

# Functional Ingredient and Nutraceutical Development of Sorghum for Health Promotion and Disease Prevention



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## EXECUTIVE SUMMARY

The research project “Functional Ingredient and Nutraceutical Development of Sorghum for Health Promotion and Disease Prevention” aimed to commercialize sorghum extract as functional ingredient for food, beverage and cosmetic industry.

The primary achievement of this project is the successful development of a sorghum extract product with enriched health beneficial components, enhanced biological activities and a reasonable shelf life.

The detailed outcomes of this project include:

1. Comparison of solvent factor on concentration of phytonutrients in sorghum and biological activities.
2. Comparison of variety factor on concentration of phytonutrients in sorghum and biological activities.
3. Optimization of extraction and processing condition to obtain sorghum extracts.
4. Investigation on stability of sorghum extracts.

The phytonutrient-concentrated sorghum extract can be further developed into a variety of food, beverage, dietary supplement or cosmetic products. It has the potential to promote human well-being, beauty and anti-aging through use of the product. It also demonstrates sorghum’s health benefits to the public, and the scientific evidence is supporting sorghum can be part of the healthy diet. Growers will benefit by the increased consumption and sales of sorghum and sorghum-based products.

## TECHNICAL OBJECTIVES

The overall goal of the project was to commercialize sorghum extract as functional ingredient for food, beverage and cosmetic industry and to promote human well-being, beauty and anti-aging through use of the product.

The specific technical objectives include:

1. Optimization of extraction efficiency to maximize the amounts and types of phytonutrients from sorghum, and to create a few product prototypes.
2. Measurements of physiological activities of sorghum extracts including antioxidants, anti-inflammation, cholesterol and blood glucose reduction.
3. Investigation on stability of sorghum extracts in various conditions.

## BACKGROUND

“It’s not a diet, it’s a lifestyle.” Recent research from Mintel (Mintel, 2015) has shown that consumers are now more health-conscious than before. Eating is not as straight forward as it used to be. With medical bills continue to go up, the majority of consumers have strong desire to either reduce the risk of, or manage, a specific health condition. For cereal and grains, it is important to characterize the functional ingredients and their health beneficial factors and to develop crop based foods concentrated in functional ingredients.

From literature and our preliminary study, it is evident that sorghum has unique phytonutrient profile. For example, it is known to contain anthocyanins with decent stability. It also consists of proanthocyanindins that delays the digestion of macronutrients, therefore effectively control blood sugar against diabetes and obesity. Through our previous study, we discovered that sorghum is rich in antioxidants and may provide anti-aging, anti-inflammatory benefits and may alleviate heart diseases.

Although United States are one of the largest sorghum producer, the majority of sorghum ends up as livestock feed and source for making ethanol. The lack of public awareness of the health benefits of sorghum and lack of available good sorghum products/ingredients may be part of the reasons. We aimed to create one or several sorghum products concentrated in healthy phytonutrients. These sorghum products may serve as ingredients for functional foods or cosmetic products. They may also be made into dietary supplements.

To achieve this goal, we disseminate it into several objectives:

1. Optimization of extraction efficiency to maximize the amounts and types of phytonutrients from sorghum, and to create a few product prototypes.

This objective includes the following steps:

- a. Investigate the solvent factor on concentration of phytonutrients in sorghum to select the best solvent for extraction.
  - b. Investigate the variety factor on concentration of phytonutrients in sorghum to select one or two varieties of sorghum.
  - c. Investigate the extraction and processing condition to obtain sorghum extract with concentrated phytonutrients.
2. Measurements of physiological activities of sorghum extracts.
    - a. Investigate the solvent factor on concentration of physiological activities in sorghum to select the best solvent for extraction.
    - b. Investigate the variety factor on concentration of physiological activities in sorghum to select one or two varieties of sorghum.
    - c. Investigate the extraction and processing condition to obtain sorghum extract with strong antioxidant activities.
  3. Investigation on stability of sorghum extracts in various conditions.

# RESULTS

1) Optimization of extraction efficiency to maximize the amounts and types of phytonutrients from sorghum, and to create a few product prototypes.

This objective includes the following steps:

- a. Investigate the solvent factor on concentration of phytonutrients in sorghum to select the best solvent for extraction.
- b. Investigate the variety factor on concentration of phytonutrients in sorghum to select one or two varieties of sorghum.

TABLE 1. EXTRACT SOLVENTS USED IN STUDY

SOLVENT CODE	EXTRACTION SOLVENT
A	1% HCl in MeOH
B	0.5% HOAc in EtOH
C	5% Citric Acid in 70% EtOH
D	70% EtOH
E	1% HCl in EtOH
F	70% Acetone 29.5% HOAc 0.5% water

