

Doi: [HTTPS://DOI.ORG/10.23910/IJEP/2018.5.1.0238](https://doi.org/10.23910/IJEP/2018.5.1.0238)

## Effect of Time and Steam Pressure on Gelatinization of Starch and Antioxidant Properties of Curcumin of Turmeric (*Curcuma Longa*) Rhizomes

Wasiya Farzana<sup>1\*</sup>, Ashitha G. N.<sup>1</sup>, Eresh Kumar Kuruba<sup>2</sup> and D. Amirtham<sup>1</sup><sup>1</sup>Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu (641 003), India<sup>2</sup>Jawahar Nehru Krishi VishwaVidyalaya, Jabalpur (482 004), India

### Corresponding Author

Wasiya Farzana  
e-mail: wasee92@gmail.com

### Article History

Article ID: IJEP0238  
Received in 29<sup>th</sup> October, 2017  
Received in revised form 4<sup>th</sup> February, 2018  
Accepted in final form 10<sup>th</sup> February, 2018

### Abstract

Turmeric grown in state of Tamil Nadu in India was analysed for its change in Curcumin content when subjected to varying pressures of steam during pressurised steam boiling under laboratory scale conditions. The same were tested in the field for optimized conditions in the already existing turmeric boiling system with the farmers, the locally available parboiling drum used for paddy parboiling and the improved steam boiling vessel developed at Tamil Nadu Agricultural University. The varying pressures which brought about varying degrees of gelatinization of starch which in turn affecting the Curcumin content were studied. Consequently the bioavailability of Curcumin and its antioxidant properties were analysed considering its health benefits. The best quality of turmeric in terms of Curcumin content was obtained at 46.43 % degree of starch gelatinization. The highest RSA (24%) was obtained at 5 minutes at 5 kg cm<sup>-2</sup> pressure treatment. The correlation between degree of starch gelatinization and antioxidant property of turmeric was found to be highly negative (-0.9577).

**Keywords:** Turmeric, curcumin content, pressures, boiling, steam, gelatinization

### 1. Introduction

Turmeric being a crop majorly produced in India having a monopoly over export market with 82% is valued for its Curcumin content, a major parameter upon which the quality is based. Curcumin, a polyphenol is the active substance of turmeric and curcumin is known as C.I. 75300 or Natural Yellow 3. It is used in canned beverages and baked products, dairy products, ice cream, yogurt, yellow cakes, orange juice, biscuits, popcorn colour, sweets, cake icings, cereals, sauces, gelatins, etc. (USDA-GRIN, 2008). It is also used in textile industry, in the preparation of oils, ointments and poultice, in cosmetic product to prepare natural and herbal creams, lotion and hair dye (Shinde et al., 2011). Turmeric is extensively used in Ayurveda, Unani and Siddha medicines as home remedy for various diseases. In old Hindu medicine, it is extensively used for the treatment of sprains and swelling caused by injury. Several studies have dealt with the pharmacological effects of turmeric components (Araujo and Leon, 2001): antioxidant (Quiles et al., 2002), anti-inflammatory (Surh, 2002), antimutagenic (Inano and Onada, 2002), anticarcinogenic (Kim et al., 2000), antimicrobial (Negi et al., 1999) and antivenom (Ferreira et al., 1992). It is used as a food additive (spice), preservative and colouring agent in Asian countries,

including China and South East Asia. The bright yellow colour of turmeric comes mainly from fat-soluble, polyphenolic pigments called curcuminoids which has curcumin as its principal component. Turmeric contains a wide variety of phytochemicals including curcumin, demethoxycurcumin, bisdemethoxycurcumin, zingiberene, curcumenol, curcumol, eugenol, tetrahydrocurcumin, triethylcurcumin, turmerin, turmerones and turmeronols (Chattopadhyay et al., 2004). The structure of curcumin (C<sub>21</sub>H<sub>20</sub>O<sub>6</sub>) was first described in 1910 by Lampe and Milobedeska (Himesh et al., 2011).

