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Research Article

The Antioxidant Activity, Vitamin C Contents, Physical, Chemical and Sensory Properties of Ice Cream Supplemented with Cornelian Cherry *(Cornus mas* L.) Paste

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Abstract

The aim of this research was to investigate the effect of cornelian cherry *(Cornus mas* L.) paste (CP) on the quality properties of ice cream. CP was added to an ice cream mix at four concentrations (0, 5, 10 and 15%, w/w) for ice cream production. The increment of CP level caused the increased of vitamin C content, a values and overrun values, whereas it decreased the viscosity of samples compared to Control ice cream sample. The results indicated that lyophilised water extracts of CP (LWECP) contain remarkable phenolic compounds. The findings showed that there is a positive correlation between the total phenolics and flavonoid contents in LWECP and ice cream samples antioxidant activity. CP has shown to be an effective source of natural antioxidants. CP may be used as a source of natural colour and flavour agent in ice cream manufacture. CP enhanced vitamin C amounts of ice cream, and improve sensory properties. In the literature surveys of Science Direct, Web of Science, Google Scholar and Scopus databases an ice cream study using cornelian cherry fruit was not found.

Keywords: *Ice cream, Cornus mas* L., *Cornelian cherry, Antioxidant activity, Sensory properties*

Kızılcık *(Cornus mas* L.) Ezmesi İlaveli Dondurmanın Antioksidan Aktivitesi, C Vitamini İçeriği, Fiziksel, Kimyasal ve Duyusal Özellikleri

Özet

Bu araştırmanın amacı, kızılcık ezmesinin (KE) dondurmanın kalite özelliklerine etkisini incelemektir. Dondurma üretimi için, dört farklı seviyede (%0, 5, 10 ve 15, w/w) KE dondurma miksine ilave edilmiştir. KE seviyesinin artmasıyla, Kontrol dondurma örneğine kıyasla, C vitamini, a değeri ve hacim artışı değerleri artmış, görünür viskozite değerleri azalmıştır. Sonuçlar, KE'nin liyofilize su ekstraktlarının (KELSE) dikkate değer fenolik bileşik içerdiğini göstermiştir. Bulgularımız, KELSE ve dondurma örneklerinin antioksidan aktivitesinde toplam fenolik madde ile flavonoid içeriği arasında pozitif bir korelasyon bulunduğunu göstermiştir. KE, doğal antioksidanların etkili bir kaynağı olduğunu göstermiştir. KE dondurma üretiminde doğal renk ve lezzet verici madde olarak uygun bir kaynak olarak kullanılabilir. KE, C vitamini miktarlarını arttırmış, duyusal özellikleri geliştirmiştir. Science Direct, Web of Science, Google Scholar ve Scopus kaynaklarında yapılan literatür taramasında, kızılcık meyvesi kullanılarak yapılan bir dondurma çalışmasına rastlanmamıştır.

Anahtar sözcükler: *Dondurma, Cornus mas* L., *Kızılcık, Antioksidan aktivite, Duyusal özellikler*

INTRODUCTION

Ice cream is a popular and nutritious dairy product which is consumed at all seasons. Its quality depends on mix formulation and processing. Actually, the highest quality of ice cream manufacture depends on excellent quality of ingredients and a mix which is formulated and balanced the proper function of components, freezing and hardening process [1]. As a result of consumer's trend ice cream technology rapidly has been developed by different taste demands [2-8]. Many researches have been focus on this field which shows that additives affects nutritional value, functional and sensory properties. In recent years, the interest of consumers has increased, the fruit rich in antioxidant compounds. Among these fruits, cornelian cherry fruits gained lately an increasing

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importance [9]. Cornelian cherry fruits are rich source in terms of their nutrients for humans such as vitamin C, organic acid, tannin, dietary fiber and some minerals [10,11] and have antioxidant effect [9,12-14]. This fruit contain significant amounts of polyphenols [9]. Antioxidant compounds have been widely used as food additives to protect food against oxidative degradation, especially caused by lipids [15]. Cornelian cherry tastes sweet-sour and slightly astringent. Fruits are not only consumed fresh but also used to produce jam, marmalade, pestil, compotes and several types of soft drinks in food area. It is known that significant amounts of anthocyanins in cornelian cherry can be used as natural food colorants [16]. Due to many beneficial effects of cornelian cherry, this study aims to examine usage of cornelian cherry fruits in ice cream production. For this reason, there are several analyses are planning to carry out physicochemical and colour analyses, vitamin C amounts, antioxidant properties and sensory characteristics of ice cream samples with cornelian cherry paste (CP). In the literature surveys of Science Direct, Web of Science, Google Scholar and Scopus databases an ice cream study using cornelian cherry fruit was not found.

