

# Investigation of the Synergistic Effect of Berry Juice and Xylooligosaccharides on Skin Health: A Clinical Evaluation

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**Abstract** This preliminary clinical study demonstrates the possibility of a prebiotic juice for improvement of skin conditions. Recently, the health benefits of probiotics and prebiotics for prevention/treatment of diseases have been underscored in the medical field. However, it is challenging to uphold the viability of probiotics in drinks with low pH ranges (e.g., juices), while prebiotics are possible to overcome the impediment. In this study, we utilized a berry juice with xylooligosaccharides (XOS) to explore the clinical benefits for skin health. There is little clinical evidence for the XOS applications in anti-aging. After 8-week juice-XOS intervention, in comparison with the baseline results, the mean levels of skin brightness, moisture, elasticity, spots, UV spots, and brown spots of subjects were improved by 2.7%, 11%, 5.1%, 3.1%, 6.2%, and 0.6%, respectively. Besides UV spots, the results of other skin parameters at 8 weeks in juice-XOS group were significantly different from the baseline results. Nevertheless, juice-XOS did not exert an obvious improving effect on body composition since the XOS content was too few to impart a remarkable improving effect on metabolism as evidenced by the previous reports. In brief, we demonstrated that prebiotic juice may provide an alternative route to daily skincare although the underlying mechanism of juice-XOS for improvement of skin health is not clear.

**Keywords:** xylooligosaccharides, berry juice, skin aging, anti-aging

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## 1. Introduction

Nowadays, the markets of functional foods and drinks are continuing to growth to fulfill the unmet needs of modern consumers for advanced health benefits. Recently, mounting pharmacological evidence has unveiled that probiotic foods may confer the beneficial effects on prevention/treatment of diseases (e.g., cardiovascular disease, inflammatory bowel disease (IBD), diarrhea, etc.) [1,2,3]. The global probiotic market is around USD 49 billion in 2018 and projected to reach USD 69.3 billion by 2023 [4]. The probiotics are referred to as "live microorganisms which when administered in adequate amounts confer a health benefit on the host" [5]. To date, dairy-related probiotic products (e.g., yogurt) account for 74% of probiotic product market shares [7]. However, certain consumers with lactose intolerance or awareness of

cholesterol and environmental protection are desired for probiotic products which are low cholesterol, lactose free, dairy free, vegetarian, or vegan friendly [8]. As such, non-dairy probiotic beverages have become another attractive development direction in food industry [7,8,9,10]. Fruit juices (e.g., orange, grape, pomegranate, peach, and apple juices) are possible probiotic carriers for oral administration of *Bifidobacterium* and *Lactobacillus* [8,11,12]. Nonetheless, the low pH ranges of juices may affect bacterial viability and survival rate under the circumstance of long storage [13].

Prebiotics is defined as "dietary fibre denotes carbohydrate polymers with 10 or more monomeric units that are not hydrolyzed by the endogenous enzymes found in the small intestine of humans" [14]. The non-digestible oligosaccharides act as the carbon sources of probiotics through fermentation; the main fermentation products short-chain fatty acids (SCFAs) may improve the intestinal barrier integrity and immune system,

along with restoring the balance of microbiome [15]. Especially, XOS, inulin, fructo-oligosaccharide (FOS), and galacto-oligosaccharides (GOS) are commonly used prebiotics for various foods (e.g., infant milk formulas, beverages, and juices) [15,16,17]. These oligosaccharides can remain their stable physical and chemical properties in acidic drinks, so that the quality control of prebiotic juices is relatively easier than that of probiotic juices. In addition to the benefits of prevention of non communicable diseases, prebiotics are also available for improvement of skin health and aging process [18,19]. Regarding skincare, studies revealed that oligosaccharides might prevent skin aging from suppressing the expression of elastase-type proteases [20]. GOS were able to significantly ameliorate skin conditions, especially for transepidermal water loss, wrinkles, and pigmentation, in healthy volunteers [21,22]. However, to the best of our knowledge, few clinical investigation point out the efficacy of prebiotic juices for improvement of skin conditions. In this clinical study, we attempted to investigate the synergistic effect of a berry juice and XOS on skin health.