Curcumin has antioxidant, anti-inflammatory, antiviral and antifungal actions.

Though there are many boiling systems used by the farmers to process turmeric, they are found to be inefficient, time consuming, laborious and costly. Pressurised steam boiling being the most advanced method of boiling turmeric has an impact over its curcumin content, moisture content, oleoresin, essential oils, hardness with variable pressures. Among these curcumin content is the deciding factor and hence taken for the study. The variety, type of boiler and dryer are also the important parameters which affect the curcumin content in turmeric.

In India turmeric is grown in an area of 1,04,500 ha producing



annually 4,30,000 t (2012-13). Although, India is leading in its production (75% of world output), the average productivity and quality are not satisfactory and these limit our export to about 10 to 15% of our production only. However, annually 18 to 20 crore worth of turmeric are exported. The major turmeric growing states in India are Andhra Pradesh, Tamil Nadu, Maharashtra, Assam, Kerala, Karnataka and West Bengal in which Andhra Pradesh (60% of total turmeric production in India) is the leading producer state followed by Tamil Nadu (13%), Karnataka and Maharashtra.

Boiling or curing of turmeric which is one of the steps which decides the final Curcumin content present in the product. Blanching (boiling in water for a set period of time) is carried out to facilitate the drying process of the rhizomes, to allow the starch granules to gelatinize and to inactivate enzymes (Plotto, 2004; Panda, 2010). The quality of final curcumin is greatly affected by small change in steam pressure and time.

The main aim of the study was to reach the optimum degree of gelatinization at which there exists highest bioavailability of curcumin which influences the antioxidant properties of the turmeric. The commodities having antioxidant properties are incorporated in the nutraceuticals for having health benefits.

## 2. Materials and Methods

### 2.1. Material

#### 2.1.1. Sample preparation

Turmeric variety PTS 10 (hybrid) grown locally in Erode district of Tamil Nadu was procured and stored under dry, dark and cool conditions.

This research was conducted in the 2015-16 in the Department of Agricultural Process and Food Engineering of Tamil Nadu Agricultural University Coimbatore.

### 2.2. Methodology

#### 2.2.1. Determination of degree of starch gelatinization

Determination of gelatinised starch using Glucoamylase and *o*-Toluidine as described by B. Y. Chiang; J. A. Johnson was followed for determining the degree of starch gelatinization in turmeric. This method is widely applicable for starch solutions having low quantities of low-molecular weight oligosaccharides like glucose, sucrose and raffinose. (Chiang and Johnson, 1976)

##### 2.2.1.1. Reagents used for determining gelatinized starch contents

***o*-Toluidine Reagent.** Dissolved 1.5 g thiourea in 940 ml of glacial acetic acid and then adding 60 ml of *o*-toluidine. This solution was stored in an amber bottle.

**Sodium Acetate Buffer.** Dissolved 4.1 g of anhydrous sodium acetate in 1 litre distilled water and adjusted pH to 4.5 with acetic acid.

**Glucoamylase Solution.** Dispersed 2g Rhizopusglycoamylase in 250 ml of acetate buffer and filtered rapidly through glass fibre paper. To be used within 2 h. Specific activity of glucoamylase was 1:2000  $\mu\text{mol}$  glucose formed  $\text{min}^{-1} \text{mg}^{-1}$  protein at pH 5.5-6.0 and 40 °C

#### 2.2.1.2. Procedure

**a. Preparing Sample with Partially Gelatinized Starch.** Dispersed 20 mg of sample in 5 ml of distilled water in a 50 ml centrifuge tube.

**b. Preparing Sample with totally Gelatinized Starch.** Dispersed 20 mg of sample in 3 ml of distilled water and 1 ml of 1 N NaOH contained in a 50 ml centrifuge tube. After five minutes 1 ml of 1N HCl was added

**c. Glycoamylase digestion and glucose determination.** Added 25 ml glucoamylase solution to each tube and incubated for 30 min at 40 °C. Added 2 ml 25% trichloroacetic acid (TCA) to inactivate glucoamylase (and to precipitate it in other proteins) and centrifuged it at 16,000xg for 5 minutes. To 0.5 ml of supernatant solution in test tubes, added 4.5 ml of *o*-toluidine reagent. Placed test tubes in boiling water for 10 minutes, cooled with cold water and added 5 ml of glacial acetic acid. Measurement of absorbance was taken at 630 nm.

