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Photochromic Properties of 3-Deoxyanthocyanidin Pigments Extracted and Purified from Sorghum Grains

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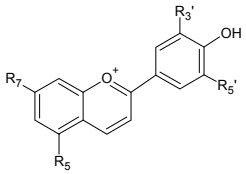
Abstract

With the aim of developing natural photochromic pigments, the selection of source materials and the extraction and purification methods for 3-deoxyanthocyanidins (3-DAs) were examined. Among the three raw materials derived from sorghum plants, the extract of Japanese Takakibi with 1, 3-butanediol contained the highest ratio of 3-DAs and exhibited the best photochromic properties. Furthermore, when fractions containing 3-DAs were collected from these materials using high-performance liquid chromatography (HPLC), the solutions decolored more readily in the light-shielding state and, hence, their photochromic performance improved drastically. Even Kaoliang food color, which had not previously shown photochromic behavior, showed photochromic performance after HPLC purification.

Key-words: *Photochromic pigment, Sorghum, 3-deoxyanthocyanidins, Anthocyanin, HPLC*

1. Introduction

Photochromic pigments are the ones that change their color when exposed to electromagnetic radiation. To date, many synthetic photochromic pigments have been studied. Some studies have also been conducted on naturally occurring photochromic pigments such as anthocyanidins and their derivatives, which have a lower environmental impact and lower human toxicity than synthetic pigments. Therefore, the industrial production of naturally occurring pigments is desirable. Luteolinidin, which is one of the 3-deoxyanthocyanidins (3-DAs) present in plants, has been reported to exhibit photochromic behavior in a water-methanol mixture[1]. 3-DAs are specific anthocyanins that have no hydroxyl group at the position 3 of the C ring (**Fig. 1**). We found that it was possible to repeatedly induce coloration and decoloration with luteolinidin in a nontoxic solution composed of weakly acidic water and 1,3-butanediol and that the other 3-DAs (e.g. apigeninidin, tricetininidin) also exhibit photochromic behavior[2]. However, the 3-DAs used in these studies were synthetic reagents and it was not clear from prior studies whether natural 3-DAs actually extracted from plants exhibit the same photochromic properties.



Anthocyanidin	R_3'	R_5'	R_5	R_7
Luteolinidin	OH	H	OH	OH
Apigeninidin	H	H	OH	OH
Tricetinidin	OH	OH	OH	OH

Fig. 1 Chemical structures of 3-deoxyanthocyanidins (3-DAs).

Sorghum grains, which are used for food and livestock feed, are known to contain 3-DAs. Sorghum is primarily classified on the basis of the color of the seed coat. Among these types, black sorghum and brown sorghum are known to contain a large amount of 3-DAs[3]. Besides 3-DAs, sorghums also contain anthocyanin pigments, which are not expected to show photochromic properties. In this study, we used raw materials derived from sorghums and investigated whether the pigments extracted from them actually exhibit photochromic properties.

2. Experimental

Three types of naturally derived samples (sorghum grains which are used for food or livestock feed) were used in this study. The first one is a commercial Kaoliang food color, which is extracted and purified from a seed of a type of sorghums (*Sorghum nervosum* Bess.). This powder was expected to contain a high quantity of anthocyanin pigments. The second is crushed black sorghum bran (*Sorghum bicolor* (L.) Moench, T x 430) from the United States, which is mainly used as cow feed and contains a large amount of 3-deoxyanthocyanidins (3-DAs). The third is the shell of the Japanese Takakibi (*Sorghum bicolor* Moench) seed from the Iwate Prefecture, which is a food grain with a shell that can easily and cheaply be obtained as waste material. The Japanese Takakibi was crushed with a food processor before