Association Between Diet and Acne Severity: A Cross-sectional Study in Thai Adolescents and Adults

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The association between diet and acne is of growing concern. Every country has its own food culture; however, only a few studies have surveyed the influence of Asian cuisine on acne. This study investigated the association between acne severity and diet/lifestyle factors in 2,467 Thai adolescents and adults. Data were collected via a validated semi-quantitative food frequency questionnaire. In Thai adolescents and adults, the prevalence of mild acne was 52%, moderate acne 22%, and severe acne 8%. No acne was found in 18% of participants. The dietary factors associated with increased severity of acne were consumption of chocolate >100 g/week (adjusted odds ratio (aOR) 1.29; 95% CI 1.07–1.56), oily and fried food >3 times/week (aOR 1.84; 95% CI 1.07–3.16) and white rice (aOR 1.80; 95% CI 1.24–2.63). Conversely, the factors associated with decreased severity of acne were consumption of sugar-free milk-free tea (aOR 0.61; 95% CI 0.43–0.87) and vegetables (aOR 0.74; 95% CI 0.62–0.89).

Key word: acne; Asia; chocolate; diet; food.

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SIGNIFICANCE

Acne is a multifactorial disease caused by genetic and environmental factors. Diet is an intriguing risk factor, which has been studied around the world. However, only a few studies have examined the influence of Asian cuisine on acne. This study showed that consumption of white rice, chocolate, and oily/fried food are risk factors for worsening severity of acne. Conversely, consumption of sugar-free milk-free tea and vegetables had a protective effect on acne.

Acne vulgaris is a common inflammatory skin disease, which occurs during puberty. Acne affects approximately 85% of young adults and may persist into adulthood (1). The pathogenesis of acne is multifactorial, including increased production of sebum, abnormal keratinization, inflammation, and proliferation of *Cutibacterium acnes* bacteria (2). Other studies have also suggested that family history and lifestyle might be risk factors (3, 4).

In 2002, Cordain et al. (5) proposed that environmental factors and Westernized diets may be associated with acne. They reported a lower of prevalence of acne in non-Westernized populations in Papua New Guinea who consumed a plant-based diet that was low in fat and had a low glycaemic load (GL). The Western diet consisted of more refined carbohydrates, oils, and dairy products than traditional cuisine, lacked fibre, and had a higher ratio of saturated fatty acids to unsaturated fatty acids (6). Some recent studies have shown that a high GL and consumption of milk are associated with acne (7–11). Although chocolate and oily or fatty foods have been frequently implicated, their influence remains inconclusive (3, 4, 12–15).

Most Asian diets include rice and various herbs and spices, but have a lower intake of dairy products in comparison with Western food. However, only a few studies have examined the influence of Asian cuisine on acne. The aim of the current study is to examine the association between dietary factors and acne in Thai adolescents and adults, using a self-reported survey.

MATERIALS AND METHODS

The study was conducted through a web-based survey in March 2020. The 2,476 participants were recruited from online platforms at Srinakharinwirot University Skin Center. Inclusion criteria were: Thai adults; age 18–44 years; ability to understand the questions; and a completed online informed consent form. Participants who do not complete compulsory questions were excluded.

The questionnaire was developed in Thai and contains 10 groups of questions. The first group of questions included a pictorial acne grading scale, family history, demographic data, biometric data, medication, and lifestyle factors. The patients self-assessed their acne using the Leeds revised acne grading system on facial acne with descriptions and a pictorial guide, and reported as "no acne"; no visible comedones or inflammatory papules, "mild acne"; multiple comedones and/or less than 10 inflammatory papules, "moderate acne"; more than 10 inflammatory papules or more than 5 nodules, "severe acne"; multiple and/or large recurrent inflammatory papules or nodule or cystic lesions. The second group of questions were for female participants only, including hormone-related questions; menstrual characteristics, menstrual cycles which are considered irregular if shorter than 21 days or longer than 35 days and use of oral contraceptive pill (OCP). The 3rd group of questions explored the health beliefs of patients regarding food and acne. The 4th and 5th groups of questions asked about various lifestyle factors: exercise, sleep, water intake, smoking, and alcohol consumption.