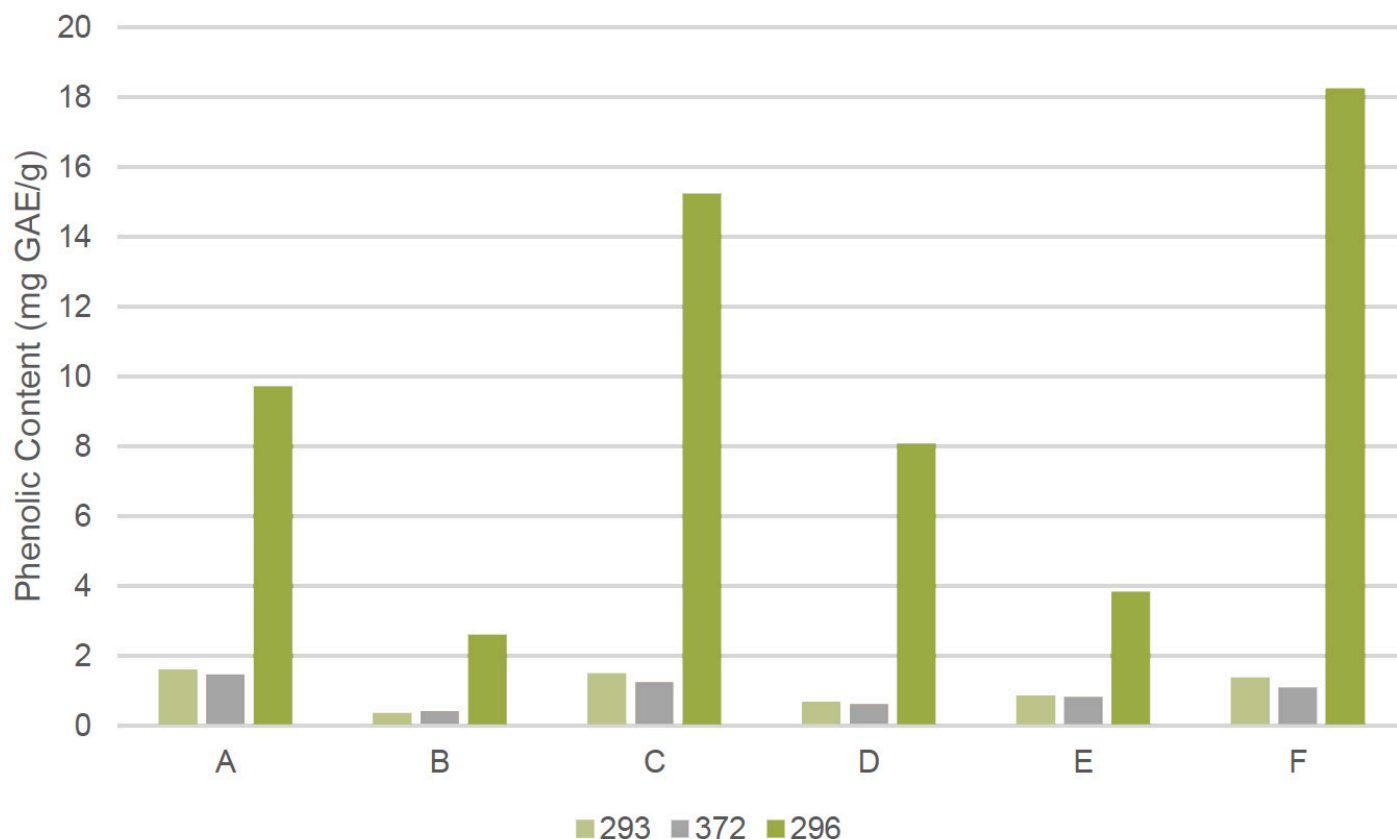
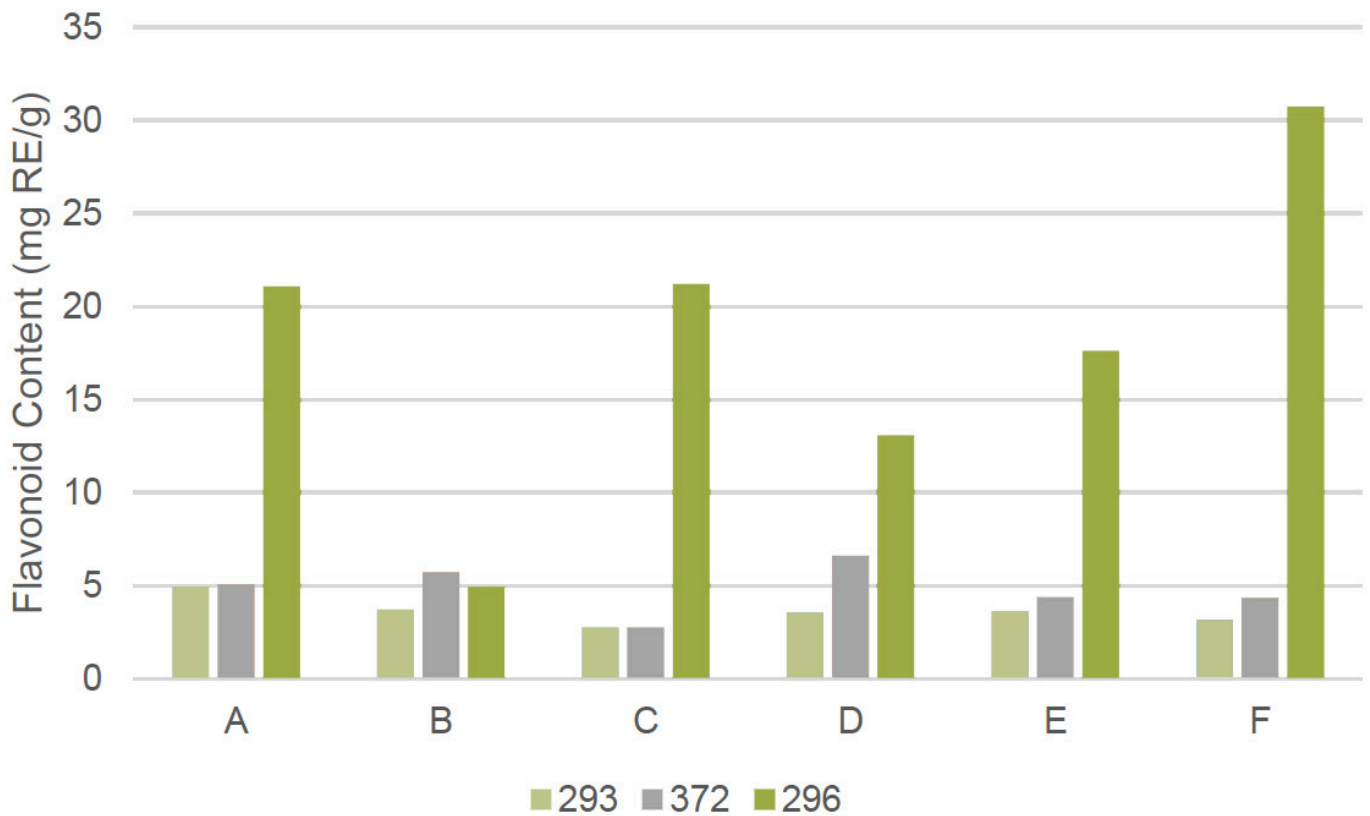
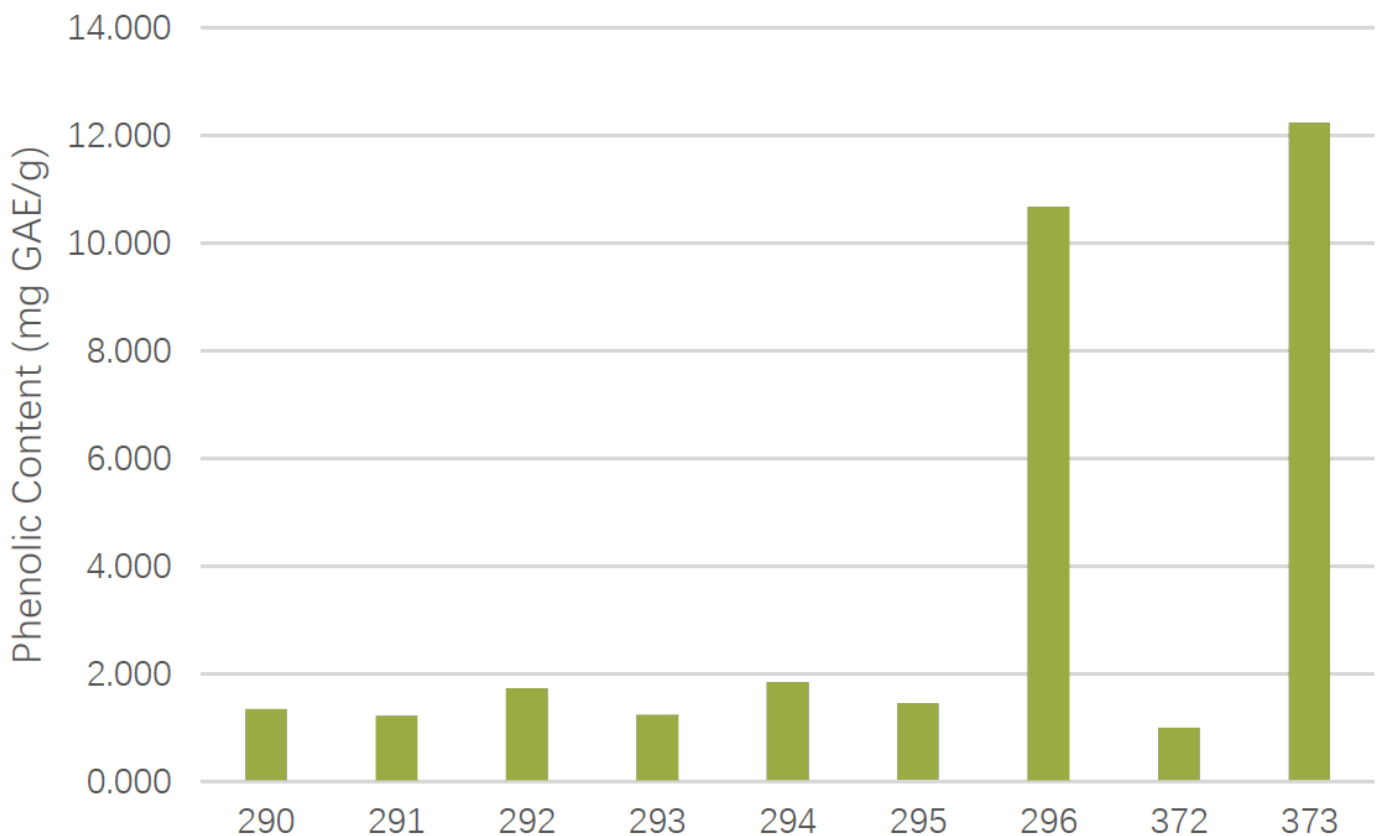


