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Development of the Production of Curcumin Powder for Application in the Food Industry

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ABSTRACT

Curcumin has been identified as the most abundant bioactive constituent in turmeric (*Curcuma longa*) extract (2 - 8% w/w). Curcumin is used as a preservative, flavoring, and yellowish colorant agent in the food industry. Modern scientific studies have confirmed its anti-inflammatory, antioxidant, anti-carcinogenic, and antimicrobial properties. Curcumin is easily oxidized and light-damaged, and it is insoluble in water. This product's shelf life should be increased. Curcumin microencapsulation into powder solves these issues. This process has been used because of its low cost, equipment availability, continuous production, and ease of industry. Curcumin powder in food could be crude turmeric powder (0.58 - 3.14%w/w), curry powder (0.11 - 0.58%w/w), or spray dried turmeric oleoresin curcumin powder (40 - 50%w/w). Spray drying coats the curcumin core material into the matrix powder, improving stability. The wall material (gum arabic, maltodextrin, or chitosan) and emulsifying agent were dispersed in continuous phase with the curcumin core material to prepare the microencapsulated flowing powders. Several formulation modifications in spray drying methods, such as co-dried and binary blend materials, have been investigated to improve the stability of curcumin. Curcumin powder is becoming more popular as a treatment for a variety of ailments, as well as a compound that is generally regarded as safe. As a result, its application as a nutraceutical or functional food has the potential to be expanded further.

keywords: Curcumin, turmeric, spray drying, powder, functional food.

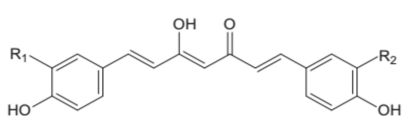
1. INTRODUCTION

The spice turmeric (*Curcuma longa*) is used in a variety of cuisines as a flavoring and coloring ingredient for meals such as rice, yogurt, and poultry [1]. These species contain mostly three categories of chemicals. Diphenyl alkanoids (nonvolatile) similar to curcumin, Phenylpropene (cinnamic acid-type) derivatives (nonvolatile). Terpenoids present in turmeric oil (volatile)[2], [3]. In addition to being used alone, turmeric can also be combined with other spices. Curcumin is the component responsible for turmeric's use in foods. Curcumin is a natural polyphenol derived from turmeric oleoresin. Its chemical formula is 1,7-bis (4 – hydroxy – 3 - methoxyphenyl) - 1,6 – diene - 3,5-dione. Curcumin is a vivid yellow color that is also regarded to be a potent functional food. It is sensitive to light, unstable at pH levels greater than seven, and degrades oxidatively. This product requires an extension of its shelf life[4], [5].

Curcumin could be made more stable through the process of encapsulation, which would be useful for the use of curcumin in functional foods and colors [6]. Spray drying is a different way that can encapsulate curcumin and is more economical than the other methods[7]–[9]. In addition, spray dried curcumin can be produced in a few different wall materials; however, once it has been employed, its physical and chemical properties are significantly diminished. Polyphenols can be protected against the deleterious effects of oxidation by encapsulating substances of many kinds, including maltodextrin (MD), as well as other forms [10], [11]. Spray drying is a procedure that may be used to encapsulate curcumin, and in order to get better results from it. It will be necessary to improve both the formulation and the development process of how it is done. The powder that was developed has potential applications in both the coloring industry and the flavoring industry as an additive[8], [12]. The goal of this study is to investigate whether or not there has been any advancement in the production of curcumin powder in order to learn more about the progress that the use of curcumin powder is making in the food industry. The supplementary data, which were gathered from publishing databases such as PubMed (https://www.ncbi.nlm.nih.gov/pubmed) and Science direct (https://www.sciencedirect.com/), are utilized to further discuss the topic.