Gelatinized starch (%) was calculated as follows:

Where Y is the % of starch gelatinised

A is absorbance of Total gelatinised starch

B=the absorbance of mixture of partially gelatinized or intact starch after 30 min enzymatic hydrolysis

C= the absorbance of mixture of partially gelatinized or intact starch after 60 min enzymatic hydrolysis

k=the absorbance of 1% of intact starch digested in 30 min and constant for each variety and specially treated starch and needs to be determined only once in routine analysis.

#### 2.2.2. Determination of antioxidant properties of turmeric

##### Determination of antioxidant properties

Antioxidant properties were determined using protocol described by Mathangi and Prabhakaran (2013)

##### 2.2.2.1. Processing of turmeric for extract preparation

About 60 g of dry sample turmeric powder was weighed and macerated with 500 ml of each solvent (hexane, ethyl acetate and methanol) separately and kept overnight in shaker. The extract was collected after filtration using Whatman No.1 filter paper and was stored. Another 75 ml of solvent was added to the residual mixture and incubated in shaker for 24 hr and the extract was collected again using a Whatman No.1 filter paper. This procedure was repeated once again and the extract was evaporated below 40 °C, which was used for further phytochemical analyses.

##### 2.2.2.2. Procedure for free radical scavenging activity



The ability of the extracts to annihilate the DPPH radical (1, 1-diphenil-2- picrylhydrazyl) was investigated by the method described by Blois (1958). Stock solution of the whole plant extracts was prepared to the concentration of 1 mg ml<sup>-1</sup>. 100 µg of each extracts were added, at an equal volume, to methanolic solution of DPPH (0.1 mM). The reaction mixture is incubated for 30 min at room temperature; the absorbance was recorded at 517 nm. The experiment was repeated for three times. Ascorbic acid was used as standard controls.

### 3. Results and Discussion

#### 3.1. Degree of starch gelatinization for lab scale studies

As shown in Figure 1 the trend for degree of starch gelatinization was found to increase with pressure and time. It was found to be highest (74.66%) in the sample treated for 1.5 kg cm<sup>-2</sup> pressure for 15 minutes. The increase in pressure leads to increase in

Varying Degree of starch gelatinization with pressure and time

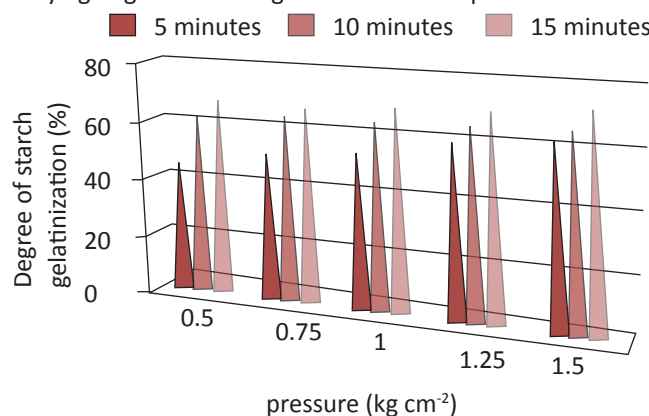


Figure 1: Varying degree of starch gelatinization with pressure and time

the heat energy given to the rhizomes and the time increment together increases the degree of starch gelatinization. While the lowest (46.43%) was found to be with the treatment of 0.5 kg cm<sup>-2</sup> for 5 minutes. The results are presented in Table 1.