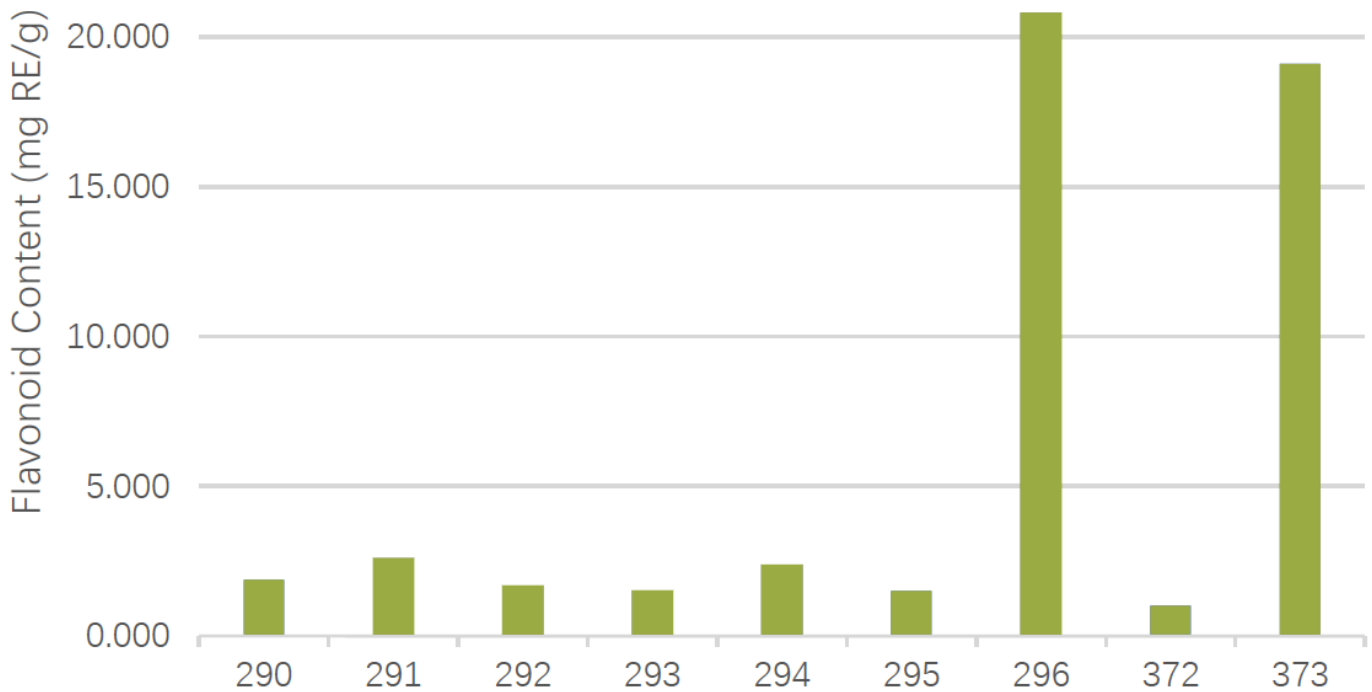
Figure 1. Phenolic content of variety coded 293, 296 and 372 extracted in six different solvent systems (A-E). Solvent C had the best efficiency, followed by F.