2. CURCUMIN

The polyphenol known as curcumin, also known as diferuloylmethane, is an active component of the perennial herb known as Curcuma longa. The yellow coloured portion of turmeric contains curcuminoids, which are chemically related to the active component that makes up the majority of turmeric, curcumin. Demethoxycurcumin, also known as curcumin II, bisdemethoxycurcumin, also known as curcumin III, and cyclocurcumin, which was very recently discovered, are the primary curcuminoids that are found in turmeric (Figure 1). The primary components of commercial curcumin are curcumin I (77%), curcumin II (17%), and curcumin III (3%) [13].



Curcumin I $R_1 = R_2 = OCH_3$ (2)
Curcumin II $R_1 = OCH_3$, $R_2 = H$ (3)
Curcumin III $R_1 = R_2 = H$ (4)

Figure 1 Diphenylheptanoid structure and natural curcumin analog [14].

It wasn't until 1815 that curcumin was first isolated, and it wasn't until 1870 that it was acquired in crystalline form. In the end, curcumin was determined to be 1,6-heptadiene-3,5-dione-1,7-bis (4 - hydroxy - 3 - methoxy phenyl)-(1E,6E) or diferuloylmethane. Yellow-orange powder that is insoluble in water and ether but soluble in ethanol, dimethylsulfoxide, and acetone. Curcumin has been shown to have anti-inflammatory properties. The melting point of curcumin is 183 degrees Celsius; its chemical formula is $C_{21}H_{20}O_6$, and its molecular weight is 368.37 grams per mole. According to spectrophotometric analysis, the maximum absorption of curcumin in methanol takes place at 430 nm, whereas in acetone, it takes place between 415 and 420 nm. Curcumin diluted to a concentration of 1% contains 1650 absorbance units. At pH 2.5–7, curcumin has a beautiful yellow hue, while at pH > 7, it has a reddish color. Both an enolic and a diketonic form of curcumin can be found. The fact that curcumin in solution is almost always found in its enolic state has a significant influence on the radical-scavenging capacity of curcumin (Fig 2). At acidic pH, curcumin is stable, but at neutral and basic pH, it degrades into ferulic acid and feruloylmethane. Curcumin is stable at acidic pH but unstable at neutral and basic pH. (Figure 3). Table 1 displays some comparative information regarding the various types of curcumin [13], [15], [16],[17].

Historically, curcumin has been used as a spice, typically in the form of a yellowish curry, and as a flavoring in a wide variety of foods, including chicken, cheese, butter, and other foods. Ayurvedic medicine is just one example of how turmeric and other naturally occurring curcuminoid compounds have been used for therapeutic purposes over the course of many centuries in traditional medicinal practices all throughout the world. It has a long history of usage in traditional medicine in the Orient, particularly as an anti-inflammatory, and many of its therapeutic effects have been validated by recent scientific research. In particular, its anti-inflammatory properties have been found to be very effective. These effects include hepatoprotective, thrombosuppressive, cardiovascular, hypoglycemic, antiarthritic, and antidepressant properties, as well as antioxidant, anti-inflammatory, anticarcinogenic, and antibacterial properties. Because of its significant use in medical applications, it may also find use in neutraceutical food products [5], [15], [18].

Table 1. Properties of curcuminoids

Common name	Curcumin I	Demetoxycurcumin (Curcumin II)	Bis-demethoxycurcumin (Curcumin III)
Name of Chemical	Diferuloymethane (1,7-bis-(4-hydroxy-3-methoxy prenyl)-1,6-heptadiene-3,5-dione)	4-Hydroxy Cinnamoyl (Feruloyl) Methane	Bis-4-Hydroxy Cinnamoyl Methane
Common name			
Molecular weight	368.4	338.0	308.1
Melting Point (°C)	183 - 186	172.5 – 174.5	224
Solubility			
Water, Hexane or ether	Insoluble	Insoluble	Insoluble
Alcohol or Acetone	Soluble	Soluble	Soluble
Percentages in turmeric oleoresin	77	17	3
UV spectra (nm)	429	424	419