The 6th to the 10th groups of questions were the Semi-Quantitative Food Frequency Questionnaire (FFQ) and FFQ. The questionnaire was answered by the participants based on their consumption over

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the previous 3 months. The portion size and frequency of consumption were also collected for 12 different food groups: chocolate, dairy products, beverages, fruit, vegetables, cured meat, fish, oily and fried food, spicy food, fermented food, complex and refined carbohydrates, and sweets and snacks.

Standardized portions was categorized as follows: 25, 50 or 100 g (a small, a medium, and a large bar) for chocolate, 8-ounce glass (250 ml) for milk and beverages, a cup (100 g) for yoghurt, a scoop (30 g) for whey protein, a thin slice for white and wholewheat bread, and 1 ladle or 0.5 cup for white and brown rice. Data on the consumption of fermented food, spicy food, oily and fried food, cured meat, and fish were collected as portions of 1 meal. Fruit and vegetable portions were categorized in portions of 1 serving, a small plate and a cup, respectively. A portion of sweets and snacks was 1 regular serving, such as a cup of ice-cream, a small bag of chips, or a piece of bakery goods.

The FFQ was validated with 20 participants, who completed 24 h of diet recall interviews over a period of 2 weeks. This questionnaire was then completed the next month, and the Pearson correlation coefficient was 0.808 for overall food consumption. The study protocol was approved by the Institutional Review Board for Ethics of the Srinakharinwirot University in Human Research, according to the Good Clinical Practice Guidelines and the provisions of the World Medical Association Declaration of Helsinki.

Statistical analysis

Statistical analyses were performed using SPSS, version23.0 Armonk, IBM Corp. The baseline characteristics of the participants were presented as means and standard deviations (SD) for continuous data, and frequency and percentage for categorical data. A χ^2 test was used to compare categorical data. Analysis of covariance (ANCOVA) was used to compare continuous data.

Statistically significant factors (p-value <0.05) in univariate ordered logistic regression analysis were included in a multivariate model. The multivariable model was predicted by multiple linear regression analysis with a forward selection method and expressed as the adjusted odds ratio (aOR) and 95% confidence interval (95% CI). A p-value <0.05 was considered statistically significant.

RESULTS

A total of 2,476 participants (681 males and 1,795 females) completed the questionnaire. The mean (SD) age of respondents was 26.17 (6.29) years. The overall prevalence of acne in this study was 81.66%. Participants were self-categorized as having mild acne (51.66%), moderate acne (21.73%), or severe acne (8.28%), while 18.34% reported having no acne (**Table I**). The severity of acne was significantly higher at a younger age, but was not different between the sexes. More than half of the participants (56.17%) lived in the Bangkok metropolitan area. The health beliefs of the participants (48.34%) were that diet could aggravate acne. This proportion was higher in respondents with acne (53.19%) than those without (24.23%) ($p<0.001$), and higher in more severe acne ($p<0.001$). The participants were most likely to suggest that oily and fried food (35.82%), chocolate (19.43%), and dairy products (14.26%) exacerbated their acne. Moreover, 59.85% of participants reported that stress aggravated their acne and was higher in cases of more severe acne ($p<0.001$).

In univariate analysis of the association between acne severity and baseline characteristics and lifestyles, younger age group, a positive first-degree relative history of acne, lack of sleep, lower age at menarche, irregular menstruation, and consumption of chocolate, milk, yoghurt, sweetened beverages, fruit, fish, cured meat, oily and fried food, spicy food, white rice, white bread, and sweets and snacks increased the risk of acne severity. While regular exercise, drinking >8 glasses/day water, black coffee, sugar-free milk-free tea, vegetables, and brown rice were negatively associated with acne severity (Appendix S1[1]). All statistically significant variables were included in multivariate analysis.