MATERIAL and METHODS

Materials

Cornelian cherry fruits were collected from Tortum/Erzurum, Turkey in September, 2013. All samples were sorted in terms of shape, colour, size, ripening stage, physical damage and then transported to the laboratory. After removal of kernels, fruits were broken into small pieces with a blender (Waring, 7011HS). Sugar, salep and emulsifier (mono- and di-glycerides) were obtained from local market. Skim milk powder was supplied by Pınar Dairy Products Co. (İzmir, Turkey). The cream and cows' milk were obtained from the Dairy Factory of Food Engineering Department, Atatürk University (Erzurum, Turkey).

Methods

Preparation of Mixes and Ice Cream Samples

Ice cream samples were produced in the Dairy Factory of Food Engineering Department, Atatürk University (Erzurum, Turkey). The mix samples were prepared at four different compositions of 0%, 5%, 10%, 15% CP, respectively. The formulation with 0% CP was accepted as Control. The fat content of milk was adjusted to 6% with cream which had 38% w/v fat content. The milk was divided into four equal parts of 4.0 L. After that 18% sugar, 0.7% stabilizer (salep), 4.8% skim milk powder and 0.2% emulsifier (mono- and di-glycerides) were added to all mixes. The mixes were stirred consistently and pasteurized at 85°C for 25 s. After cooling to 4°C and they were remained at constant temperature for 24 h. Fresh CP was added to the aged ice cream mixes at three different concentrations of 5%, 10% and 15%, respectively. They were frozen in ice cream machinery (Ugur Cooling Machineries Co., Nazilli, Turkey) and hardened at -22±1°C for one day. Ice cream samples stored at -18±1°C.

Physical and Chemical Analysis

Colour analysis were carried out with a colorimeter (Minolta, Model CR-200; Minolta Camera Co., Osaka, Japan). Measurements were done according to Chunthaworn *et al*.[17]. Colour saturation (C) and Hue angle (H°) values were calculated according to the formula by Mendoza *et al*.[18]. For the overrun (OR) analysis was used a standard 100-mL cup. OR values were calculated using the following formula [19].

Overrun (%) = (weight of the ice cream mix – weight of same volume of the ice cream sample)/(weight of same volume of the ice cream sample) × 100

First dripping and complete melting analysis of the samples were carried out at room temperature (20°C) according to the method of Güven and Karaca [20]. The viscosity of ice cream samples was determined with a digital viscometer (Brookfield Engineering Laboratories, Model DV-II, Stoughton, MA, USA) according to Çakmakçı *et al*.[7]. pH, total solids, protein and ash of ice cream samples were done according to AOAC [21], while fat was determined according to Gürsel and Karacabey [22]. Ascorbic acid amount of fresh CP and ice cream samples were determined according to Çakmakçı *et al*.[7].

The overall experimental procedures were duplicated.

Antioxidant Methods

Antioxidant activity of liyophilised water extract of CP (LWECP) was determined by various *in vitro* methods. To prepare LWECP, 100 g of seedless fruit was grounded into a fine powder in a mill and added to 250 mL distilled water. This mixture was stirred by a magnetic stirrer for 1 day at 25°C. Then, the extract was filtered through filter paper (Whatman No.1). The filtrates were frozen and lyophilised in a lyophiliser (Labconco, Freezone 1 L) at 5 mmHg at -50°C. Following measurements and evaluations were done according to Apak *et al*.[23] and Çakmakçı *et al*.[7]. FRAP assay is based on the reduction of Fe^{3+} – TPTZ complex under acidic conditions [24]. $DPPH^{\cdot}$ scavenging activity assay was used in order to determine the DPPH free radical scavenging activity of LWECP. $DMPD^{\cdot+}$ radical scavenging activity of sample was measured by the N,N´-dimetil-*p*-fenilendiamin dihidroklorür (DMPD) method proposed by Fogliano *et al*.[25]. Total phenolic and flavonoid compounds in the CP and ice cream samples were done according to Slinkard and Singleton [26]. The concentration of total phenolic and flavonoid compounds in CP was determined as µg of standard compounds equivalent.

