

The Chemistry of Curcumin, the Health Promoting Ingredient in Turmeric

by

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“Ah! My favorite!” Leroy exclaimed as he opened the door to the aroma of lentil soup wafting through the house. He took off his jacket and hurried to the table, where a bowl of the soup awaited him. He eagerly took a sip, and then paused as he noticed a subtle but unusual taste.

“How is the soup?” Mona asked.

“Delicious! I taste something different though. It seems from the color that you added saffron to the soup,” Leroy observed.

“Not saffron; I added some turmeric.”

“Did you say turmeric?” Leroy asked with a puzzled look.

“Yes, I added a pinch of turmeric. I read that it is good for you. In fact, I added more than a pinch. I read that turmeric contains a chemical called curcumin, which is believed to provide many health benefits. It may be beneficial in treating Alzheimer’s disease and rheumatoid arthritis and in preventing some forms of cancer and even in controlling diabetes,” Mona explained.

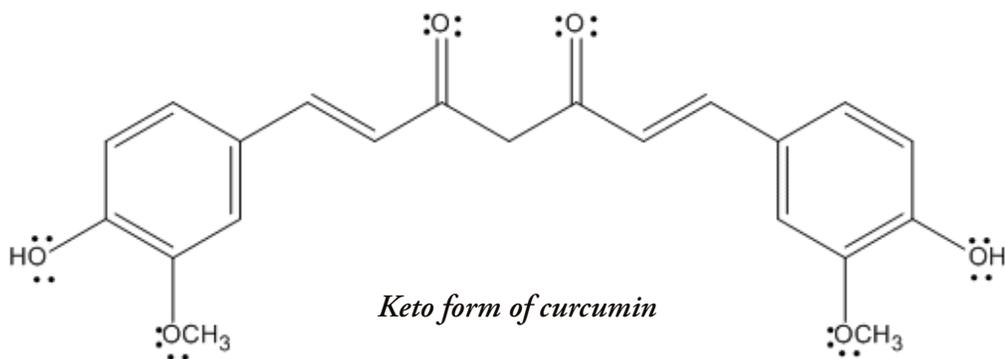
Leroy nodded appreciatively as he continued eating. Then, looking up from the bowl, he said: “Honey, you did say that you added turmeric, right? I thought that turmeric has a yellow color. I know that it is used in both curry and mustard, and it’s what gives them both their characteristic yellow color. But this lentil soup has an orange tinge, not a yellow color,” Leroy observed.

“Well, let me explain what happened. I started making the soup in the traditional way. I added all the ingredients and a good sprinkling of turmeric. The boiling mixture became yellow. But the baby started crying, and so I turned the stove off and attended to her. After a while, she went to sleep and I turned the stove back on and continued boiling the lentils. But then I looked at the clock and realized you would be home in about minutes and that the soup would probably not be done by then. The lentils were still uncooked! So I added some baking soda. I had read somewhere that baking soda speeds up the cooking of food. As I added the baking soda, I noticed that the soup changed color from yellow to orange,” Mona explained.

“Strange. I wonder if the health promoting chemical in turmeric was destroyed by the baking soda. It doesn’t matter though, the soup is lovely!” Leroy blurted out between spoonfuls of soup.