The factors independently associated with worsened acne severity in the multivariate regression analysis model are shown in **Table II**. Participants with severe acne were more likely to be younger (18–25 years) (aOR 1.73; 95% CI 1.42–2.09, $p<0.001$). A history of acne in a first-degree relative was associated with a doubled risk of

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Table I. Baseline characteristics of Thai adolescents and adults and acne severity

Characteristic	Total	No acne	Mild acne	Moderate acne	Severe acne	*p*-value
Population, *n* (%)	2,476 (100)	454 (18.34)	1,279 (51.66)	538 (21.73)	205 (8.28)	
Age, years, mean (SD)	26.17 (6.29)	28.39 (6.64)	26.30 (6.17)	24.81(5.99)	24.01 (5.30)	**<0.001***
Sex, *n* (%)						**<0.001***
Male	681 (27.50)	140 (30.84)	321 (25.10)	139 (25.84)	81 (39.51)	
Female	1,795 (72.50)	314 (69.16)	958 (74.90)	399 (74.16)	124 (60.49)	
BMI, kg/m^2, mean±SD	21.34±3.56	21.06±3.26	21.44±3.66	21.40±3.68	21.56±3.22	0.258
BMI class, kg/m^2, *n* (%)						0.450
<18.5	551 (22.25)	100 (22.03)	280 (21.89)	132 (24.54)	39 (19.02)	
18.5–22.99	1,395 (56.38)	269 (59.25)	720 (56.29)	288 (53.53)	119 (58.05)	
≥23	529 (21.37)	444 (21.96)	279 (21.81)	118 (21.93)	47 (22.93)	
Province, *n* (%)						**<0.001****
Bangkok Metropolitan area	1,388 (56.17)	313 (69.56)	689 (53.91)	280 (52.04)	106 (51.71)	
Other provinces	1,083 (43.83)	137 (30.44)	589 (46.09)	258 (47.96)	99 (48.29)	
Acne aggravation beliefs, *n* (%)						
Diet could aggravate acne	1,197 (48.34)	110 (24.23)	652 (50.98)	314 (58.36)	121 (59.02)	**<0.001****
Stress could aggravate acne	1,482 (59.85)	179 (39.43)	810 (63.33)	365 (67.84)	128 (62.44)	**<0.001****

SD: standard deviation; BMI: body mass index.
*Statistically significant at $p<0.05$, analysis of variance (ANOVA) test. **Statistically significant at $p<0.05$, χ^2 test.

Table II. Multivariate analysis of factors associated with worse acne severity

Factor	aOR (95% CI)	*p*-value
Age group		
18–25 years	1.73 (1.42–2.09)	**<0.001***
26–44 years	Reference	
First-degree relative history of acne		
No	Reference	
Yes	2.42 (1.95–2.99)	**<0.001***
Menstruation		
Regular	Reference	
Irregular	1.38 (1.14–1.68)	**0.009***
Sleep, h/day		
>8	Reference	
6–8	1.08 (0.73–1.59)	0.710
<6	1.84 (1.17–2.90)	**0.009***
Chocolate		
None	Reference	
>100 g/week	1.29 (1.07–1.56)	**0.009***
Oily and fried food		
None	Reference	
<3 times/week	1.31 (0.74–2.31)	0.348
≥3 times/week	1.84 (1.07–3.16)	**0.029***
White rice		
None	Reference	
<2 portions/day	1.78 (1.21–2.62)	**0.004***
≥2 portions/day	1.80 (1.24–2.63)	**0.002***
Vegetables		
None	Reference	
≥3 times/week	0.74 (0.62–0.89)	**0.001***
Tea (no milk, no sugar)		
None	Reference	
≥3 glasses/week	0.61 (0.43–0.87)	**0.006***

The multivariable analysis model included and adjusted for age group, first-degree relative history of acne, exercise, water intake, sleeping, age at menarche, menstruation, and consumption of chocolate, milk, yoghurt, black coffee, tea (no sugar), sweetened beverage, fruits, vegetables, fish, cured meat, oily and fried food, spicy food, white rice, brown rice, white bread, and sweets and snacks.
aOR: adjusted odd ratio; 95% CI: 95% confidence interval
*Statistically significant at $p<0.05$, multivariable analysis.

acne severity (aOR 2.42; 95% CI 1.95–2.99, $p<0.001$). Female participants with irregular menstruation cycles were 38% more likely to have worse acne severity than those with regular cycles (aOR 1.38; 95% CI 1.14–1.68, $p<0.009$). As for lifestyle factors, sleeping less than 6 h per day compared with more than 8 h per day, was associated with an increase in the risk of worsened acne severity by 84% (aOR 1.84; 95% CI 1.17–2.90, $p=0.009$).