Sensory Analysis

The sensory characteristics of the ice creams were evaluated according to the modified version of hedonic scale suggested by Bodyfelt *et al.*[27]. Samples were tested by fifty consumer panellists. All sensory properties were graded from 1 to 9 (1: poor, 9: excellent) on point scales. Coded ice cream samples were stored at -18°C for 2 days before analysis. The samples (~50 g) were placed on white colour plates. Each panel member evaluated the ice cream samples in terms of their six sensory attributes including colour & appearance, texture, flavour, sweetness and overall acceptability.

Statistical Analysis

The experimental design consisted of a completely randomised design in a factorial arrangement: four treatments (ice cream samples: Control (without CP), +5% CP, +10% CP and +15% CP, as seen *Table 1*), and two replicates. Statistical analysis were performed with using SPSS 17.0 (SPSS Inc., Chicago, U.S.A) software. Statistical comparisons between samples were carried out using Duncan's Multiple Range method. Differences were considered as significant at P<0.05.

RESULTS

Physical Properties

The colour values of ice cream samples are shown in *Table 1*. The average of the overrun values achived in the ice cream samples are summarised in *Table 2*. The highest overrun and the lowest viscosity values were observed bythe 15% CP added ice cream sample *(Fig. 1)*. The first and complete melting behaviours of the samples are illustrated in *Fig. 2*. The lowest first dripping and complete melting times (840 and 3870 s, respectively) were determined in Control sample while the highest (1290 and 4620 s, respectively) were 15% CP added ice cream sample.

Chemical Properties

Dry matter (%), protein (%), ash (%), pH and vitamin C (mg/100 g) contents of CP were found, respectively, as follows: 14.83; 0.66; 0.54; 3.93; 48.8. Our ascorbic acid result is in accordance with this reported by Tural and Koca [28]. Our dry matter and ash results are lower reported by Ayar *et al.*[29].

The chemical composition of ice creams can be seen from *Table 2*. Control sample had the highest dry matter, protein, fat, ash and pH values. There were no significant difference (P>0.05) in the ash and fat contents for ice cream samples. As can be seen from *Table 2*, pH values of samples were found between 5.3 and 6.7. Vitamin C content of the CP which is the material of ice creams in this study had an average of 0.488±0.42 mg/g. It is clearly shown that in *Table 2*, increasing level of CP which was added in to the ice cream samples, was significantly increased the vitamin C amount (P<0.05).

Antioxidant Properties

Table 3 indicates the reducing activity of CP and the standards (BHA, BHT, α-tocopherol and trolox) using different antioxidant activity methods. The human diet contains plants which include a variety of phenolic and flavonoid compounds. Additionally, it was reported that these molecules are with respect to antioxidant capacity.

Table 1. *Comparison of colour parameters for ice cream samples and CP*

Samples	*L**	*a**	*b**	*H°*	*C**
Control	90.02±0.18e	-2.77±.0.09a	9.66±0.02e	106.00±0.71e	10.05±0.04d
+5% CP	83.03±0.08d	2.50±0.01b	6.34±0.11d	70.93±0.17d	6.82±0.04a
+10% CP	79.12±0.37c	5.62±0.13c	4.49±0.05c	39.85±0.64c	7.20±0.12b
+15% CP	74.89±0.16b	9.08±0.10d	3.25±0.07b	16.95±0.17b	9.64±0.09c
CP	29.50±0.20a	34.69±0.07e	2.43±0.28a	4.01±0.05a	34.72±0.02e

Means ± standard deviation; Values followed by different letters in the same column are significantly different (P<0.05); ***CP:*** *Cornelian cherry paste*

Table 2. *Effect of the addition of CP on the gross chemical composition of ice cream samples*