**Figure 2.** Flavonoid content of variety coded 293, 372 and 296 extracted in six different solvent systems (A-F). Solvent F was most efficient in extracting flavonoid in 372, while solvent A was best of all solvents when extracting variety 293. Overall, solvent A, C and F were efficient on flavonoid extraction.



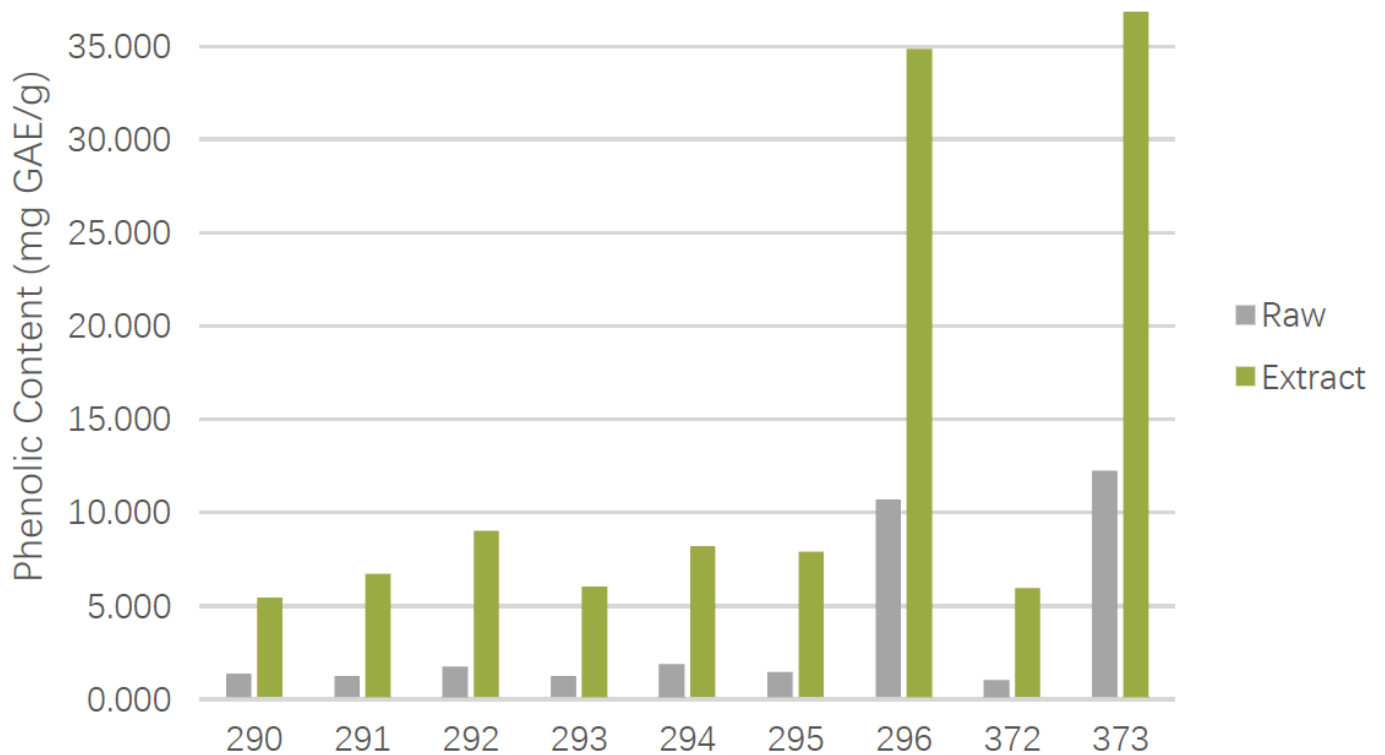
**Figure 3.** Phenolic content of different varieties of sorghum extracted with solvent C. Variety coded 373 had the highest concentration of phenolics, followed by 296.