In terms of dietary factors, the consumption of any kind of chocolate of more than 100 g per week was associated with an increase in the risk of worsened acne severity by 29% (aOR 1.29; 95% CI 1.07–1.56, $p=0.009$). Consumption of oily and fried food at least 3 times per week was associated with an increase in the risk of worsened acne severity by 84% (aOR 1.84; 95% CI 1.07–3.16, $p=0.029$). In addition, consumption of white rice, which is commonly consumed in Thailand and parts of Asia, was associated with increased acne severity compared with no consumption (<2 portions/day; aOR 1.78, 95% CI 1.21–2.62, $p=0.004$ and ≥2 portions/day aOR 1.80; 95% CI 1.24–2.63, $p=0.002$). In contrast, consumption of brown rice had a lower GL and glycaemic index (GI) and was not associated with an increase in the risk of worsened severity of acne. After adjusting for the confounding factors, the consumption of dairy products, sweets and snacks, and sugary drinks did not influence acne severity. The consumption of vegetables, at least 3 portions a week, was a protective factor for acne severity, the risk decreased by 26% (aOR 0.74; 95% CI 0.62–0.89, $p=0.001$). Moreover, drinking tea without sugar and milk, at least 3 glasses per week, also reduced the risk of severe acne by almost 40% (aOR 0.61; 95% CI 0.43–0.87, $p=0.006$). The goodness-of-fit of the ordered logistic multivariate model was tested. The model had good fit, as indicated by the Pulkenstenis-Robinson test, by a value of ($p=0.0588$) and pseudo $R^2=0.0527$.

To identify the role of diverse foods in different age groups, participants were categorized into adolescents (age 18–25 years, $n=1,389$) and adults (age 26–44 years, $n=1,087$), and multivariate analysis was performed. The differences among the 2 age groups were notable, as shown in **Table III**. In adolescence, women were less likely than men to have severe acne, and lack of sleep increased the severity of acne; however, these trends were not seen in adults. Family history of acne remained the main risk factor in both age groups. Dietary factors predominantly affected the severity of acne in adolescents, while adult acne was influenced by irregular menstruation. In the adolescent subgroup, consumption of bread, sweets, and fruit was associated with increased risk of severe acne, while brown rice was a protective factor. The impact was not significant in the adult age group.

DISCUSSION

Although acne is a multifactorial disease, diet is an intriguing risk factor that is studied around the world. Cuisines vary between cultures; therefore the influence of dietary habits differ in each country. Thai food is unique and not dairy based, but the relationship of acne and diet in Thais has not been widely studied. Moreover, this study was conducted with populations in late adolescence and adulthood, which unmask the effect of puberty, unlike most studies conducted in only in teenagers. The current study confirmed the multifactorial pathogenesis of acne, including genetic, hormonal effects, lifestyle and dietary factors. Some foods were independent factors worsening acne severity, particularly in adolescents, while adult acne was influenced by hormone levels.

Chocolate is one of the most popular foods believed to aggravate acne, but results from previous research on chocolate and its contribution to acne vary. The current study found that consumption of any kind of chocolate of more than 100 g per week was associated with increased risk of worsened acne severity (aOR 1.29). This finding could be due to increased production of inflammatory cytokines induced by *Cutibacterium acnes*, which are key in the pathogenesis of acne after consumption of chocolate (16). A large cross-sectional survey of Europeans, age range 15–24 years, found that a higher consumption of chocolate was associated with a higher chance of developing acne (4). In addition, in clinical

Table III. Multivariate analysis of factors associated with worse severity of acne in adolescent and adult subgroups