Ice Cream Samples	Total Solids (%)	Protein* (%)	Fat* (%)	Ash* (%)	pH	Vitamin C (mg/100 g dry matter)	Overrun (%)
Control	41.4±0.11c	12.0±0.67a	13.0±0.34a	2.6±0.07a	6.7±0.07d	< 6.0a	28.4±3.39a
+5% CP	38.0±0.09b	11.9±0.60a	12.9±0.40a	2.7±0.08a	5.9±0.04c	11.8±0.72b	39.6 ±2.83b
+10% CP	37.7±0.08a	11.6±0.40a	12.8±0.40a	2.7±0.11a	5.5±0.02b	17.5±0.61c	41.2±2.55c
+15% CP	37.7±0.19a	11.6±0.72a	12.6±0.36a	2.8±0.09a	5.3±0.07a	18.3±0.50c	42.3±2.97c

** in dry matter; Mean values followed by different letters in the same column are significantly different (P<0.05);* ***CP:*** *Cornelian cherry paste*

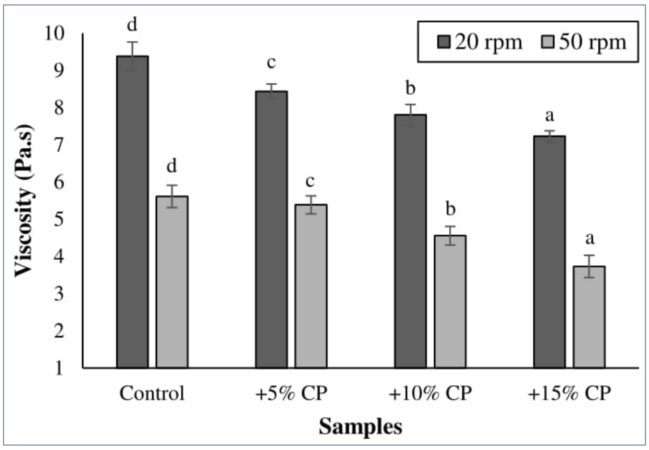

Fig 1. Viscosity values of ice cream mixes
Different letters above the bars indicate significant differences by Duncan multiple comparison test (P<0.05)

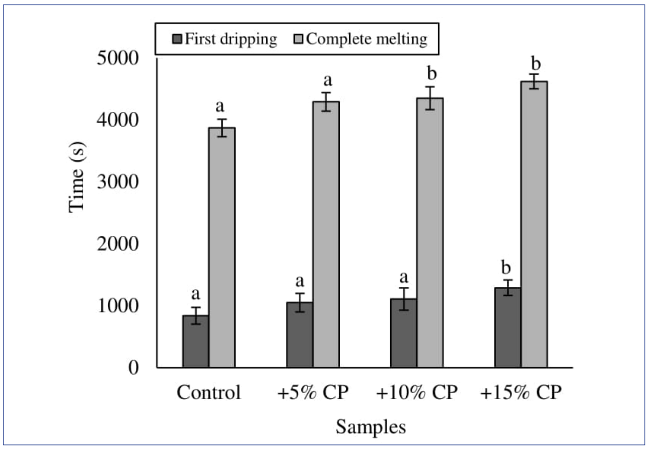

Fig 2. First dripping and complete melting times of ice cream samples
Different letters above the bars indicate significant differences between samples (P<0.05) (Duncan multiple comparison test)

***Table 3.** Ferric ions (Fe^{3+}) and cupric ions (Cu^{2+}) reductive potential and FRAP assay, DPPH˙ scavenging assay, DMPD˙⁺ scavenging assay of CP and reference antioxidants at the same concentrations (20 µg/L)*

Antioxidants	Fe^{3+}-Fe^{2+} Reducing Assay	Cuprac Assay	FRAP Assay	DPPH˙ Scavenging Assay	$DMPD^{\cdot+}$ Scavenging Assay
BHA	1.86	0.45	2.16	0.08	0.61
BHT	1.95	0.46	2.14	0.49	0.64
α-Tocopherol	0.78	0.33	1.32	0.04	0.55
Trolox	0.31	0.31	0.38	1.18	0.68
CP	0.19	0.07	0.52	1.28	0.76

CP: Cornelian cherry paste

In this study, total phenolic and total flavonoid content of CP and ice cream samples are shown in *Table 4*. It was observed that, 89.5 µg of gallic acid equivalent of phenols and 67.20 µg of quercetin equivalent of flavonoids were found in 1 mg of CP.