**Figure 4.** Flavonoid content of different varieties of sorghum extracted with solvent C. Variety coded 296 had the highest concentration of flavonoids, followed by 373.

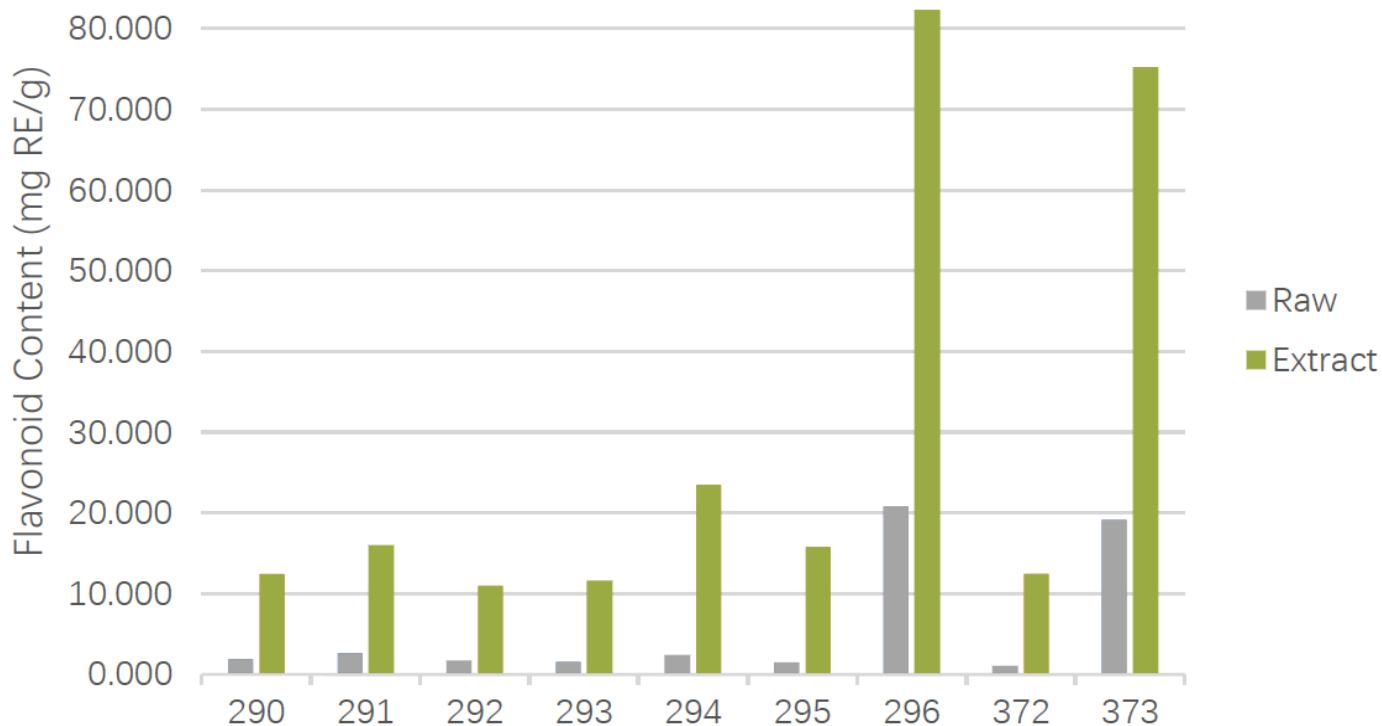
c. Investigate the extraction and processing condition to obtain sorghum extract with concentrated phytonutrients.

Initial concentration of the sample extracts to obtain dry powders by nitrogen evaporation and lyophilization was not successful due to high sugar content. Subsequent isolation and purification was achieved by Amberlite XAD-2 resin.



**Figure 5.** Phenolic content of different varieties of sorghum before and after extraction. Extraction and processing were able to increase the concentration of phenolics up to six times. Variety coded 373 had the highest concentration of phenolics, followed by 296.





**Figure 6.** Flavonoid content of different varieties of sorghum before and after extraction. Extraction and processing were able to increase the concentration of flavonoids up to 12 times. Variety coded 296 had the highest concentration of flavonoids, followed by 373.

2. Measurements of physiological activities of sorghum extracts.

- a. Investigate the solvent factor on concentration of physiological activities in sorghum to select the best solvent for extraction.

