Eke (2000).

#### 3.1.1.3 Water absorption capacity (ml/g):

Table 3 presents the water absorption capacity of turmeric powder, which was influenced by different processing methods. The results showed a significant effect ( $p < 0.001$ ) of the processing methods on water absorption capacity. The range of water absorption capacity for the turmeric powders was 3.35 - 5.35 g/ml, with the sundried sample exhibiting the lowest value and the cooked/oven dried sample showing the highest. Additionally, the oven dried sample (4.13 g/ml) and the blanched/oven dried sample (3.92 g/ml) had the highest values, with no significant difference observed between these two treatments.

The cooking/oven drying treatment demonstrated a significant increase in the water absorption capacity of the turmeric powder. This could be attributed to the denaturation of proteins during the cooking/heat treatment process. Khalid et al. (2003) reported that heat-treated flours have a higher tendency to absorb water due to carbohydrate gelatinization and protein denaturation caused by heat. Obatolu et al. (2001) also observed that increased cooking time led to the denaturation of yam bean protein, resulting in increased water absorption capacity. Turmeric powders with high water absorption capacity can be employed as food thickeners in various food systems. Therefore, cooked/oven dried turmeric powder can be suitable for this purpose.

#### 3.1.1.4 Swelling power (g/g):

The swelling power of turmeric powder, influenced by various processing methods, is presented in Table 3. The results indicate that the processing methods had a significant impact ( $p < 0.001$ ) on the swelling power. The swelling power ranged from 6.29 g/g to 7.89 g/g, with the sun-dried sample having the lowest value and the cooked/oven-dried sample having the highest value. Similarly, the blanched/oven-dried sample (6.92 g/g) and the oven-dried sample (6.64 g/g) showed the highest values, with no significant difference between these two treatments.

The cooking/oven drying treatment was found to significantly enhance the swelling power of the turmeric powders. This improvement could be attributed to the reduction of fat content during the cooking process. According to Yakubu et al. (2015), high heat during cooking causes the fat to melt, resulting in a decrease in fat content. Igbokwe et al. (2016) further explained that high levels of fat can lead to the formation of amylase-lipid complexes, which restrict the swelling phenomenon. Additionally, the heating process disrupts some of the intermolecular hydrogen bonds, making the swelling more noticeable (Ihekoronye & Ngoddy, 1985).

#### 3.1.1.5 Solubility (%):

Table 3 presents the solubility of turmeric powder affected by different processing methods. The results indicate a significant impact ( $p < 0.001$ ) of these methods on solubility. The lowest solubility was observed in cooked/oven dried and sun-dried samples, with values of 16.75% and 17.29% respectively. The highest solubility of 21.11% was found in the oven dried sample. The blanched/oven dried sample had a solubility of 19.38%, which was significantly different ( $p < 0.001$ ) from the other treatments.

In this study, cooking/oven drying, blanching/oven drying, and sun drying resulted in a significant reduction in the solubility of turmeric powders, while oven drying alone improved solubility. Falade & Okafor (2015) defined solubility as the ability of solids to dissolve or disperse in an aqueous solution, typically water. Based on the obtained results, it can be inferred that the high temperatures used in the oven drying process might have weakened the starch granules, leading to increased solubility.

#### 3.1.2 Physico-chemical properties :

Table 2. Effects of different processing methods on physico-chemical properties of turmeric rhizome var. Kapurkot haledo-1

Treatments	Moisture (%)	Total ash (%)	Curcumin (%)	pH	
OD	4.75c	7.38a	2.05b	6.92b	*, ** and *** indicate significant at p < 0.05, p < 0.01 and p < 0.001 respectively. Means followed by the same letter(s) in the column are not significantly different at 5% by DMRT. OD = Oven Dried turmeric
BOD	5.13bc	7.37a	2.35b	6.75b	
COD	8.63a	7.10b	3.11a	6.75b	
SUN	6.13b	7.03b	2.99a	7.25a	
LSD	1.03	0.27	0.32	0.26	
p-value	<0.001	0.0277	<0.001	0.00356	
F-test	***	*	***	**	
SEm(±)	0.42	0.05	0.12	0.06	
CV(%)	10.81	2.42	7.79	2.42	
Grand mean	6.16	7.22	2.63	6.92	

powder; BOD = Blanched + Oven Dried turmeric powder; SUN = Sun Dried turmeric powder; COD = Cooked + Oven Dried turmeric powder.