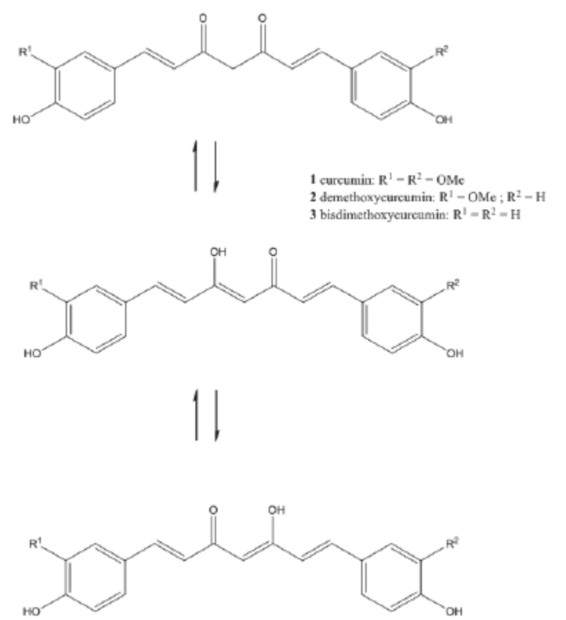


Figure 2. Principal curcuminoids of turmeric shown as ketone- enol equilibrium[19]

3. CURCUMIN POWDER PRODUCTION

The use of turmeric, like all other uses of this spice, must increase its value. It refers to the means by which the marketability of an agricultural product can be improved. Turmeric powder finds its primary application in the retail sector, more specifically within the food processing industry. However, curcumin loses its stability when exposed to light, oxidation, or alkaline conditions. A longer shelf life is required for it. Because of its simplicity and its applicability in the food industry, microencapsulation into powder constitutes the superior processing method. The production of curcumin powder was represented by the chart in figure 4.

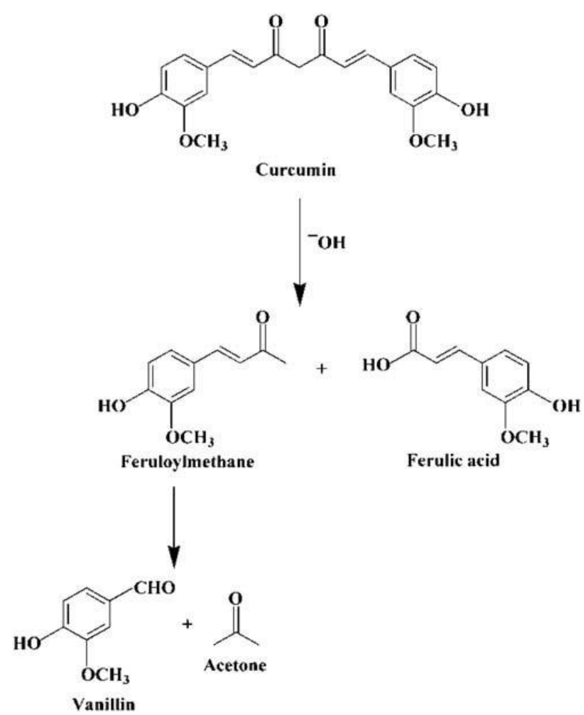


Figure 3. Sheme 1. Ketonic hydrolysis of curcumin aqueous and base medium catalyzed by OH− ion.