## 2. Materials and Methods

### 2.1. Materials

Berry juice (50 mL; ingredients: various berries, lychee vinegar, mulberry vinegar, aronia extract, grape juice, mixed berry juice, blackcurrant juice, grape seed extract, acerola extract, acai extract, pectin, noni powder, fructose, L-cysteine monohydro, L-ascorbic acid, citric acid, B-complex vitamins, 77 fruits and vegeta), prebotic (AKK Formula™; ingredients: banana enzymes, xylooligosaccharide, lactitol).

### 2.2. Participants and Study Design

This study was designed as a controlled and double-blinded study. This clinical study was approved by the ethics committee of the Antai Medical Care Corporation Antai Tian-Sheng Memorial Hospital (IRB No. 19-081-B). Subjects returned their written consent forms before the study.

40 subjects were enrolled in this study and allocated them (in a ratio 1 : 1) to juice group or juice with prebiotic (juice-XOS) group. The eligible volunteers were recruited from healthy adults over 20 years old and did not contradict the following the exclusion criteria. The exclusion criteria contained: i) pregnant or breastfeeding woman; ii) menopausal woman; iii) metabolic disorders; iv) kidney diseases; v) liver diseases; vi) cardiovascular diseases; vii) constant drug use; viii) skin disorders; ix) allergy to food, drugs, or cosmetics; and x) the treatments of esthetic medicine (intense pulse light, medical peelings, or laser therapy) before 4 weeks of the study. Subjects were required to intake a bottle of juice or juice-XOS for 8 weeks. The skin, biochemical, and anthropometric measurement analyses were conducted at weeks 0, 4, and 8.

### 2.3. Skin Measurement

Skin brightness was analyzed by a Chroma Meter MM500 (Minolta, Japan); the degree of skin brightness

was indicated by L\* value (L\* range: 0-100). Skin moisture was analyzed by a Corneometer CM825 (Courage + Khazaka Electroni, Germany); the skin moisture was determined by the change of the dielectric constant in skin surface. Skin elasticity was analyzed by a Soft Plus (Callegari 1930, Italy); the measured value was defined by the calculation of stress/deformation after suction (field: 0-50 u.c.). Skin, UV, and brown spots were analyzed by a VISIA® Complexion Analysis (Canfield Scientific, U.S.A.); the instrument used UV photography to profile skin marks, pigmentation, and discoloration of surface and subsurface.

### 2.4. Statistical Analysis

The experimental results were analyzed by Student's t-test in EXCEL, as  $p < 0.05$  considered significant.

## 3. Results and Discussion

In this study, we used XOS rather than GOS to assess the skin improvement effect given that the clinical exploration of XOS is scarce. All subjects accomplished the clinical study and complied with the clinical protocol in the study. There was no any adverse effect as reported by participants and the results of biochemical analysis.

### 3.1. Body Composition

Several studies have unveiled the benefit of prebiotics for weight management, thus the anthropometric measurement was also included in this study [23]. In light of the recruitment criteria, normal and overweight individuals would participate in this study. Note that the definition of overweight [body mass index (BMI)  $\geq 24$  (kg/m<sup>2</sup>)] abided by the official information by the Ministry of Health and Welfare in Taiwan. The results of body composition for normal and overweight people were separately analyzed considering the basis of appropriate comparison (Table 1). The distributions of overweight participants in juice group (30 %) and juice-XOS group (35%) were similar. As compared with the baseline results, the improving effect of XOS on weight loss in overweight population was not obviously observed; by contrast, the mean levels of visceral fat grade, waistline, and hipeline in normal population were significantly ameliorated after XOS intervention. The disparaging results of weight management may be due, in part, to the low amount of XOS here. Based on the previous efforts by other groups, 1.2-2 g of XOS could not reach the remarkable improving effect for body composition in humans although the abundance of beneficial bacteria (e.g., *Lactobacillus* spp. and *Bifidobacterium* spp.) in the GI tract was increased [24,25]. Hence, the efficacy of XOS on weight management requires further investigation.

### 3.2. Skin Health

The improving effects of juice-XOS on skin parameters appeared after 4-week intervention, and the progresses of amelioration extended to the end of study (Table 2).