#### 3.1.2.1 Moisture (%):

Moisture content of turmeric powder, as affected by different processing methods is presented in Table 4. The processing methods significantly ( $p < 0.001$ ) affected the moisture content. Moisture content ranged from 4.75 – 8.63 % with oven dried sample as the lowest and cooked/oven dried sample as the highest. Similarly, sun dried (6.13 %) and blanched/ oven dried samples (5.13 %) followed the highest value, both the treatments being at par.

Higher moisture contents observed in the cooked/ oven dried and blanched/oven dried samples are mainly due to the absorption of water by the turmeric rhizomes during the processes of cooking and blanching. Also, sun dried sample has been found to contain higher moisture content. This could be due to the lower drying days and relatively lower sunlight intensity during the day hours. Moisture gives a measure of the water content of the flour samples. It is also an index of storability of the flour as reduced moisture content implies better shelf life and stability (Eke-Ejiofor & Kin-Kabari, 2010).

#### 3.1.2.2 Total ash (%):

Total ash content of turmeric powder, as affected by different processing methods is presented in Table 4. The processing methods significantly ( $p < 0.05$ ) affected the total ash content. Total ash content of the turmeric powders was recorded highest i.e. 7.38 % and 7.37 % in oven dried and blanched/ oven dried samples respectively, both the treatments being non-significant to each other. Similarly, the lowest total ash content of 7.10 % and 7.03 % was recorded in cooked/oven dried and sun-dried samples respectively, both the treatments being non-significant to each other.

Ash content gives us the glimpse of total amount of inorganic substances, including trace and major minerals (Hirko et al., 2019). The amounts of total ash content in the rhizomes are more affected due to increased boiling duration. The findings of this result, which signifies the quality and purity of the turmeric powder, is in accordance with Abraham et al., (2018) who reported an average ash content of 8.39% represented the purity of the samples. Total ash content of 13.08% from rhizomes treated at 80°C for 30 min and the least 9.95% ash for rhizome boiled at 100°C for 75 minutes were reported by Zerihun et al., (2017).

### 3.1.2.3 Curcumin (%):

Curcumin content of turmeric powder, as affected by different processing methods is presented in Table 4. The processing methods significantly ( $p < 0.05$ ) affected curcumin content. Curcumin content of the turmeric powders was recorded highest i.e. 3.11 % and 2.99 % in cooked/oven dried and sun dried samples respectively, both the treatments being non-significant to each other. Similarly, the lowest curcumin content of 2.35 % and 2.05 % was recorded in blanched/oven dried and oven dried samples respectively, both the treatments being non-significant to each other.

Curcumin is the main ingredient of turmeric powder, responsible for its bright – yellow colour, and it is heat and light sensitive (Raza et al., 2018). Thus, this sensitive nature could be the reason why cooking/oven drying and sun drying has resulted to a significant reduction in the curcumin content of the processed turmeric powders. The findings of this study are consistent with that of Raza et al., (2018) who reported that boiling and sunlight affects the curcumin concentration significantly. Suresh et al., (2007) also reported that the curcumin content was lost by 27-53% during heat processing with maximum loss in pressure cooking for 10 min.

### 3.1.2.4 pH:

pH value of turmeric powder, as affected by different processing methods is presented in Table 4. The processing methods significantly ( $p < 0.01$ ) affected the pH value. pH value of the turmeric powders was recorded highest i.e., 6.92, 6.75 and 6.75 in oven dried, blanched/ oven dried and cooked/oven dried samples respectively, all these treatments being statistically at par. Sun dried sample recorded the highest pH value of 7.25, being statistically significant ( $p < 0.01$ ) to the other treatments.

The pH is linked with the development of a pleasant taste (Niba, 2001) . Also, pH is an important factor in developing flavour and aroma characteristics of foods and also determines the stability of the food product (Ardiah & Wariyah, 2021). The high pH value as reported in sun dried turmeric powder is undesirable as it might predispose the product to bacterial spoilage. Generally, turmeric water has pH nearer to neutral value i.e. 7.

### 3.2 Association among functional and physico-chemical properties:

The correlogram showing the association among functional and physico-chemical properties of turmeric rhizome powder is shown in Figure 2. The highest positive correlation value of 0.93 was observed between water absorption capacity and oil absorption capacity, both being the functional properties. Similarly, the lowest negative correlation value of -0.74 was recorded between dispersibility and pH. Generally, the pairs among the functional properties and among the physico-chemical properties were positively correlated, while the pair comprising the correlations between functional and physico-chemical properties had weak positive correlation and/ or negative correlation.