#### 3.2. Degree of starch gelatinization for field studies

As shown in Figure 2, the degree of starch gelatinization was found to reduce with improvements in boiling system. In the present study it was observed that the improved turmeric cooking vessel has the least starch gelatinization (%) with a value of 49.46 % followed by parboiling drum with 51.73% and then by open steaming 52.29%. This may be due to larger time of cooking in open steaming with time being 15 minutes compared to parboiling drum having 10 minutes and improved vessel having 7 minutes of steaming. The results are presented in Table 2.

Leonel et al. (2003) have recorded 47% of starch content in *C. longa* and 57.7 % in *C. zedoaria*. Kuttigounder et al. (2011) reported the starch yield as 56% .

Dhivya (2015) reported that maximum starch content of 57.79

Table 1: Degree of starch gelatinization for lab scale studies

Sl. No.	Pressure	Duration	Degree of starch gelatinization %
1.	0.5	5 minutes	46.43
2.	0.75		51.84
3.	1		54.72
4.	1.25		60.93
5.	1.5		63.21
6.	0.5	10 minutes	64.02
7.	0.75		65.11
8.	1		65.34
9.	1.25		66.48
10.	1.5		68.22
11.	0.5	15 minutes	68.43
12.	0.75		68.51
13.	1		70.84
14.	1.25		71.52
15.	1.5		74.66

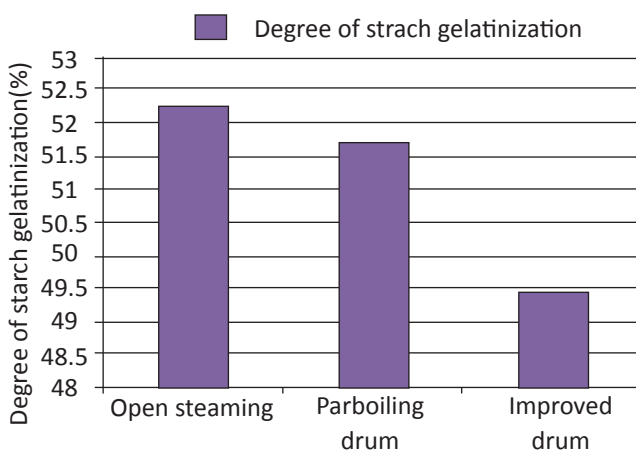


Figure 2: Varying degree of starch gelatinization for field studies

Table 2: Degree of starch gelatinization for field studies

Sl no	Different vessels for boiling	Degree of starch gelatinization %
1	Open steaming	52.29
2	Parboiling drum	51.73
3	Improved drum	49.46

% was recorded by Erode finger samples and minimum of 56.68 % was recorded by Salem bulb samples.

#### 3.3. Antioxidant property of turmeric for laboratory studies

The antioxidant property was found after giving different pressures and time combinations. RSA % is presented in Table

3. The highest value obtained was for 0.5 ksc for 5 minutes (Figure 3). This can be explained that with increasing starch gelatinization the curcumin decreases. Curcumin content directly influences the level of radical scavenging property.

Table 3: Radical scavenging activity (%) for lab scale studies

Sl. No.	Duration	Pressure	Radical scavenging activity (%)
1.	5 minutes	0.5	24
2.		0.75	21
3.		1	20
4.		1.25	19.4
5.		1.5	19.2
6.	10 minutes	0.5	18.7
7.		0.75	18.1
8.		1	17.4
9.		1.25	17.2
10.		1.5	16.7
11.	15 minutes	0.5	15.17
12.		0.75	15.01
13.		1	14.27
14.		1.25	14.1
15.		1.5	13.4

