Journal of Food Health and Bioenvironmental Science

Journal homepage : http://jfhb.dusit.ac.th/

Sun Protection of Rice, Gac Fruit and Wood Apple Powders for Developing Face Powder

Watchara Senajuk*, Sasamol Phasuk, Poonyanuch Nilsang & Pannraphat Takolpuckdee

Science Education Department, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani, 13180 Thailand

Article info

Article history:
Received : 1 January 2021
Revised : 26 April 2021
Accepted : 28 April 2021

Keywords:
Face powder, Natural sources, Color, Sun protection factor

Abstract

Face powder, in different colors, is used to beautify the skin of the face and neck and make it appear more attractive than natural skin. General characteristics are that it should be fine, soft, easily applied to the skin, long-lasting, disperse well when moist and able to hide wrinkles or dark spots; further, in harmony with the skin color, it should reduce oiliness, have a pleasant smell or color, look natural and not harm the user. We studied the effect of gac fruit and wood apple on color and SPF in face powder containing rice. We examine the natural contents of rice, gac fruit and wood apple in face powder according to the percentage of each recipe. However, the natural extracts were able to absorb UV radiation and used in mixtures with synthetic extracts for sunscreen protection, thus reducing the use of synthetic products. Further, no heavy metals were found in the natural extracts.

Introduction

Thai people focus more than before on beauty and skin care, especially faces that clearly reflect the charm of women. Face powder is a popular cosmetic, for daily use, to beautify the face and help to conceal spots and smooth the skin. Skin powders come in many forms, including face powder, body powder, talcum powder for children, lotion, eyeshadow and powder used by teenagers to sparkle their skin. Face powder normally uses talcum, as the main ingredient, but talcum contains substances with asbestos-like properties, that cannot be digested and excreted from the body. Talcum aerosols contain tiny particles that may be inhaled and accumulate in the lungs. The cells in the lungs catch these particles, which adversely affect the respiratory system, especially those of infants (Chucham, 2012). In addition, studies have shown that using talcum powder in women's intimate areas increases the risk of ovarian cancer, from talcum penetrating into the vagina (Balsam & Sagarin, 1972; Kabthong et al., 2015). In some countries, many doctors recommend avoiding talcum powder, because of its unsafe properties. Other countries are following, even though the price of alternatives is higher and the quality is lower than talcum powder. As consumers pay more attention to health and beauty, rice became a choice for making cosmetic products. However, face powder made from rice powder is still not popular. For example, Chucham (2012) developed a face powder made from Thai jasmine rice. It was found that the particles of the jasmine rice powder were uneven and its texture was harsher than talcum. However, the powder offered a

* Corresponding Author
e-mail: senajuk.w@gmail.com

unique jasmine rice aroma, and the jasmine rice powder absorbed water better than talcum. The jasmine rice powder offered the best quality when it replaced 17% of talcum in the pressed face powder. It had a light yellow texture, was smooth and easily attached to the skin. The powder compressed well into the container and was not easily broken. Kabthong et al. (2015) studied the development of color from dragon fruit in combination with rice powder to achieve an optimum powder formula.

Health care, based on natural extracts, is gaining in popularity among people all over the world. This encourages Thais to increasingly use products made from herbs or natural extracts. In addition, natural extracts have developed a quality and performance comparable to those of synthetic substances. Therefore, health care can now avoid side effects and toxicity from some chemicals. Also, using natural substances is increasingly popular in cosmetic and beauty products (Chucham, 2012). Most cosmetic products are colored - either by natural or synthetic substances. It is thus important to consider the color in cosmetics: it must be safe and intrinsically non-toxic or in reaction with other substances mixed with it. The color should resist changes in light, heat or pH. Most natural colors were found to be non-toxic and inexpensive (Kabthong et al., 2015): they can be obtained from local plants, *e.g.* pandan, butterfly pea and gac fruit.

Gac Fruit (*Momordica cochinchinensis* Spreng) is a native plant in Vietnam, China, Myanmar, Thailand, Lao PDR, Bangladesh, Malaysia and the Philippines, and is commonly called spring bitter cucumber. The gac fruit contains 10 times more carotene than carrots and 12 times more lycopene than tomatoes. Lycopene is a group of carotenoids, found in some vegetables and fruits, which acts as a pigment to collect light for plants and prevent oxidation, generating free radicals from excess sun light. Therefore, it reduces oxidation and cancer. It also helps alleviate cell deterioration by protecting skin from sunlight, when mixed into cosmetics (Chuyen et al., 2015).