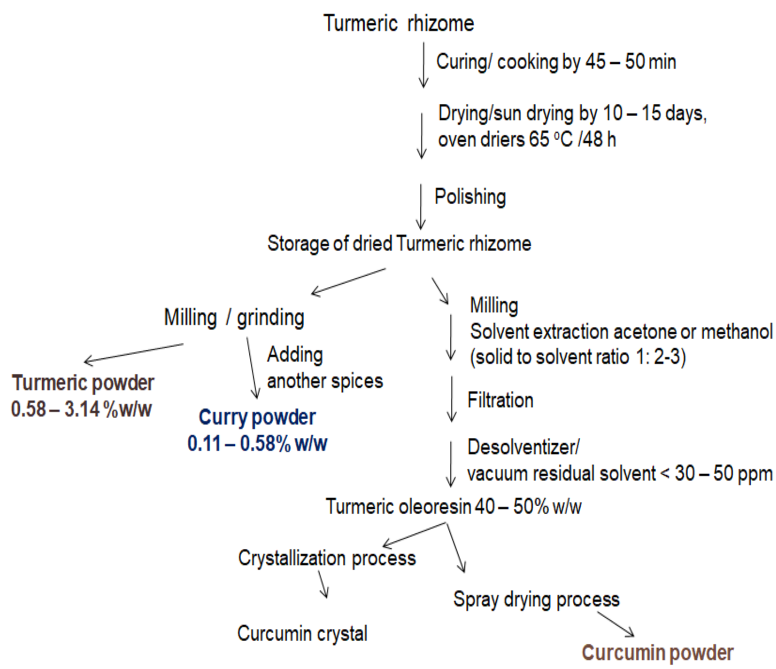


Fig 4. Chart describes the production of curcumin powder [20].

3.1 Turmeric Powder

The ubiquitous ingredient that is used all over the world in "Indian Curry" is turmeric powder. It can be found in the form of powder, paste, and also mixed in with other ground processed spices like black pepper. The most common applications for turmeric powder in the food industry are those of a coloring and a flavoring agent [21]. The material to be powdered is put into the top hopper, where it passes through an opening in the chute that can be controlled, and then it makes its way to the center of the grinding stones. The particles are broken up by the rotating stone as it comes into contact with the stationary stone. The mechanism that was provided in the machine allowed for the clearance between the stones to be adjusted in accordance with the material that needed to be milled and the desired size of the finished product. On the other hand, the accumulation of rhizomes in the feeding section is typically the source of the problem. In order to solve this issue, spiral splines with a pitch of 144 millimeters and a pressure angle of 45 degrees have been installed. These features have helped to improve the feeding process of rhizomes toward the grinding zone. However, as of late, a hammer mill has been utilized for the grinding process. The turmeric powder that is produced should have such small particles that it is able to pass through a sieve with a mesh size of 300 micrometers and leave no residue behind [20].

One of the primary benefits of this method is how simple it is to obtain the powders. There are, however, a number of drawbacks to consider because the spice that is going to be powdered in the mill will almost certainly become hot, and the volatiles that it contains may be lost, although this is something that is dependent on the type of mill that is used and the speed at which it is crushed. When it comes to turmeric, factors such as heat and oxygen during the milling process may contribute to the degradation of the compound known as curcumin. Cryogenic milling in liquid nitrogen eliminates oxidation and prevents the loss of volatile components, but it is a pricey process that is not widely used in the food industry. After being ground, spices are size-sorted using screens, and the larger particles are further reduced in size. Studies on the storage of turmeric powder using a variety of different types of packaging materials revealed that aluminum foil laminate provides the highest level of protection against the loss of volatile oil and the introduction of moisture. Polyethylene film pouches of 200 and 300 gauges were also found to be incapable of providing the desired level of protection against volatile oil losses during storage. This is due to the fact that it was discovered that between 60 and 70 percent of volatile oils were lost over the course of 150 days. There have been reports of differences in curcumin content between different batches of turmeric powder. The percentage of the active ingredient curcumin that is present in turmeric powder ranges from 0.58% to 3.14% across 9 distinct "commercially available products"[20], [22].