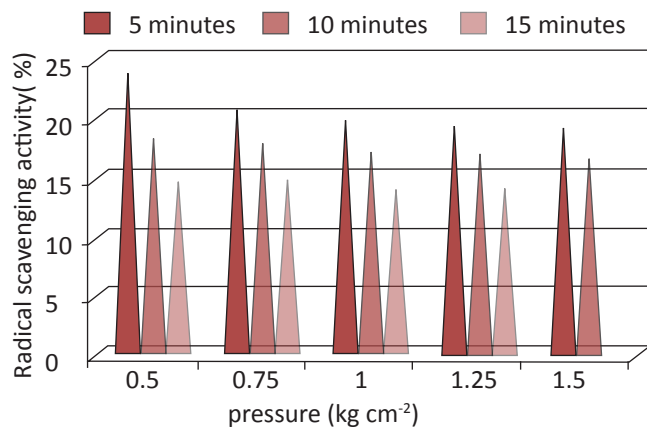


Figure 3: Varying degrees of antioxidant properties with pressure and time

### 3.4. Antioxidant property of turmeric for field studies

The colorant present in the turmeric which is curcumin has anti-oxidant property which was checked by DPPH method. The improved drum showed the highest value in the field trials having RSA=23.7% and the least value was shown by open steaming having the value of RSA=15%. This may be due to the fact that curcumin is heat sensitive as shown in Figure 4. The longer duration of cooking in open steaming leads to loss of curcumin, directly affecting the antioxidant property of turmeric. Results are presented in Table 4.

Table 4: Radical scavenging activity (%) for field studies

Sl. No.	Different vessels for boiling	Radical scavenging activity %
1.	Open steaming	15.08
2.	Parboiling drum	18.84
3.	Improved drum	23.7

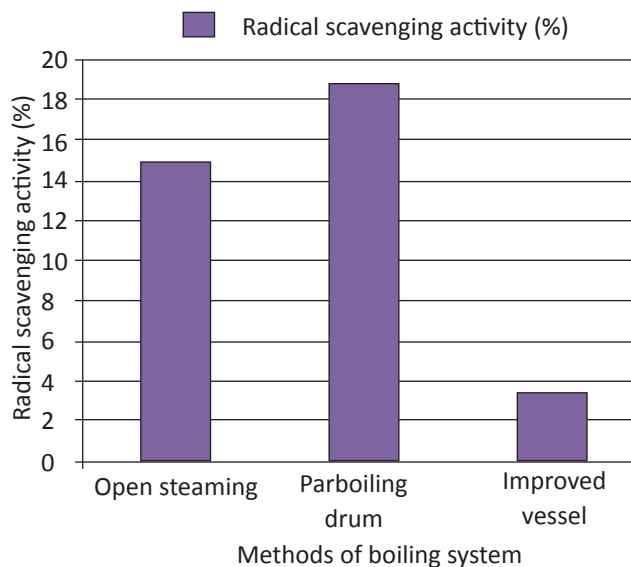


Figure 4: Impact of methods of boiling on Radical scavenging activity (%) for field studies

### 3.5. Correlation between degree of starch gelatinization and antioxidant properties

The correlation between the degree of starch gelatinization and antioxidant properties for laboratory scale studies was found out. There exists a high negative correlation between the degree of starch gelatinization and the antioxidant properties with a value -0.9577. This indicated that the RSA (%) decreased as the degree of starch gelatinization increased.

## 4. Conclusion

The relation between degree of starch gelatinization and antioxidant property was found out with laboratory experiments and it was observed that with increasing degree of starch gelatinization the antioxidant property decreased. The same was observed to be true with the field studies. Statistically this relation was found to be the same.

## 5. Acknowledgement

The authors acknowledge the Tamil Nadu Agricultural University, Coimbatore for funding the project. The authors are also indebted to the Professor and Head, TNAU AEC&RI Coimbatore campus for providing the requisite facilities for the work.