Wood apple (*Limonia Acidissima* L.) has several medicinal as well as cosmetic properties, for example, the fruit is used as a substitute for bael (*Aegle marmelos* (L.) Corrêa) in diarrhea and dysentery (Vishakha et al., 2019; Pratima & Rekha, 2014). Thus, today, herbs play vital role in every industry due to their wide variety of properties. Here, we show the importance of wood apple in cosmetics and illustrate its pharmacological activities and medicinal uses. Different parts of wood apple show different useful properties, *e.g.* essential oil obtained from the leaves has anti-bacterial activity, due to its carvacrol and cyclodecandine constituents; shells show anti-fungal activity against gram positive and gram negative bacteria, because of psoralene found in them; the pulp benefits the skin, because of its higher moisture content. The other key constituents are saponins, flavonoids, amino acids, beta carotene, tannins, carbohydrates, vitamin B and triterpene. These constituents are responsible for some cosmetic properties, so that wood apple has cosmetic applications (Vishakha et al., 2019).

Sunscreen cosmetics are very popular for protecting the skin from the sun. Sunscreen either reflects or absorbs UV. The active substances consist of aromatic rings, bound to carbonyl groups in the chromophore, which can absorb UV and then release energy in the form of heat. Chemicals commonly used in sunscreens, include benzoate, 2-phenyl-benzimidazole-5-sulfonic acid (PBSA), methyl anthranilate, homosalate, octocrylene (2-ethylhexyl-2-cyano-3,3-diphenyl-2-propenoate), octyl salicylate and octylmethoxycinnamate (Gasparro et al., 1998). Currently, several plant extracts are used as sunscreens, *e.g.* extracts (with sun protection factor (SPF)) from cucumber (3.19), tomato, (14.7), papaya (16.0), carrot (1.34), aloe vera (1.28) and coconut (7.38) (Kumar et al., 2016; Madhu et al., 2018; Shenekar et al., 2014; Malsawmtluangi et al., 2013). In addition, *Feronia limonia* (L.) Swingle, also commonly called wood apple or Thanaka in Thailand, similar to *Licodia acidissima* Limonia acidissima L. in the same family Rutaceae, shows various skin benefits, *e.g.* it is anti-inflammatory, does not thin facial skin, brightens it and reduces blemishes and dark spots, tightening pores, smooths facial skin and contains antioxidants as well as components which naturally block sunlight and contribute to SPF (Namchot et al., 2012; Tidchai, 2019).

Accordingly, we focused on using broken Pathum Thani and Riceberry rices, as the main material to develop face powder, replacing talcum. Other natural substances, gac fruit and wood apple, were used as coloring agents. We also assessed the SPF as an alternative for consumers choosing natural face powder instead of talcum. Our results may help increase the value of broken Pathum Thani and Riceberry rices, as well as the local plant varieties, by encouraging the use of face powder, made from natural sources, for future commercial potential.

Materials and methods

1. Sample preparation and face powder formulae

Pathum Thani and Riceberry rices were obtained from community enterprise of Thai Suan Pepper subdistrict, Pathum Thani province. Both rices were ground, until they passed a 200 mesh filter by peeling off the rice shells. Gac fruit provided from the plantation garden in Prasat district in Surin province, was made from the flesh covering its seeds. Wood apple powder was derived from wood apple tree branches that were collected from In Buri district in Sing Buri province. Face powder formulaes were prepared using the mixtures listed in Table 1, ground, mixed together and packed in containers (Senajuk et al., 2020). Powder formulaes were coded as Fgf_xwa_y where x denotes the fraction of gac fruit and y the fraction of wood apple, so that $Fgf_{18}wa_5$, had 18% gac fruit and 5% wood apple.

Table 1 Face powder formulae

Component (%w/w)	Fgf_0wa_{10}	Fgf_2wa_{10}	Fgf_5wa_{10}	$Fgf_{10}wa_{10}$	$Fgf_{10}wa_5$	$Fgf_{18}wa_5$	$Fgf_{25}wa_5$	$Fgf_{31}wa_4$
Pathum Thani rice	40	40	40	40	40	32	29	27
Riceberry rice	10	10	10	10	10	9	8	8
Wood apple	10	10	10	10	5	5	5	4
Gac fruit	-	2	5	10	10	18	25	31
Zinc oxide	5	5	5	5	5	5	4	4
Zinc stearate	10	8	5	5	5	4	4	4
Magnesium carbonate	10	10	10	5	5	5	4	4
Calcium carbonate	10	10	10	10	15	19	17	16
Kaolin	5	5	5	5	5	5	5	4
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Remark: Samples were coded as described in the text.