	Adolescent ($n = 1,389$)		Adults ($n = 1,087$)	
Factors	aOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Sex				
Male	Reference	**0.001***	Reference	0.92
Female	0.68 (0.53–0.86)		1.01 (0.77–1.34)	
First-degree relative history of acne				
No	Reference		Reference	
Yes	2.25 (1.76–2.88)	**<0.001***	2.55 (1.98–3.28)	**<0.001***
Menstruation				
Regular	–	–	Reference	
Irregular			1.71 (1.27–2.31)	**<0.001***
Sleep, h/day				
>8	Reference		–	–
6–8	1.38 (0.94–2.01)	0.096		
<6	2.72 (1.71–4.34)	**<0.001***		
Tea (no milk, no sugar)				
None	–		Reference	
≥3 glasses/week			0.98 (0.70–1.36)	0.890
Oily and fried food				
None	–	–	Reference	
<3 times/week			1.10 (0.65–1.87)	0.728
≥3 times/week			1.61 (0.98–2.63)	0.058
Brown rice				
None	Reference		–	–
<2 portions/day	0.75 (0.59–0.94)	**0.012***		
≥2 portions/day	0.48 (0.34–0.68)	**<0.001***		
Bread				
None	Reference		–	–
≥3 portions/week	1.38 (1.06–1.78)	**0.015***		
Sweets				
None	Reference		–	–
<3 portions/week	1.38 (0.94–2.03)	0.100		
≥3 portions/week	1.83 (1.29–2.58)	**0.001***		
Fruit				
None	Reference		–	–
<3 portions/week	1.63 (1.12–2.35)	**0.01***		
≥3 portions/week	1.63 (1.16–2.29)	**0.005***		

The multivariable analysis model in adolescents included and adjusted for sex, body mass index (BMI), family history, hours of sleep per day, consumptions of all chocolate, total milk, yoghurt, sweetened beverage, spicy food, oily and fried food, cured meat, fish, fruits, white rice, brown rice, white bread, and sweets. The multivariable analysis model in adults included and adjusted for sex, family history, consumption of all chocolate, oily and fried food, sweets, and sugar-free milk-free tea.
aOR: adjusted odd ratio; 95% CI: 95% confidence interval.
*Statistically significant at $p < 0.05$, multivariable analysis.

studies, chocolate consumption was associated with increased acne lesion formation in 1–4 weeks (17–19). Conversely, some studies did not find an association between chocolate consumption and acne (20, 21). A possible explanation for these mixed results is the wide range of ingredients in chocolate, as it remains unclear whether cocoa itself or other ingredients influence acne.

In the current study, regular intake (>3 times/week) of oily and fried foods increased the severity of acne, and these data were consistent with the results from several studies. A previous study reported that higher consumption of saturated fat and trans-fats was associated with moderate to severe acne (22). Another study found an association between oily food and moderate or severe acne (23). Recently, a large cross-sectional study of 24,452 participants by Penso et al. (24) also revealed a relationship between acne and high consumption of fatty and sugary products. Saturated fat, hyperglycaemic carbohydrates and dairy products stimulated the production of mammalian target of rapamycin complex (mTORC1). The increased mTORC1 level enhanced peroxisome proliferator-activated receptors gamma (PPARγ), resulting in dysseborrhoea and acne (25). The current results suggest that acne is affected by a fat-rich diet and support the hypothesis that a Westernized diet is associated with development of acne (5).

Interestingly, the current study found that consumption of white rice was associated with increased severity of acne. Rice is a primary carbohydrate source in Asian diets, especially white rice, and it is consumed daily in most Thai meals. White rice, on average, has a higher GI and higher GL than brown rice (GI 89, GL 83 for white rice, and GI 50, GL 16 for brown rice, per 150 g serving) (26). While several studies have proposed an association between a high GI diet and/or high GL and acne (27–29), white rice has been under-recognized as a trigger factor for acne. Furthurmore, dietary intervention studies found that a low GI/GL diet could reduce acne lesion counts (30, 31). Other small studies also showed that low GL diet group were associated with lower androgen concentrations and decreased outflow of sebum (15, 32). Food with a high GI and/or GL may exacerbate acne by increasing the signalling pathway of insulin and insulin-like growth factor 1 (IGF-1), which enhance androgenic stimulation and lipogenesis by sebaceous glands (33). Insulin and IGF-1 suppress the activity of the

metabolic transcription factor forkhead box O1 (FoxO1), which is a negative coregulator of androgen receptor, peroxisome proliferator-activated receptor-γ (PPARγ), liver X receptor-α, and sterol response element binding protein-1c (SREBP-1c) (25, 34). Upregulated PPARγ and SREBP-1c stimulate sebum production as a result of FoxO1 suppression, and expression of SREBP-1c also alters sebum triglyceride fatty acid become more proinflammatory and comedogenic composition. Thus, insulin and IGF-1 are potent stimulators of sebocyte proliferation and aggravation of acne.