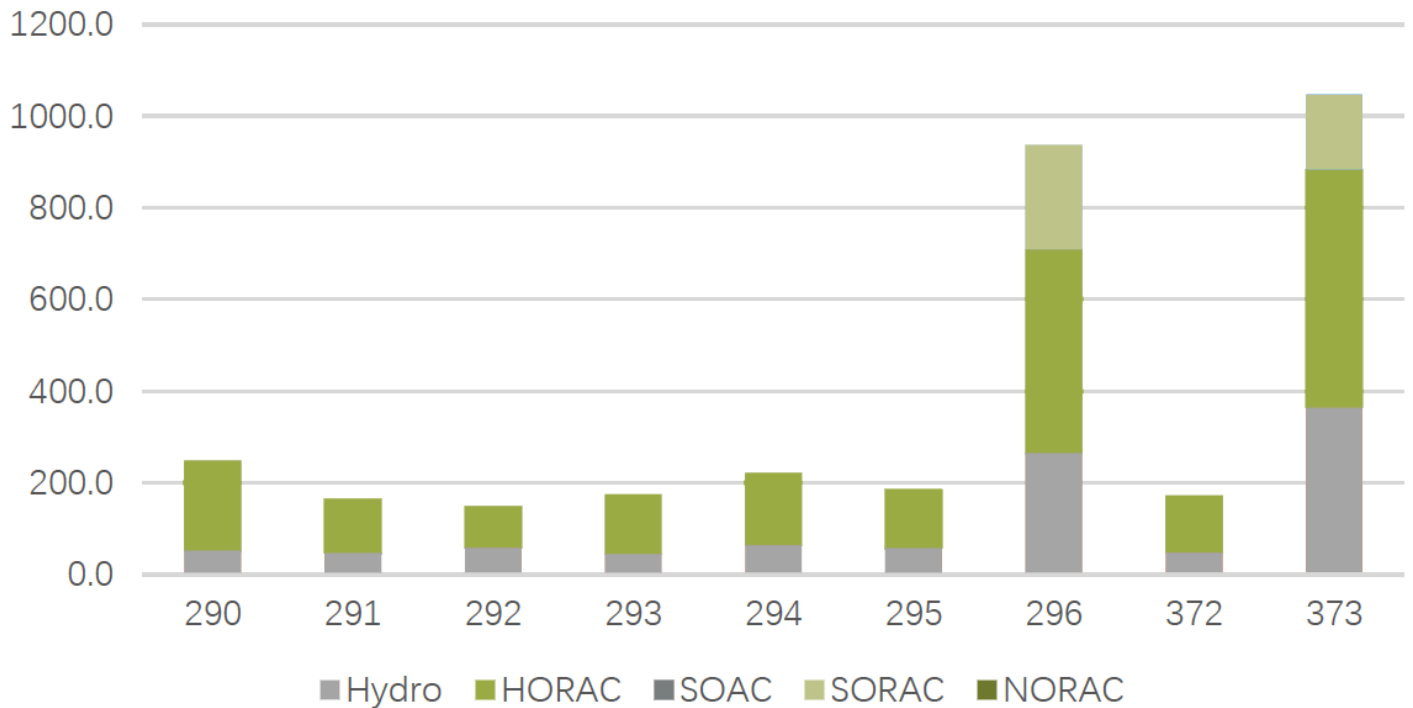
**TABLE 2. ANTIOXIDANT CAPACITIES OF VARIETY CODED 293, 372, 296 EXTRACTED IN 6 DIFFERENT SOLVENT SYSTEMS (A-F).**

	Solvent	Hydro	HORAC	NORAC	S-ORAC	SOAC	NaOCl	Total ORAC
293	A	34.56	28.3	14	N.D.	135.6	61.1	262.4
	B	25.26	9.19	1.07	N.D.	N.D.	47.5	83.02
	C	43.79	62.83	4.69	93.15	N.D.	73.94	278.4
	D	46.88	33.29	2.02	N.D.	N.D.	60.79	142.98
	E	24.52	12	1.51	N.D.	N.D.	N.D.	38.03
	F	43	33	3.76	N.D.	N.D.	114.9	194.66
296	A	86	155	15.39	134.71	438.71	452.96	1282.77
	B	271	49.76	3.54	79.72	N.D.	122.71	526.73
	C	160	241.71	16.08	271.09	1764	575.27	3028.15
	D	135.32	73	4.8	70.04	N.D.	105.38	388.54
	E	132.05	104.43	14.16	156.97	192.84	283.26	883.71
	F	262	244	7.25	74.48	N.D.	160.14	747.87
372	A	28	19.19	3.01	N.D.	152.64	46.67	249.51
	B	43.51	6.16	1.73	N.D.	N.D.	65.31	116.71
	C	34	58.68	4.9	104.97	N.D.	56.29	258.84
	D	35	26.85	4.26	N.D.	N.D.	83.03	149.14
	E	23.05	6.52	1.82	N.D.	N.D.	N.D.	31.39
	F	39.71	28	3.22	N.D.	N.D.	98.88	169.81

Similar to phytonutrients' data, samples in solvent C had the best antioxidant potency in all three varieties.