3.2 Curry Powder

Curry powder is a mixture of different spices that are used for seasoning dishes such as meat, fish, poultry, or vegetables, predominantly in the tropical countries. These dishes can be found in countries such as India, Thailand, Malaysia, and Indonesia. In point of fact, one of the primary components of the ubiquitous "Indian curry" is turmeric. Turmeric powder accounts for approximately 40–50% of the total volume of curry powder (Nair, 2013a). Curry blends can be very different from one manufacturer to the next, and there are many different blends that can be purchased in stores and markets. Coriander seeds, turmeric, chillies, cumin seeds, fenugreek seeds, fennel seeds, trifala and nagkeser (both of which are fragrant spices), cloves, cassia, garlic, curry leaves, and salt are typically the components that make up curry blends. The purest form of turmeric powder has the highest concentration of curcumin, whereas samples of curry powder only have a moderate amount of the compound present. The curry powder had a curcumin content of between 0.11% and 0.58%, ranging from 19 different commercial samples[20], [22].

3.3 Curcumin Crystal

The process of crystallization of curcumin is used to purify curcumin for use in medical applications. Crystallization of curcumin can be accomplished through the use of an anti-solvent in place of the traditional cooling and evaporation processes. Crystal formation and particle size distributions of pharmaceutical substances can be modified through the use of an anti-solvent crystallization process. This process can also change the physical properties of pharmaceutical substances. In addition, water can be used as an anti-solvent because it has a low solubility toward most drug compounds and a relatively high miscibility with a small number of polar solvents. This allows water to be used in place of polar solvents. Consequently, additional experimental parameters such as ultrasonic waves may be utilized all the way through the crystallization process. During the crystallization process, the use of ultrasound is known to affect the rate of nucleation and crystal growth, and it also has the potential to alter the physical properties of the particles that are produced as a result of the process [23], [24].

3.4 curcumin spray-dried powder

Microencapsulation of oleoresin, a process that involves spray drying, is one way to protect curcumin from the damaging effects of light, heat, oxygen, and alkaline environments. Curcumin is extremely sensitive to these factors. Spray drying the oleoresin of turmeric on a sugar matrix, such as maltodextrin, will result in the formation of a powder that can subsequently be utilized as a coloring agent in dry cereals or beverages [25], [26]. In order to prepare the microencapsulated flowing powders, the wall material (gum arabic, maltodextrin or chitosan) and emulsifying agent (tween) were dispersed with the curcumin core material into a continuous phase. This was done **Tables 2** and **Table 3** present an overview of the current state of the spray drying process used in the production of curcumin powder.

Table 2. overview of condition of spray drying process of curcumin

Core material	Wall material	Emulsifier	Conditions
Turmeric Powder Curcumin oleoresin Curcumin (99%)	Maltodextrin, β-Cyclodextrin, Gelatinised brown rice flour Casein, Chitosan, gum arabic	Tween gelatin Sodium caseinate	Inlet temperature : 120 – 170 ^oC Outlet Temperature : 70 – 90 ^oC

Table 3. Spray Dried Curcumin Powder Formulation and Condition in several reports.