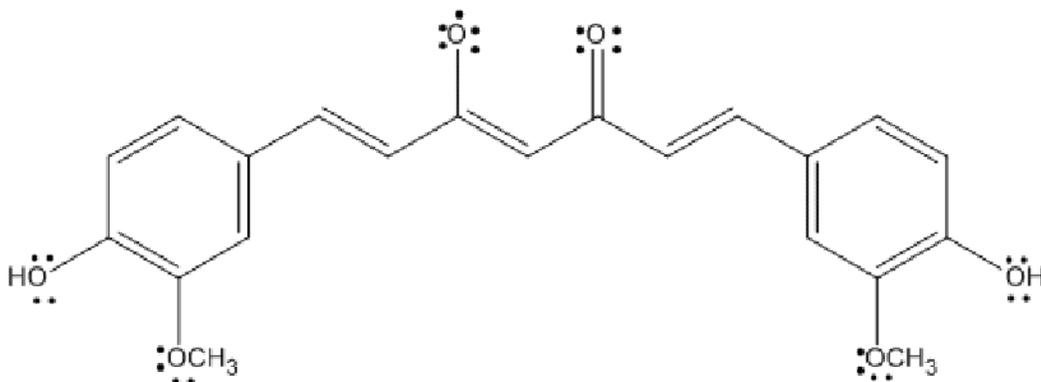
Questions

1. Curcumin is a polyphenol that exists in two tautomeric forms: a keto and an enol. (*See figure on next page.*)

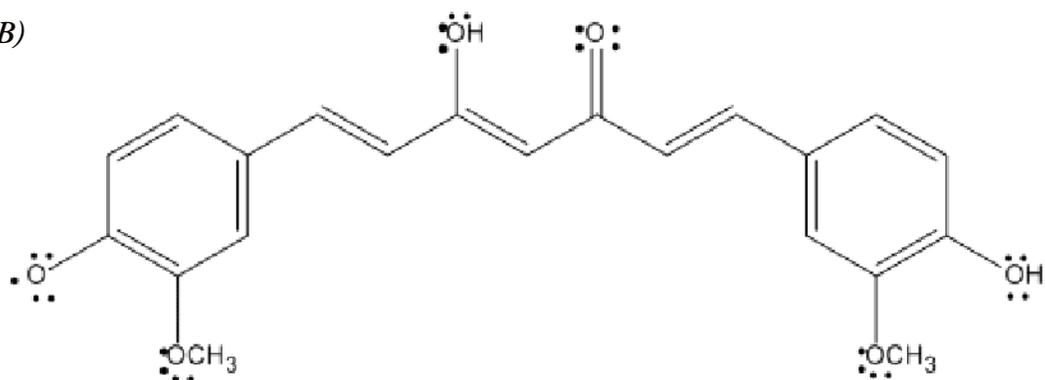


- a. Use curved arrows to show how the keto form of curcumin can be converted to the enol.
 - b. Carbonyl compounds with hydrogen(s) on their α -carbon equilibrate with their corresponding enols. The equilibrium is such that, for most carbonyl compounds, the enols are present in very small quantities. For example, acetone contains only about . . . % enol. Curcumin, however, exists predominantly as the enol form. Why do you think this is so?
2. What reaction is likely to occur between baking soda (NaHCO_3) and curcumin? Use resonance theory to rationalize the reaction that you suggest.
 - . Do you think that the explanation provided by Mona for the color of the soup is plausible? Explain the reason for your answer.
 4. Leroy loved Mona dearly but was skeptical of her explanation. What simple experiment can Leroy perform in his kitchen to determine if Mona's story was true?
 - . Many of the purported health benefits of consuming turmeric are ascribed to the fact that it has chemicals, such as curcumin, that have anti-oxidant properties. Antioxidants interact with and stabilize free radicals and may prevent some of the damage free radicals might otherwise cause. The antioxidant property of curcumin can be explained by the fact that it forms relatively stable radicals, which can then react with (and consume) free radicals they come in contact with. The relative stabilities of free radicals can be predicted by resonance theory. The latter predicts that curcumin radicals would be relatively stable as each has several resonance structures. Draw the likely resonance structures for the two curcumin radicals (A and B) shown below.

