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LETTER TO THE EDITOR

Rapid Hydroxylation of Soybean Lecithin Under Microwave-Assisted Conditions

M. S. L. Karuna · V. Vandana · P. S. Sai Prasad · P. Vijaya Lakshmi · R. B. N. Prasad

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Sir,

Soybean lecithin is an important co-product of oil processing obtained during degumming step of oil refining. Soybean lecithin is a complex mixture and comprises of phospholipids (PLs) and triglycerides along with minor amounts of other constituents like phytoglycolipids, phytosterols, tocopherols and fatty acids. Soybean lecithin has potential as a multifunctional additive for food, pharmaceutical and other industrial applications [1–3]. An effective way to improve water dispersability or enhance emulsifying properties of vegetable lecithins for o/w system is hydroxylation [4, 5] of the unsaturated fatty acids present in it. Hydroxylated lecithin is useful in baking applications where it can improve the dispersion of fats and retard staling [6].

Hydroxylation involves insertion of hydroxyl groups at the double bonds of unsaturated fatty acids present in PLs using hydrogen peroxide under the catalytic action of water-soluble aliphatic carboxylic acids (e.g., lactic acid, acetic acid, tartaric acid, citric acid) [7]. Lactic acid has been mostly used when the product is preferred for edible purposes. The conventional hydroxylation methods involve reacting 28% of hydrogen peroxide (50% concentration) in presence of organic acids for about 10% reduction in iodine value (IV) [8]. The use of higher concentration of hydrogen peroxide and exposure of lecithin to higher temperatures for longer reaction times may degrade the PLs. Microwave-irradiation conditions accelerate any type of organic reactions compared to conventional thermal heating due to its high heating efficiency in a short time [9]. Microwave heating also has the unique feature of providing environmentally friendly processes. Thus, there is a growing interest in the application of microwaves in process industry. The objective of the present work is to provide a simple, rapid and an environmentally friendly microwave-assisted process for hydroxylation of crude soybean lecithin using hydrogen peroxide solution at lower reaction times with higher conversion rates.

Crude soybean lecithin (dried gums) was procured from M/s Alpine Industries Ltd., Indore, India. Lecithin was found to contain 60% PLs as determined by standard AOCS method Ja 4-46 [10]. Hydrogen peroxide (30% aqueous solution) and lactic acid (75%) were procured from M/s Qualigens Fine Chemicals, Mumbai. The microwave reactions were carried out in Ethos 1600 Microwave lab station (Sorisole, Italy). The color of the hydroxylated lecithin was determined using Lovibond 3000 Comparator Gardner Color Unit [10]. Emulsification test was performed as per the procedure described by Aura et al. [11].

Crude soybean lecithin (10 g) was taken in a Teflon tube and to this lactic acid (3% of lecithin, wt/wt) and hydrogen peroxide (15% of lecithin, v/wt.) were added and irradiated to microwaves at a temperature of 70–75 °C at various time intervals of 5–60 min at 400–600 W power. The product was dried under reduced pressure and analyzed for IV [10]. The reaction was also carried out using conventional thermal heating under similar conditions for 2 to 18 h and the product was analyzed for IV (Tables 1, 2).

In the case of reactions using 400 and 500 W power, the reaction was slow with a slight reduction in IV. The

M. S. L. Karuna · V. Vandana · P. Vijaya Lakshmi · R. B. N. Prasad (✉)
Centre for Lipid Research, Indian Institute of Chemical Technology, Hyderabad 500 007, India
e-mail: rbnprasad@iict.res.in

P. S. Sai Prasad
Inorganic and Physical Chemistry Division, Indian Institute of Chemical Technology, Hyderabad 500 007, India

Table 1 Change in iodine value during hydroxylation of lecithin using conventional heating

Reaction period (h)	Iodine value[a]	Reduction in iodine value (%)
0	99.5	–
2	82.5	17.1
3	79.1	20.5
5	76.1	23.5
7	71.0	28.6
8	66.4	33.3
12	64.8	34.6
18	64.4	34.9

Reaction temperature, 70–75 °C

[a] Values are mean of three experiments

Table 2 Change in iodine value of hydroxylated lecithin under microwave-assisted conditions

Reaction period (min)	Iodine value[a]	Reduction in iodine value (%)
0	99.5	–
5	79.3	20.3
10	78.5	21.1
15	75.6	24.0
20	72.4	27.2
25	69.4	30.3
35	65.5	34.2
40	62.4	37.3
60	62.4	37.3

Reaction temperature, 70–75 °C, power, 600 W

[a] Values are the means of three experiments

reaction was greatly accelerated under microwave irradiation using lactic acid (3 wt% of lecithin) and hydrogen peroxide (15 wt% of lecithin) at 70 °C and 600 W power. Under microwave irradiation conditions, an impressive IV reduction (Table 1) was observed within 5 min as against 3 h in conventional thermal hydroxylation. Maximum hydroxylation was observed using microwave-assisted reactions in 40 min (IV, 62.4) which could not be achieved using conventional heating even after 18 h (IV, 64.4) under similar reaction conditions (Tables 1, 2). The color of the hydroxylated lecithin obtained under microwave-irradiation conditions was found to be 15 Gardner Color Units as against 18+ Gardner Color Units for crude lecithin.

The emulsion stability behavior of crude soybean lecithin and maximum hydroxylated soybean lecithin was determined as follows. The crude soybean and hydroxylated soybean lecithins were dissolved in sunflower oil at 0.1% (wt/v) of the total emulsification volume [11] consisting of sunflower oil and water in 2:3, v/v. The contents were homogenized using Ultra-Turrax, T-25 at 5,000 rpm for 60 s at 50 °C and the emulsion was poured into a 100 mL measuring cylinder. The time required for the separation of 10 and 20 mL aqueous layer from oily layer was observed. The values indicated that the emulsion formed with hydroxylated soybean lecithin (43 min for 10 mL; 120 min for 20 mL) was more stable compared to crude soybean lecithin (32 min for 10 mL; 78 min for 20 mL).

In conclusion the process reported is a simple, rapid and efficient microwave-irradiated method for the production of hydroxylated soybean lecithin.

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