**Table 1. Demographic characteristics and anthropometric measurement results (N = 20). Note that the statistical comparison was analyzed among the results of juice and juice-XOS in the same time frame**

	Juice		Juice-XOS		Statistical difference P value (BMI ≥ 24, BMI < 24)
	BMI ≥ 24 (n = 7)	BMI < 24 (n = 13)	BMI ≥ 24 (n = 6)	BMI < 24 (n = 14)	
<b>Age (years)</b>	35.4 ± 3.4	30 ± 1.7	38.5 ± 2.9	37.6 ± 1.9	
<b>Male, Female</b>	3, 4	0, 13	1, 5	2, 12	
<b>BMI (kg/m<sup>2</sup>)</b>					
Baseline	28.9 ± 1.8	20.1 ± 0.5	27.7 ± 0.7	22.1 ± 0.5	
Week 4	28.9 ± 1.8	20.2 ± 0.6	27.8 ± 0.6	22.2 ± 0.5	0.6, 0.015
Week 8	28.7 ± 1.8	20.2 ± 0.5	27.7 ± 0.6	22.2 ± 0.5	0.652, 0.011
<b>Body mass (kg)</b>					
Baseline	80 ± 6.6	51.7 ± 2	72.9 ± 3.7	60.3 ± 2	
Week 4	79.9 ± 6.5	51.9 ± 2	73 ± 3.4	60.5 ± 1.9	0.39, 0.005
Week 8	79.4 ± 6.5	51.8 ± 2	72.9 ± 3.3	60.5 ± 0.1	0.4152, 0.004
<b>Body fat percentage (%)</b>					
Baseline	34.5 ± 1.8	35.7 ± 0.7	34.8 ± 2.1	34 ± 0.8	
Week 4	33.1 ± 2.2	35.5 ± 0.8	34.4 ± 2.1	34.3 ± 1.1	0.68, 0.360
Week 8	32.7 ± 2	34 ± 1.2	34.2 ± 2.1	33.9 ± 0.9	0.614, 0.932
<b>Visceral fat grade</b>					
Baseline	11.3 ± 2.5	2.2 ± 0.3	11.2 ± 1.6	5 ± 0.9	
Week 4	11.1 ± 2.5	2.1 ± 0.3	11.2 ± 1.9	5.1 ± 0.9	0.99, 0.004
Week 8	10.9 ± 2.5	1.9 ± 0.3	10.7 ± 1.6	5.6 ± 0.8	0.951, < 0.001
<b>Waistline (inch)</b>					
Baseline	35.3 ± 2.1	27.8 ± 0.7	34.1 ± 1.3	32.7 ± 0.8	
Week 4	35.1 ± 2	27.2 ± 0.5	33.8 ± 1.2	32.6 ± 0.9	0.6, < 0.001
Week 8	34.2 ± 1.9	27 ± 0.5	34.4 ± 1.3	32.3 ± 0.9	0.9236, < 0.001
<b>Hipline (inch)</b>					
Baseline	40.3 ± 1.9	35.1 ± 0.6	39.9 ± 1.1	38 ± 0.5	
Week 4	40.2 ± 1.8	35 ± 0.6	40.4 ± 0.9	38.3 ± 0.4	0.93, < 0.001
Week 8	40.2 ± 1.7	35.4 ± 0.6	40.4 ± 1	38.1 ± 0.5	0.924, < 0.001

**Table 2. Measurement results of skin parameter in volunteers (N = 20). Note that the statistical comparison was analyzed between the baseline result and measurement time points or between juice and juice-XOS (denoted as †)**