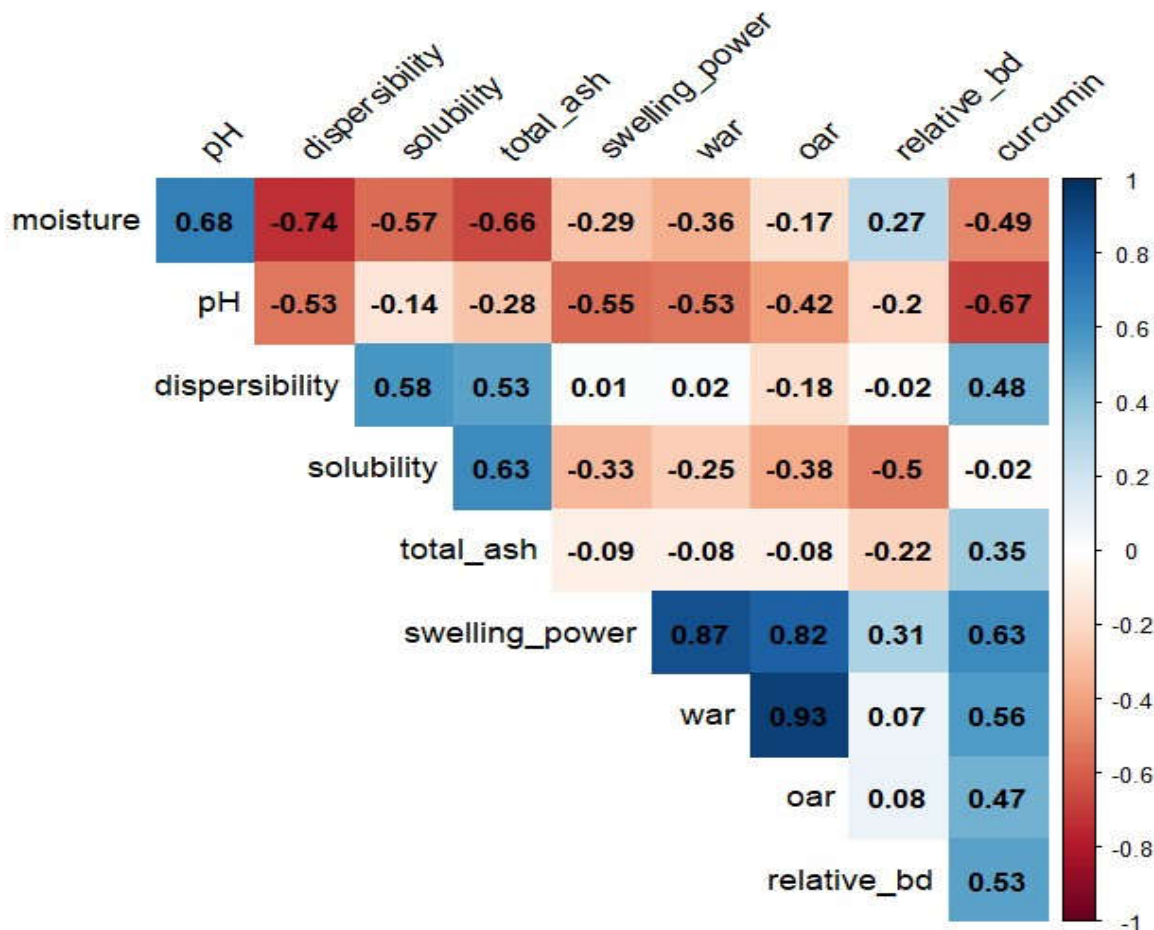


Figure 1. Correlogram showing the relationship between functional and physio-chemical properties of turmeric rhizome powder var. Kapurkot haledo-1.

### 5. Conclusion

With the completion of this experiment, the analysis of functional properties reveals the effectiveness of blanching and cooking/ oven drying in improving bulk density, swelling power and water and oil absorption capacities. Thus, these two processing methods can be used widely in food industries to impart bulkiness on turmeric powder for proper packaging and handling, and in food constituents to impart characteristic flavor and aroma of turmeric. Higher solubility in oven dried powder and higher dispersibility in sun dried powder can be attributed to better hydrophilic and reconstitution properties of turmeric powder respectively. As curcumin is a heat labile component, the use of low heat and low-pressure cooking method can retain its maximum properties. By the correlogram analysis, it can be stated that the parameters among functional properties and among the physico-chemical properties are positively correlated, while the pairs comprising the correlations between functional and physico-chemical properties have weak positive correlation and/or negative correlation.

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