Sensory Properties

The sensory characteristics of ice cream samples are shown in *Table 5*. The addition of the CP as ingredient significantly affected the sensory analysis results of the ice cream samples.

DISCUSSION

Colour is an important factor for consumers due to the fact that colour of food is closely associated with freshness, ripeness, desirability and food safety. *L** and *b** values decreased significantly (P<0.05) with increase in CP concentration. Black and blue character-istics increase when CP concentration increase in the ice cream samples. A disparate trend was observed in *a** values. The highest *a** value was determined at 15% CP added ice cream sample. Morever, Yüksel *et al.*[8] reported that similar result was observed in terms of *a* values of ice cream with terebinth coffee. The highest *C** value was achieved with Control while the lowest was 15% CP added sample. Data also showed that *H°* value progressively decreased by CP addition in increasing concentrations. The hue angle value of Control sample represents a colour in the yellow/green region due to between 90° and 180°. This region changed towards the red/yellow region with CP addition. The phenolic substance addition changes the colour properties of ice creams compared to Control sample [30].

Overrun is an important parameter for evaluating an ice cream product. This situation relates to a rising in the volume of ice cream during processing [31]. The highest overrun and the lowest viscosity values were observed by the 15% CP added ice cream sample. The lowest overrun was determined Control sample. There are opposite results about overrun and viscosity values at literature. Researchers generally studied with dried fruits or concentrated fruit products in these studies. For example, one of the study of Hwang *et al.*[32] about grape wine lee (GWL) paste explain that addition of GWL in ice cream product with increasing concentration caused decreasing of overrun and increasing in viscosity values. In this study, CP which has high water content is the material of this experiment. Therefore, the general increment in overrun and decrement in viscosity values

Table 4. *Total phenolic and flavonoid contents of CP and ice cream samples*

Samples	Total Phenolic Content (µg GAE/mg)	Flavonoid Content (µg QE/mg)
CP	89.5±1.45e	67.20±1.10e
Control	18.1±2.20a	13.6±2.10a
+5% CP	47.06±2.13b	38.65±1.30b
+10% CP	53.50±3.10c	49.23±2.50c
+15% CP	68.75±1.20d	53.47±2.00d

Mean values followed by different letters in the same column are significantly different (P<0.05); ***CP:*** *Cornelian cherry paste*

Table 5. *Sensorial properties of ice cream samples (1: poor, 9: excellent)*

Properties	Samples			
	Control	+5% CP	+10% CP	+15% CP
Colour and appearance	7.2±1.04a	7.4±0.93b	7.8±0.82c	7.9±0.48c
Texture	7.2±0.57a	7.4±1.14b	7.9±0.54c	8.0±0.64d
Flavour	6.8±1.01a	7.5±0.83c	7.4±0.25b	7.4±0.45b
Sweetness	7.4±0.82c	7.4±0.78c	7.2±0.48b	6.9±0.25a
General acceptability	7.2±1.00a	7.6±0.56b	7.6±0.59b	7.7±0.86b

Mean values followed by different letters in the same column are significantly different (P<0.05); ***CP:*** *Cornelian cherry paste*

with CP addition were considered as normal. *Fig. 1* illustrates the viscosity values of samples which are measured at 20 and 50 rpm. Addition of CP with a concentration of 5%, 10% and 15% caused a significant decrement (P<0.05) in the apparent viscosity when it was compared to Control sample.

The lowest first dripping and complete melting times were determined in Control sample while the highest one was 15% CP added ice cream sample. At the same time 15% CP added sample had the highest overrun value, as previously reported. Similarly, Sakurai *et al.*[33] and Sofjan [34], reported that ice creams with lower overruns had faster melting rates.

The chemical composition of ice cream samples can be seen in *Table 2*. Control sample had the highest total solids, protein, fat, ash and pH values. There were no significant difference (P>0.05) in the ash and fat contents for ice cream samples. As can be seen from *Table 2*, pH values of samples were in the range of 5.3 to 6.7. All of ice cream samples added to CP had statistically (P<0.05) lower pH values when it compared to Control sample.