Item	Group	Week	Mean ± SE	Difference/%	P value
Skin brightness	Juice	0	59.7 ± 0.7		
		4	60.1 ± 0.7	+ 0.8	0.0066
		8	60.9 ± 0.7	+ 2.1	0.0003
	Juice-XOS	0	57.6 ± 0.4		
		4	58.2 ± 0.5	+ 1.1	0.0008, 0.0423 <sup>†</sup>
		8	59.1 ± 0.5	+ 2.7	<0.0001, 0.0616 <sup>†</sup>
Skin moisture	Juice	0	38.9 ± 1.2		
		4	40.8 ± 1.2	+ 5.0	0.0387
		8	41.2 ± 1.5	+ 6.0	0.0164
	Juice-XOS	0	35.9 ± 1.6		
		4	37 ± 1.4	+ 3.1	0.0268, 0.0675 <sup>†</sup>
		8	39.8 ± 1.4	+ 11.0	0.0035, 0.5214 <sup>†</sup>
Skin elasticity	Juice	0	0.238 ± 0.003		
		4	0.245 ± 0.002	+ 2.7	0.0003
		8	0.246 ± 0.002	+ 3.3	0.004
	Juice-XOS	0	0.232 ± 0.003		
		4	0.236 ± 0.003	+ 1.9	0.0198, 0.039 <sup>†</sup>
		8	0.244 ± 0.002	+ 5.1	<0.0001, 0.4715 <sup>†</sup>
Skin spots	Juice	0	75.2 ± 7.1		
		4	71.7 ± 6.0	- 4.7	0.2122
		8	70.1 ± 5.8	- 6.8	0.0707
	Juice-XOS	0	102.1 ± 9.0		
		4	99.8 ± 10.2	- 2.3	0.563, 0.0391 <sup>†</sup>
		8	98.9 ± 10.6	- 3.1	0.4222, 0.0446 <sup>†</sup>
UV spots	Juice	0	265.4 ± 12.0		
		4	264.1 ± 17.8	- 0.5	0.9212
		8	269.8 ± 15.4	+ 1.7	0.7185
	Juice-XOS	0	337.2 ± 13.3		
		4	326.9 ± 13.3	- 3.1	0.2882, 0.0164 <sup>†</sup>
		8	316.2 ± 14.7	- 6.2	0.0437, 0.0675 <sup>†</sup>
Brown spots	Juice	0	245.5 ± 16.7		
		4	249.9 ± 17.6	+ 1.8	0.4795
		8	243.8 ± 16.3	- 0.7	0.8395
	Juice-XOS	0	331.4 ± 19.7		
		4	328.1 ± 20.5	- 1.0	0.6186, 0.0173 <sup>†</sup>
		8	329.5 ± 19.9	- 0.6	0.7509, 0.0084 <sup>†</sup>

Despite of the fact that juice also reached continuous improvements for most skin items, juice-XOS still showed better improving effects than juice. After 8-week juice-XOS intervention, in comparison with the baseline results, the mean levels of skin brightness, moisture, elasticity, spots, UV spots, and brown spots of subjects were improved by 2.7%, 11%, 5.1%, 3.1%, 6.2%, and 0.6%, respectively. Besides UV spots, the results of other skin parameters at 8 weeks in juice-XOS group were significantly different from the baseline results. The positive improvements of skin may be attributed to the synergistic effect of antioxidants, vitamins, and prebiotics. Berry juices are a good source of vitamins and phytochemicals (i.e., phenolic compounds), which possess antioxidative, anti-inflammatory, and anti-cancer activities [26,27,28]. These bioactive compounds have been proved to be beneficial for modulation of oxidative stress, down-regulation of the expression of collagenases, and inhibition of aging-related inflammatory response in fibroblasts and rodents [26,29]. In addition, XOS may enhance the abundance of *Bifidobacterium* spp. and *Lactobacillus* spp. and suppress the growth of *Enterorhabdus* and *Clostridium perfringens* in the gastrointestinal tract [24,25,29]. Enormous studies have proved that *Bifidobacterium* spp. and *Lactobacillus* spp. are able to treat skin disorders and delay skin aging [19]. As such, XOS can provide the benefits for improvement of skin health. Although the underlying mechanism is not clear, we least demonstrated that prebiotic juice may provide an alternative route to daily skincare.

#### 4. Conclusion

This preliminary clinical study demonstrates the possibility of a prebiotic juice for improvement of skin conditions. XOS are not commonly employed in the past studies and little evidence uncovers its clinical effects on anti-aging. Here, we combined a berry juice with XOS to assess the improving effects on skin conditions. In comparison with the baseline results, juice-XOS significantly improved the mean levels of skin brightness, moisture, elasticity, spots, and brown spots of subjects after 8-week intervention, which might be caused by the synergistic effect of antioxidants, vitamins, and prebiotics. Nevertheless, juice-XOS did not exert an obvious improvement effect on body composition since the XOS content here was too few to impart a remarkable improving effect on metabolism on the basis of previous reports. In brief, we demonstrated that the prebiotic juice may provide an alternative route to daily skincare although the underlying mechanism of juice-XOS for improvement of skin health is not clear.

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