2. Color measurement

Color was measured with a ColorFlex EZ Spectrophotometer, model D65. Colors perceived by human eyes derive from the light reflected from the object and delivered to the brain for translation into the color perception. The Commission Internationale de I'Eclairage (CIE) defined perception color standards described in the L*a*b* system which describes points in a 3D space. L* indicates how light (or dark) the sample is; higher values define lighter samples. The a* indicates a point on the red (+a*) – green (-a*) axis and b* indicates a position on the blue (-b*) – yellow (+b*) axis (Mir et al., 2013). A color difference between a reference and a sample, ΔE, can be derived from:

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$$

where $\Delta L = L^* - L$, $\Delta a = a^* - a$, and $\Delta b = b^* - b$ and L*, a*, b* refer to colors of the reference object and L, a, b refer to colors of the sample.

3. Sun protection factor measurement

Measurement of sun protection factors followed Dutra et al. (2004), with slight modification. A 100 g sample was weighed and transferred to a 100 ml volumetric flask, diluted to volume with ethanol then shaken for 5 minutes, then filtered through a Whatman No.1 filter paper. The filtrate was collected after rejecting the first 10 ml of filtrate. Then a 5.0 ml aliquot was transferred to 50 ml volumetric flask and diluted to volume with ethanol. Subsequently a 5.0 ml aliquot was transferred to a 25 ml volumetric flask and the volume completed with ethanol. The filtered solution was put in a quartz cell and the absorbance was measured from 290 to 320 nm at 5 nm steps by a UV-spectrophotometer. The measurement was repeated three times. The SPF was calculated following Mansur et al. (1986).

$$SPF = CF \times \sum_{290}^{320} EE\,(\lambda) x\, I(\lambda) x\, Abs(\lambda)$$

where *EE(λ)* is an erythemal effect spectrum, I*(λ)* mean solar intensity spectrum, *Abs(λ)* means absorbance of sunscreen products and *CF* means correction factor (=10).

4. Morphology and elemental composition

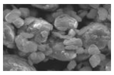
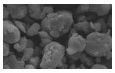
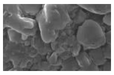
Sample morphologies were observed by scanning electron microscopy (SEM) using a model LEO 1455 VP, Germany, coupled with energy-dispersive X-ray (EDX Oxford, ISIS 300, England) analyzer that measured the elemental composition.

Results and discussion

1. Raw materials qualifications

In previous work, it was found that Riceberry extract samples contained phenolic and flavonoids with the highest level at 26.5 mg GAE/g of extract and 102 mg Rutin/g of extract. Free radical scavenging activity of the Riceberry extract sample indicated the EC_{50} at 108 µg/mL (Senajuk et al., 2020). Table 2 shows the SPF values, color, heavy metals, and morphology of the materials in making up the face powders. SPF was calculated by applying Mansur's equation (2). SPF numbers of raw materials ranged from 1.12 (Pathum Thani rice) to 6.78 (wood apple). Almost all other samples are having the same or almost similar SPF values as calculated from Mansur equation. All the color values are noted that the whitest of all raw materials was measured to be Pathum Thani rice with L* 81.03, followed by gac fruit with wood apple the darkest, at L* ~56. The highest a* value was shown by gac fruit, the reddest at 42.77. Gac fruit was also the most yellow, with b*= 20.78. Checking for heavy metal contamination indicated that no raw materials contained heavy metals. The physical characteristics of the raw materials were similar. They were fine powders with different colors. The examination using SEM micrographs showed that physical characteristics were similar in clusters of spherical particles.

Table 2 SPF, Color, element content and morphology of raw materials

Properties	Riceberry rice	Pathum Thani rice	Gac fruit	Wood apple
SPF values	1.83±0.08	1.12±0.16	1.58±0.15	6.78±0.10
Color				
L*	63.92±0.01	81.03±0.07	56.70±0.02	56.73±0.26
a*	4.31±0.01	1.02±0.01	42.77±0.02	4.71±0.00
b*	12.67±0.02	16.20±0.04	40.94±0.05	20.78±0.02
%Element value				
Lead	nd	nd	nd	nd
Arsenic	nd	nd	nd	nd
Mercury	nd	nd	nd	nd
Barium	nd	nd	nd	nd
Image				
Morphology	 magnification x 10,000	 magnification x 10,000	 magnification x 10,000	 magnification x 10,000