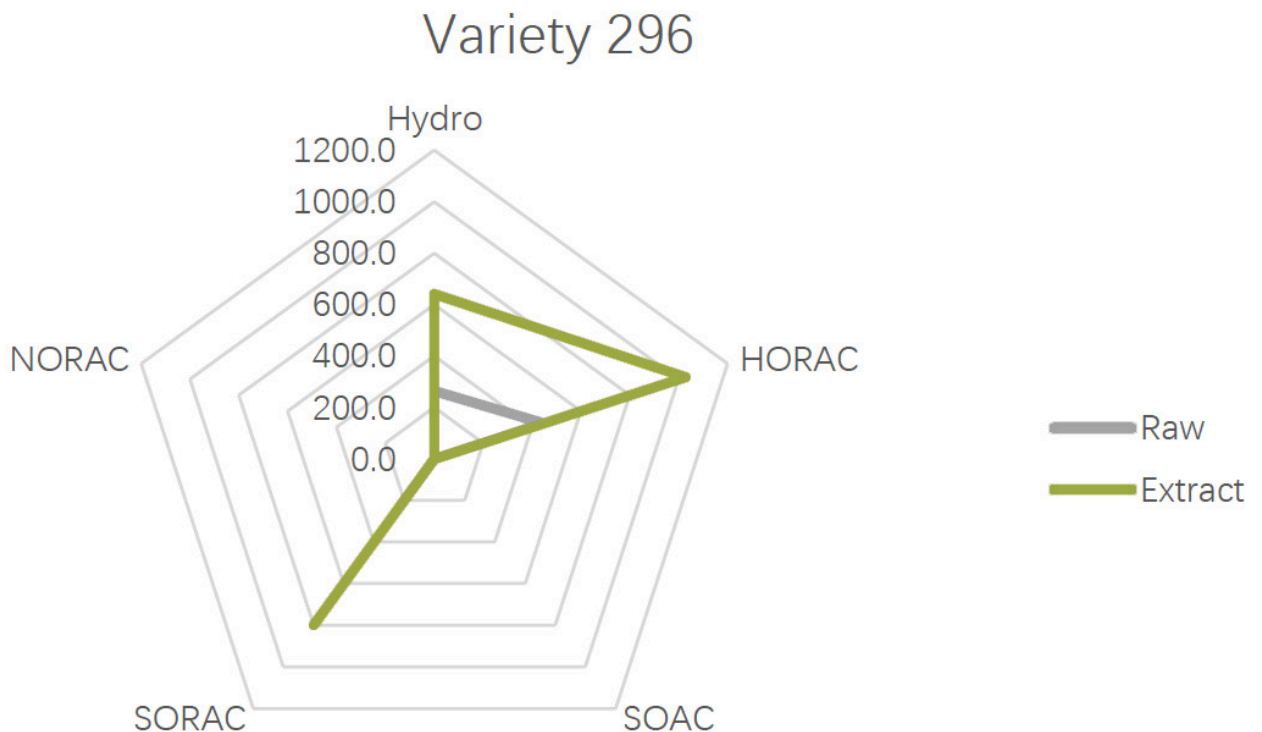
b. Investigate the variety factor on concentration of physiological activities in sorghum to select one or two varieties of sorghum.

## Antioxidant Activity

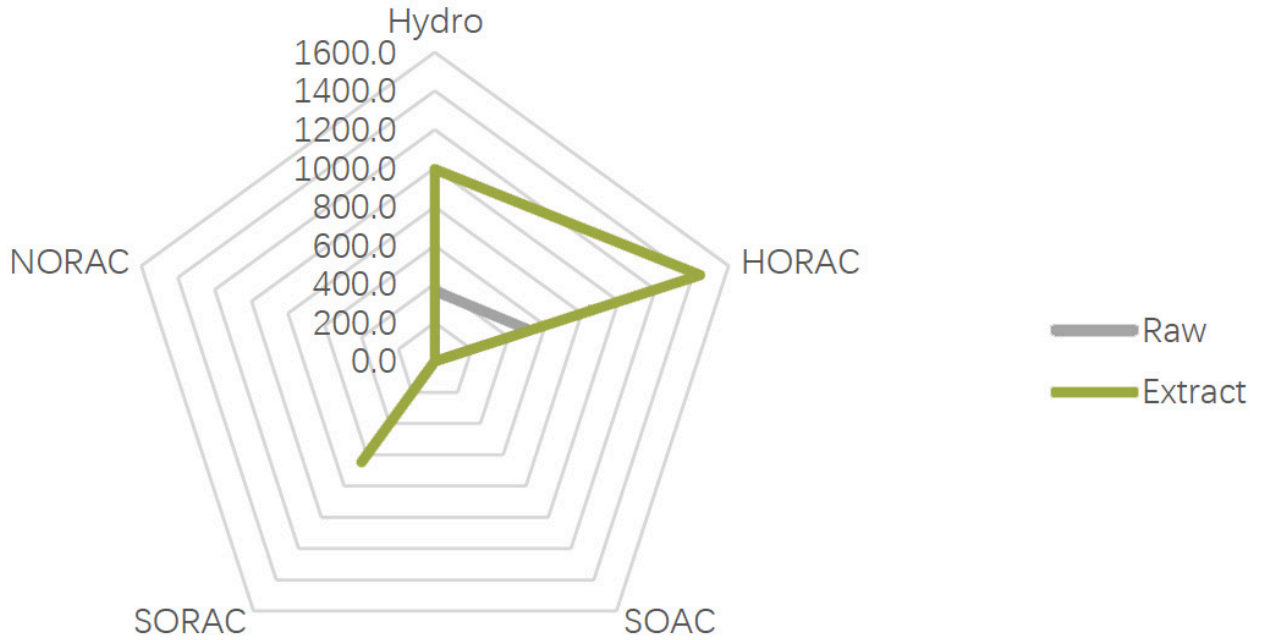


**Figure 7.** Antioxidant capacities of different varieties of sorghum. Variety coded 373 had the highest overall antioxidant capacities, followed by 296. Variety coded 296 on the other hand, had superior capacity against SORAC radicals.

c. Investigate the extraction and processing condition to obtain sorghum extract with strong antioxidant activities.