## 6. References

Araujo, C. C., Leon, L.L., 2001. Biological activities of *Curcuma*

- longa* L. Mem Inst Oswaldo Cruz 96(5), 723–728.
- Blois, M.S., 1958. Antioxidant Determinations by the Use of a Stable Free Radical. *Nature* 181, 1199–1200.
- Chattopadhyay, I., Biswas, K., Bandyopadhyay, U., Banerjee, R.K., 2004. Turmeric and curcumin: Biological actions and medicinal applications. *Current Science* 87, 44–53.
- Chiang, B.Y., Johnson, J.A., 1976. Measurement of Total and Gelatinized Starch by Glycoamylase and o-Touluidine Reagent. *Cereal Chemistry* 54(3), 429–435.
- Dhivya K., 2015. Development of Rapid Grading Method for Quality Evaluation of Turmeric Rhizomes Using Ft-Nir Spectroscopy. M.Tech. theses Tamil Nadu Agricultural University, Coimbatore, TN, India.
- Ferreira, L.A., Henriques, O.B., Andreoni, A.A., Vital, G.R., Campos, M.M., Habermehl, G.G., de Moraes, V.L., 1992. Antivenom and biological effects of ar-turmerone isolated from *Curcuma longa* (Zingiberaceae). *Toxicon* 30, 1211–8.
- Himesh, S., Sharan, P.S., Mishra, K., Govind, N., Singhai, A.K., 2011. Qualitative and Quantitative Profile Of Curcumin From Ethanolic Extract Of *Curcuma longa*. *International Research Journal of Pharmacy* 2 (4), 180–184.
- Inano, H., Onoda, M., 2002. Radioprotective action of curcumin extracted from *Curcuma longa* LINN: inhibitory effect on formation of urinary 8-hydroxy-2'- deoxyguanosine, tumorigenesis, but not mortality, induced by gamma-ray irradiation. *International Journal of Radiation Oncology, Biology, Physics* 53,735–743.
- Kim, K.I., Kim, J.W., Hong, B.S., Shin, D.H., Cho, H.Y., Kim, H.K., Yang, H.C., 2000. Antitumor, genotoxicity and anticlastogenic activities of polysaccharide from *Curcuma zedoaria*. *Mol Cell* 10(4), 392–398.
- Kuttigounder, D., Lingamallu, J.R., Bhattacharya, S., 2011. Turmeric Powder and Starch: Selected Physical, Physicochemical, and Microstructural Properties. *Journal of Food Science* 76(9), 1284–1291.
- Lampe, V., Milobedeska, J., Kostanecki, V., 1910. Synthese von p, p'-dioxo- and p-oxydicinnamoylmethchenchemischen Gesellschaft 43, 2163.
- Leonel, M., Sarmiento, S.B.S., Cereda, M.P., 2003. New starches for the food industry: *Curcuma longa* and *Curcuma zedoaria*. *Carbohydrate Polymers* 54(3), 385–388.
- Negi, P.S., Jayaprakasha, G.K., Rao, L.J.M., Sakariah, K.K., 1999. Antibacterial activity of turmeric oil: a byproduct from curcumin manufacture. *Journal of Agricultural and Food Chemistry* 47, 4297–4300.
- Mathangi, T., Prabhakaran, P., 2013. DPPH Free Radical Scavenging Activity of the Extracts of the Aquatic Fern, *Marsilea quadrifolia* Linn. *International Journal of Current Microbiology and Applied Science* 2(10), 534–536.
- Panda, H., 2010. Handbook on Spices and Condiments (Cultivation, Processing and Extraction). Asia Pacific Business Press Inc., New Delhi, India, 22.
- Plotto, A., 2004. Turmeric: Post-Production Management, Food and Agriculture Organization of the United Nations (FAO).
- Quiles, J.L., Mesa, M.D., Ramirez-Tortosa, C.L., Aguilera, C.M., Battino, M., Gil, A., Ramirez-Tortosa, M.C., 2002. *ArteriosclerThrombVasc Biology* 22(7), 1225–1231.
- Shinde, U.G., Kamble, K.J., Harkari, M.G., More, G.R., 2011. Process Optimization in Turmeric Heat Treatment by Design and Fabrication of Blancher. *International Conference on Environmental and Agriculture Engineering IPCBEE vol.15, IACSIT Press, Singapore.*
- Surh, Y.J., 2002. Anti-tumour promoting potential of selected spice ingredients with anti-oxidative and inflammatory activities: a short review. *Food Chemistry and Toxicology* 40, 1091–1097.
- USDA-GRIN, 2008. *Curcuma longa* information from NPGS/GRIN. Available from <http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?12676>. Accessed in November 2017.