type of encapsulates	Binders/ wall materials/ carier	Method and Condition of Encapsulation	The Best results	References
Spray dried Turmeric Powder	b-cyclodextrin and gelatinised brown rice flour containing	Drying conditions for the entire experiment were: 25 °C feeding temperature, 1 L/h feeding rate, 15 psi atomising pressure, 150 ± 5 °C hot-air-inlet temperature to generate 80 ± 5 °C outlet temperature.	The microcapsules which consisted of 5% of core loading (based on 7% of gelatinised BRF solution) with addition of 20 g/L of b-CD was an optimal formulation, because it produced powder of high curcuminoids encapsulation but low volatile release, moisture content and hygroscopicity.	[27]
Spray dried curcumin powder	Chitosan and Tween 20 or 80, curcumin dissolve into acetic acid 1%	The method Using Taguchi- based statistical optimisation 1. Concentration of chitosan (0.025, 0.05 and 0.1 %) 2. Detergent concentration (0, 0.025, 0.05%) 3. inlet temp (80, 100, 120 °C) 4. air flow rate (100, 120, 150 L/min)	The results from taguchi : spray drying in 1% acetic acid, 0.025 %w/v tween 20, 0.05 % w/v of chitosan, inlet temp. 120 °C flow 150 L/min all curcumin samples is trapped in chitosan particles, thus EE is nearly 100%.	[26]
Spray dried powder curcumin	Gelatin in porous starch (1/20, 1/30,. 1/40), curcumin dissolve into acetone 10%	The orthogonal design for optimisation uses 2 experiments for optimization of curcumin in spray drying process	The optimal condition ratio core and wall material 1/30, embedding temperature 70 °C, embedding time 2 h, inlet T 190 °C. Feed flow 70 ml/min that have good solubility solubility and stability before and after spray drying.	[28]
Spray dried curcumin powders s	4 gram Sodium Caseine in 200 mL ethanol warm solution (40%)	The curcumin was mixed with NaCs solution, then do homogenizer and centrifuge. Supernatan do into Spray drying in inlet temperature of 105 °C and outlet temperature 68 °C. And then evaluate hydrating of the powders	Upon the hydrating of the powder improved 4 fold when compared to simply mixing. Solubility 4 decades higher than solubility of curcumin in water. The powder reduced crystalinity of curcumin.	[29]
Spray dried extract of turmerin as powder dyes	Maltodextrin (28%)	The optimisation uses CCD method for 2 paremeter inlet and outlet temperature.	The optimal condition from CCD were inlet temperature 159 °C, outlet Temperatur of 75 °C in atomization speed of 28000 RPM. Encapsulation Efficiency is around 35%.	[25]

The current study, which was conducted to improve the stability of curcuma after spray drying, also investigated [27] the odour-masking potential of a binary blend wall material, which consisted of brown rice flour and cyclodextrin, in comparison with a wall material that consisted solely of brown rice flour. Brown rice flour was chosen because it offers benefits to human health that go beyond those associated with basic nutrition. On the other hand, the addition of beta-cyclodextrin demonstrated a greater effectiveness on masking properties as well as the efficiency of curcuminoids encapsulation. Because it produced powder with high curcuminoids encapsulation but low volatile release, moisture content, and hygroscopicity, the microcapsules that consisted of 5% of core loading (based on 7% of gelatinized brown rice flour solution) with addition of 20 g/L of cyclodextrin was chosen as an optimal formulation. Due to the fact that the stability after spray drying is restricted to the range pH 2.5%–7, it is unable to dissolve in either an acidic or neutral environment. Dispersion in liquid and formulation using co-dried powder are both methods that can be utilized to find a solution to this problem [8], [17], [29].

When compared to the other powder form, the stability of the curcumin powder is superior. The spray drying process is a method that can encapsulate core material into matrix binder, which shields curcumin from the surrounding environment [30]. (Ray, Raychaudhuri, & Chakraborty, 2016).

4. THE FURTHER STUDY OF CURCUMIN POWDER

The crucial aspect of incorporating curcumin powder into health care and medicine applications is to conduct additional research in order to enhance the substance's stability. Numerous studies will be carried out in order to improve the solubility and bioavailability of encapsulated curcumin. These studies will include the following: dissolving curcumin in the oil body of emulsions in order to improve dispersibility and bioavailability[8], [31], [32], utilizing nano formulations that utilize either synthetic or natural polymers, such as zein nanoparticles poly(ethylene glycol) alginate-chito [33].

5. CONCLUSION

Turmeric contains a compound known as curcumin, which is a bioactive ingredient with applications in both food and medicine. Powdered forms of curcumin can be found in food products in the form of turmeric powder, curry powder, and spray-dried curcumin powder. The instability of curcumin, which can be caused by oxidation, light, or alkaline conditions, is a problem that arises from the product. When compared to another form, the curcumin powder that has been spray dried has a higher degree of stability. Curcumin, thanks to recent advances in research, has been shown to be a compound that can cure a wide variety of illnesses and may therefore have potential as a functional food. However, the product's stability needs to be improved even further.

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