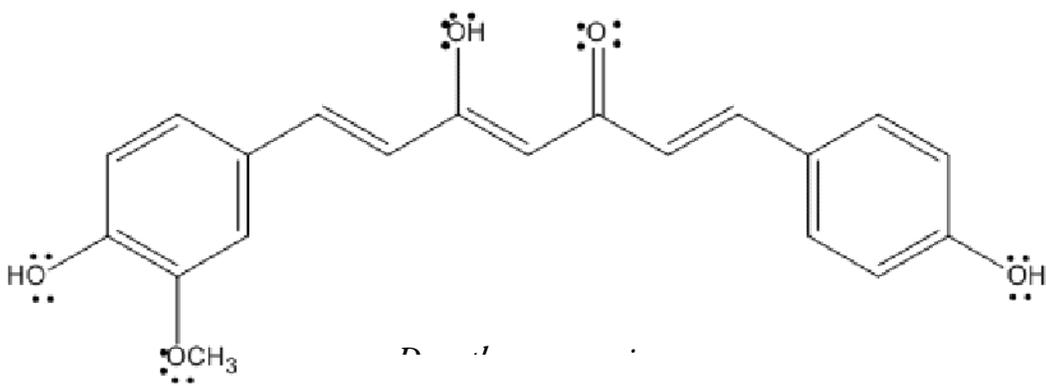
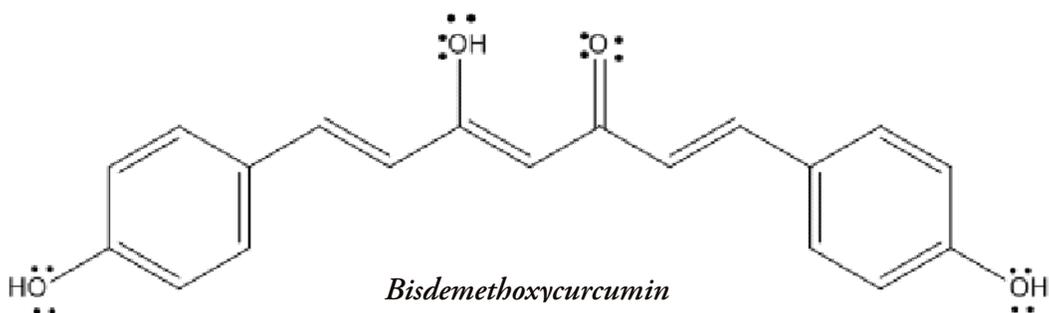
(A)



(B)



6. Curcumin has the potential to affect iron metabolism in the body as it chelates iron. Such an effect might be related to its anticancer effect, but could pose risks to those with iron deficiency. Explain why curcumin chelates iron.
7. Pectin is a polysaccharide that acts as a cementing material in the cell walls of all plant tissues. This polysaccharide is made up of units of galacturonic acid and its ester. As such, pectin has free -OH, -COOH, and -COOCH₃ functionalities.
 - a. What changes will occur in these functionalities in the presence of sodium bicarbonate?
 - b. How might these changes lead to a “softening” of lentils?
8. Turmeric contains (in lower amounts) several analogues of curcumin. Two of these are demethoxycurcumin (DMC) and bisdemethoxycurcumin (BDMC), whose structures are shown below.



9. What other food products, besides those mentioned in the case, contain curcumin?
- Curcumin is also sold as a supplement, commonly in capsules of around _____ mg, and is likely consumed by many at such doses. What is known about the toxicity/side effects of curcumin at such dose levels?

Resources

Curcumin and Alzheimers

Pan, R., S. Qiu, D.X. Lu, and J. Dong. 2008. Curcumin improves learning and memory ability and its neuroprotective mechanism in mice. *Chinese Medical Journal [in English]* 121(9):832–839. <http://www.ncbi.nlm.nih.gov/pubmed/> [Last accessed: 12/24/]

Curcumin and Rheumatoid Arthritis

Park, C., et al. 2007. Curcumin induces apoptosis and inhibits prostaglandin E(2) production in synovial fibroblasts of patients with rheumatoid arthritis. *International Journal of Molecular Medicine* 20():365–372. <http://www.ncbi.nlm.nih.gov/pubmed/17671742> [Last accessed: 12/24/]

Curcumin and Cancer

American Institute for Cancer Research (AICR). 2006. Stronger than iron, curcumin may prevent tumors. AICR ScienceNow . http://www.aicr.org/site/News?page=NewsArticle&id=&news_iv_ctrl=&abbr=res_ [Last accessed: 12/24/]

Deeb D., et al. 2004. Curcumin sensitizes prostate cancer cells to tumor necrosis factor-related apoptosis-inducing ligand/Apo2L by inhibiting nuclear factor-kappaB through suppression of IkappaBalpha phosphorylation. *Molecular Cancer Therapeutics* (): –812. <http://www.ncbi.nlm.nih.gov/pubmed/> [Last accessed: 12/24/]

Jiao, Y. et al. 2008. Curcumin, a cancer chemopreventive and chemotherapeutic agent, is a biologically active iron chelator. *Blood: In press*. Pre-print available online at: <http://www.ncbi.nlm.nih.gov/pubmed/> [Last accessed: 12/24/]

Curcumin and Diabetes

Turmeric for Diabetes, ScienCentral http://es.youtube.com/watch?v=ITCL_fQslzg [Last accessed: 2/24/]

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