Remark: nd means not detected

2. Influence of raw materials on SPF

Fig. 1 shows the effects of raw materials on SPF for the different face powder formulae. Fgf_0wa_{10}, with no added gac fruit had SPF = 0.69, but the SPF increase to 1.20 as gac fruit up to 10% was added. Reduction of wood apple content, $Fgf_{10}wa_{10}$ to $Fgf_{10}wa_5$, decreased SPF by about 10%. At lower wood apple content (5%), varying gac fruit led to little change of SPF values, close to 1. Commercial loose powder has SPF ~40, significantly higher than with natural ingredients. These commercial products contain synthetic chemicals, that provide high levels of sun protection. Our research suggests that natural substances can also provide sun protection and we are working in the lab on further development, which will require further advanced tools. Jarupinthusophon & Anurukvorakun (2021) developed compact powder by using Jasmine rice flour replaced 100% talcum, compared with commercial product and found that the developed compact powder does not provide much different sun protection effectiveness compared the commercial compact powder. However, increasing gac fruit content affected the color, as shown in Table 3. It is therefore concluded that the amount of wood apple affected SPF.

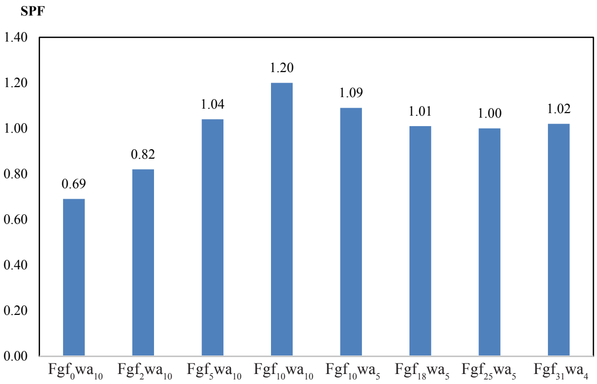


Fig. 1 Effect of raw materials on SPF

3. Influence of raw materials on Color

Colors were measured in the CIE L*a* b* space-see Table 3. The 'whitest' of all samples, Fgf_2wa_{10}, had L* = 79.63, followed by Fgf_0wa_{10}. The 'darkest' was $Fgf_{10}wa_{10}$ with L* = 76.00. As might be expected, the highest a* (i.e. reddest) was $Fgf_{31}wa_4$ with 31% gac fruit, a* = 5.12, but this value was still small, and the powder appeared 'white'. Yellowness, b*, varied very little in all the rice powder samples: 10% gac fruit and 10% wood apple, $Fgf_{10}wa_{10}$, showed the highest b* = 13.41. In contrast, the commercial face powder No.1 showed much higher b* = 22.90, i.e. it was significantly more 'yellow' than the rice derived powders.

Table 3 Color characteristics (CIF space) of face powder formulae

Formula	L*	a*	b*	ΔE	Physical picture
Commercial face powder No.1	73.23±0.00	10.92±0.00	22.90±0.00	-	

Table 3 (Continude)

Formula	L*	a*	b*	ΔE	Physical picture
Fgf_0wa_{10}	79.40±0.01	0.98±0.00	10.97±0.01	16.71±0.00	
Fgf_2wa_{10}	79.63±0.00	1.16±0.00	11.06±0.00	16.63±0.00	
Fgf_5wa_{10}	77.53±0.14	1.72±0.02	12.22±0.01	14.74±0.04	
$Fgf_{10}wa_{10}$	76.00±0.16	2.33±0.06	13.41±0.06	13.10±0.12	
$Fgf_{10}wa_5$	77.43±0.01	2.54±0.01	12.42±0.01	14.06±0.01	
$Fgf_{18}wa_5$	79.10±0.01	2.70±0.01	11.55±0.02	15.19±0.01	
$Fgf_{25}wa_5$	78.15±0.03	3.94±0.01	11.97±0.01	13.87±0.01	
$Fgf_{31}wa_4$	77.79±0.04	5.12±0.03	12.39±0.03	12.84±0.02	

Conclusion

We developed sunscreen face powder, using natural sources, with Riceberry and Pathum Thani rice replacing talcum and as gac fruit and wood apple, which are safe for skin use, providing color. They are suitable for use as ingredients in face powder, that offer a unique product, that strengthens local identify and builds pride, while generating income and creating careers for people in the community. The SPF values showed that natural sources can protect skin from sun damage and alleviate cell aging and reduce the use of synthetic sunscreens. Up to 10% of wood apple and gac fruit increased SPF, while excessive amounts of both, on the other hand, did not increase SPF, but increased color intensity. All natural samples had some UV protection capabilities. Along with their several other beneficial effects and safety, these natural products could become a good, inexpensive and readily available ingredients in sunscreen products.

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