The cornelian cherry fruit contains high amount of ascorbic acid between 0.164 and 0.786 mg/g as reported by researchers [10,11,35]. In this aspect, ascorbic acid content is significantly higher when it compared to other fruits which contain high ascorbic acid such as oranges (0.31 mg/g), strawberries (0.46 mg/g) and kiwis (0.29-0.80 mg/g) [13]. Vitamin C analysis is essential for fruity ice creams which have high vitamin C contents. The added of CP with increasing level (5%, 10% and 15%) dramatically increased the vitamin C amount of ice cream samples (P<0.05). The highest vitamin C value was achieved by 15% CP added sample (18.3 mg/100 g) while the lowest was in Control sample (<6.0 mg/100 g).

Antioxidants may be used to help the human body in reducing oxidative damage by free radicals and active oxygen [36]. The antioxidants use to protect quality of lipids and fatty foods. Therefore, antioxidants play much more important role in the food industry [15,37]. The antioxidant activity of CP and the standards (BHA, BHT, α-Tocopherol and Trolox) with using different antioxidant method are presented in *Table 3*. For measuring reductive activity of CP, the Fe^{3+}-Fe^{2+} transformation was investigated in the existence of CP. CP has a approximate effect trolox rather than other standarts in all metods. In addition, cupric ion (Cu^{2+}) reducing power of CP and standards decreased in order of CP < trolox < α-Tocopherol < BHA < BHT. When the FRAP (Ferric reducing antioxidant power) assay of CP and the same amount of the standard compounds was examined, CP has a higher activity than Trolox.

$DPPH^{\cdot}$ scavenging activity of CP and standards increased in the following order: α-Tocopherol> BHA> BHT> Trolox> CP. According to results obtained from $DMPD^{\cdot+}$ radical scavenging assay *(Table 3)*, DMPD scavenging ability of CP has similar to the all standards.

Flavonoids are the most common group of polyphenolic compounds in the human nutrition and they are commonly found in fruits and vegetables [6,12]. Known quantities of gallic acid and quercetin were used as the standart for calibration curves for analysis of total phenolic and flavonoid compounds. Our datas showed that phenolic and flavonoid contents of ice cream samples increased with the addition of CP when compared with control group. It was observed that, 89.5 µg of gallic acid equivalent of phenols and 67.20 µg of quercetin equivalent of flavonoids were found in 1 mg of CP. Our results are higher than the results reported by Moldovan *et al*.[9]. As seen in *Table 4* total phenolic and total flavonoid content of ice cream samples in the range of 18.1-68.75 µg GAE/mg and 13.6-53.47 µg QE/mg, respectively. These findings clearly demonstrate that there is a positive correlation between the total phenolics and flavonoid contents in the samples and antioxidant activity.

The addition of the CP as ingredient significantly affected the sensory analysis of the ice cream samples *(Table 5)*. Samples have different colour and appearence score range between 7.2 and 7.9. The highest score was determined in sample +15% CP. CP gave reddish colour to ice cream that was desirable for the panellists. The samples containing CP showed relatively high scores in terms of organoleptic characteristics such as colour and appearance, texture, flavour compared to the Control group. The highest value of colour is +15% CP, although the lower values of colour are +10% CP, +5% CP and Control samples, respectively. Morever, the addition of CP positively affected colour, texture, flavour. The highest flavour score is determined in +5% CP sample. The highest sweetness score was determined in Control sample and following order +5% CP, +10% CP and +15% CP. Therefore, the addition of CP decreased sweetness of ice cream samples. The general acceptability scores were higher in all CP samples compared to Control group. Ayar *et al*.[29] have determined that yogurt made with CP is more appreciated than yoğurt samples made with *Diocypros kaki*, *Diocypros lotus* and rosehip (*Rosa rugosa*). Also, Celik *et al*.[38] stated that CP can be successfully used in fruit yogurt production.

The addition of CP significantly affected the physico-chemical, colour, sensory and antioxidant properties of ice cream. CP has a sweet-sour, slightly astringent taste and pleasing colour. Thus, ice cream samples with the fruit were preferred by the panellists. CP can be used as easily accessible source of natural antioxidants and a potential food additive in food industry. CP enhanced the amounts of vitamin C and improved sensory properties in ice cream. Generally, the best properties were determined in +10% CP concentration compared with Control group. CP may be used as a source of natural colour and flavour agent in ice cream manufacture. In general evaluation of the research results, this fruit which is less known can be as a potential functional food or value ingredients in our digestive system.

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