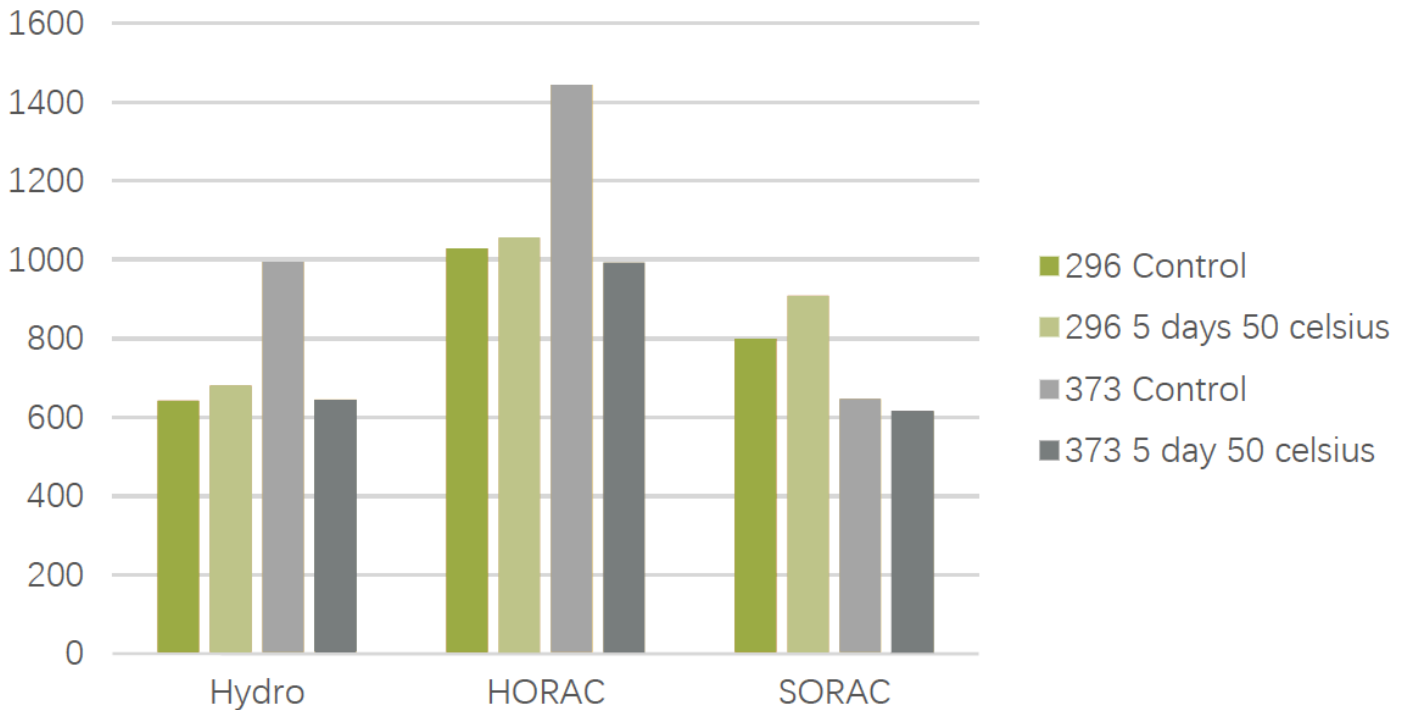
## Variety 373



**Figure 8.** Antioxidant capacities of two varieties of sorghum before and after extraction. Significant increase in antioxidant capacities has been seen in this radar chart.

3. Investigation on stability of sorghum extracts in various conditions.

## Shelf Life



**Figure 9.** Shelf life study result for two varieties of sorghum. Variety coded 373 had the higher antioxidant values, however, the antioxidant capacities were not very stable. Variety 296 had the best stability.

## CONCLUSIONS

The current research project met the overall goal of developing sorghum extract products with enriched health beneficial components, enhanced biological activities and a reasonable shelf life. Five percent Citric Acid in 70% EtOH has been selected as the extraction solvent. Variety coded 296 had the highest flavonoid content, antioxidant capacity against SORAC radicals, as well as the best stability on shelf life study. Variety coded 373 had the highest phenolic content, overall antioxidant capacities. Based on the need of desired phytonutrients and physiological activities, one of these two varieties can be used to develop a commercial extract.

The obtained extracts had substantially increased (more than 12 times) phytonutrient levels and antioxidant capacities, proving that the extraction and processing method is feasible to concentrate those health beneficial compounds.

## IMPACT

Although still on a bench-scale development stage, the phytonutrient-concentrated sorghum extracts have shown great potential to be further developed into a variety of food, beverage, dietary supplement or cosmetic products. It has the potential to promote human well-being, beauty and anti-aging through use of the product. It also demonstrates sorghum's health benefits to the public, and the scientific evidence is supporting sorghum can be part of the healthy diet. Growers will be benefited by the increased consumption and sales of sorghum and sorghum-based products.