This could explain the finding that consumption of white rice seemed to worsen the severity of acne. The current study also found that consumption of bread and sweets, which are hyperglycaemic carbohydrates, increased the risk of severe acne, while brown rice was a protective factor in the adolescent subgroup. The diet of adolescents may be higher in sugary products, or adults may develop a healthier diet as they grow older, resulting in disparity of exposure. Therefore, unrefined carbohydrates, such as brown rice, are a better alternative for patients with acne, especially for adolescents, who appear to be more susceptible to diet-induced acne.

The frequent consumption of milk, 2 glasses per week, was associated with more severe acne in univariate analysis; however, the relationship was not significant in terms of multivariate analysis. In contrast, previous studies showed an association between milk consumption, especially skimmed milk, and acne, while the association of consumption of other dairy products, such as yoghurt and cheese, with acne remained inconclusive (7, 9–11). In 2018, Dai et al. (8) studied the effects of milk consumption on acne; meta-analysis of observational studies found that the odds ratio was 1.41 for 1 glass of milk per day and 1.24 for 2–6 glasses of milk per week. In contrast to previous research, the amount of milk consumption among Thai adults was found to be relatively low; the median milk consumption in the current study was only 4 glasses per week, and the median consumption of low-fat or skimmed milk was less than 1 glass per week, and was not sufficient to influence the risk of acne.

The consumption of spicy food in Thai cuisine was not independently associated with severity of acne in this study. Thai pepper (bird chilli) and cayenne pepper are regularly consumed in many dishes. Previous studies have found similar results; red and black peppers did not exacerbate acne lesions, and a study in China found no association between acne and consumption of spicy/oily food (29, 35). In contrast, epidemiological research in North East China found that spicy food was associated with risk of acne development (36). Spicy foods are popular in Asia, and the use of herbs and spices differs between regions, and thus its effects may vary.

The identification of protective dietary factors is important to prevent more severe acne; the current study discovered that regular consumption of vegetables and sugar-free milk-free tea was a protective factor. Vegetables provide fibre, and a substantial amount of fibre consumption might improve acne. A low-fibre, high-fat, westernized diet negatively affects the gut microbiome, depleting the production of anti-inflammatory short-chain fatty acids, which contribute to the skin barrier function (12, 32, 37, 38). Studies have found a negative association between consumption of fish, fruit and vegetables, and acne (20, 22). However, in subgroup analysis, the current study found that consumption of fruit had the opposite effect in adolescents; this could be due to the method of data collection, which included high GI fruits. Notably, the current study found another protective factor, tea without sugar and milk, and this could be the impact of consumption of green tea, which is the most consumed tea in Thailand. In a Taiwanese randomized placebo-controlled clinical trial conducted among 80 women with post-adolescent acne, participants received either decaffeinated green tea supplement or placebo for 4 weeks. The participants received supplements containing a green tea extract with epigallocatechin gallate (EGCG) significantly, which reduced acne lesions (39). However, the relationship requires further research.

Study limitations

The limitations of this study are: (*i*) the population of the study was recruited online by convenience sampling, which may have resulted in selection bias; (*ii*) the participants were mostly female, had an interest in acne, seeking information or treatment, and thus the prevalence of acne may be higher than in the general population due to response bias; (*iii*) the causal association cannot be determined in the cross-sectional study. Due to methodical limitations, further randomized control clinical trials are needed to elucidate the relationship between identified foods and acne.

Conclusion

Acne is a multifactorial skin disease; both individual and environmental factors play an important role. Chocolate, white rice and oily/fried food, which is high in fat with a high GL, are dietary risk factors for acne severity. Conversely, regular consumption of vegetables and sugar-free milk-free tea are identified as protective factors.

The authors have no conflicts of interest to declare.

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