

# Role of Commodity Boards in Advancing the Understanding of the Health Benefits of Whole Foods

## California Dried Plums

Phyllis E. Bowen, PhD, RD

Food and agriculture commodity boards have become important funders of nutrition research. There are benefits and cautions (biases toward health benefits, failure to publish negative results, and aggressive promotion of single studies) for this activity. The California Dried Plum Board, along with other commodity boards, have developed independent Scientific Nutrition Advisory Panels to guide and evaluate the research they fund. In the case of the California Dried Plum Board, this has resulted in research that has distinguished the nature and dose of dried plum and juice to maintain bowel health and opened up a surprising new function for dried plum in the prevention of age-related bone loss. *Nutr Today*. 2017;52(1):19–25

Dietary patterns and whole foods, such as fruits and vegetables, are now recognized for providing health benefits that single ingredients cannot hope to imitate. There has been a lack of published research on whole foods compared with single vitamins such as vitamin E,  $\beta$ -carotene, and others, perhaps because of the difficulty in chemically defining a whole food. To address this problem, agricultural commodity boards have started to fill the breach by funding small studies that clarify chemical composition and explore

**Phyllis E. Bowen, PhD, RD**, is professor emerita of the Department of Kinesiology and Nutrition of the University of Illinois at Chicago. She was a member of the faculty of the Department of Nutrition and Dietetics (now Kinesiology and Nutrition) for 30 years and her areas of research concentration have been the human metabolism of carotenoids and oxidative stress.

The author is a founding member of the Nutrition Advisory Board of the California Dried Plum Board. This article was her suggestion at one of their Board meetings and no remuneration was accepted for this paper. The role of commodity boards in research is the subject of this paper and is clearly described.

Correspondence: Phyllis E. Bowen, PhD, RD, 150 LeMoyné Pkwy, Oak Park, IL 60302 (pbowen@uic.edu).

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possible health benefits of specific foods and their mechanisms of action. These boards range from the 22 national boards recognized by the US Department of Agriculture (USDA) (as part of the 2014 Farm Bill) eligible to propose topics for research that will be cofunded as part of the Agriculture and Food Research Initiative, as well as state commodity boards. California alone has 57 of these, ranging from artichokes to kiwifruit. USDA Cooperative Extension Experiment Stations also have long supported such research. However, suspicion is cast on such research because of its self-serving nature, such as the well-known tendency for negative findings to remain unpublished.<sup>1</sup> This concern was addressed in an editorial by Marion Nestle in *JAMA Internal Medicine*. She conducted her own study to explore industry influence on scientific findings and found that, between March and October 2015, she identified industry-funded studies, of which 70 reported results favorable to the sponsor's interest.<sup>2</sup> On the other hand, the developing literature on publication bias (especially by industry funded studies, mostly drug trials) finds little bias in the published studies using industry funding.<sup>3,4</sup> However, the promotional arms of food merchandisers also put out overreaching press releases based upon a single small positive study. The public is left with a dizzying array of “wonder foods” and little inclination to delve deeper. The hypervigilant consumer stocks his/her larder and gathers recipes for the latest fad food while most people ignore the “wonder-press” as too good to be true. Can commodity boards play a role in moving nutrition science forward and providing responsible and practical information to the public? Commodity boards are included in what is called the private sector in the formation of public-private partnerships (PPPs) for food and nutrition research. The Interagency Committee for Human Nutrition Research of the US federal government (USDA, Centers for Disease Control and Prevention, Food and Drug Administration [FDA], and National Institutes of Health) convened a working meeting in 2014 and invited numerous health-related scientific societies/organizations and industry scientists. The purpose was to discuss and revise 12 previously published guidelines to ensure integrity in the conduct of food and nutrition research

collaborations among public, nonprofit, and private sectors and “to maximize research opportunities addressed collaboratively.” These formalized partnerships, PPPs, were “reserved for specific applications of the private sector working with government agencies, generally with multiple partners.” Some of the guidelines are instructive for the smaller collaborations that occur between university-based researchers and commodity boards. These include (1) defined and achievable goals to benefit the public, (2) defined rules on accountability, transparency, and mutual respect, (3) appropriate levels of bargaining power (eg, publication of results), (4) mutually agreed-upon long-term sharing of data, and (5) established ongoing and transparent communication among partners and the public.<sup>5</sup>

## **CALIFORNIA DRIED PLUM BOARD AS AN EXAMPLE OF INDUSTRY/ACADEMIC PARTNERSHIP**

This article explores how these goals have been implemented through the research program of 1 small commodity board, the California Dried Plum Board (CDPB). The CDPB obtains funds for research through a grower’s check-off program, which supports a limited number of projects on dried plums (also known as prunes) based on sufficient resources. My role as a founding member of the Nutrition Advisory Panel (NAP) of CDPB may serve as an instructive example of responsible scientific partnership between academically based scientists (public) and commodity boards (private).

The NAP was established in 1999, in partial response to advice given to the CDPB who had joined the University of Illinois Functional Foods for Health Program.\* The CDPB was receiving proposals, in abstract form, from various university-based researchers to use prunes (the FDA approval to also use the term *dried plums* came in 2001) in their dietary fiber research. Functional Foods for Health Program professors quickly saw that the CDPB had no framework for making decisions as to what to fund. We suggested that they develop a panel of independent scientists that could evaluate research proposals, determine future direction for research efforts, and evaluate research results for efficacy and worthiness for public relations efforts. In return, these scientists would receive a small honorarium for their efforts.

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\*The Functional Foods for Health Program was a joint program between the Chicago and Urbana campuses of the University of Illinois that brought faculty and students from a variety of disciplines and industrial affiliates together for scientific meetings that included guest speakers and poster sessions and discussion groups. I was a founding member and I was the first Chicago campus faculty leader. At its peak, it had over 100 faculty and 35 industrial affiliates.

Currently, the NAP is composed of academic scientists with particular expertise in gastroenterology, oxidative stress, immunology, bone and energy metabolism, as well as health promotion to the public. These scientists are not now actively engaged in research using dried plums; however, a few have received grant funding in the past.<sup>†</sup> Our work consists of determining the most productive avenues of inquiry, issuing requests for proposals in particular areas of interest, evaluating research proposals, and suggesting further measurements to researchers with the goal of publication in respected scientific journals. The vision is to establish promising areas where dried plums (prunes) may improve human health and to draw additional researchers and funding sources to the effort. The CDPB also provided dried plum powder for animal studies upon request. Over the years, we have followed a number of leads: oxidative stress, cancer, heart disease, bone metabolism, and intestinal health. Two areas of research appear most promising. They are intestinal health and bone health.

## **NUTRIENT AND BIOACTIVE COMPOUNDS IN DRIED PLUMS AND PRUNE JUICE**

Before launching into these findings, it is appropriate to share what we know about the chemical composition of dried plums. The NAP advised the need for 2 extensive reviews of the literature (1 at the outset<sup>6</sup> and 1 as an update<sup>7</sup>) of what was known of dried plum nutrient content and their health benefits. Dried plum is made from a special plum (*Prunus domestica* L cv d’Agen) that can fully ripen on the tree without fermenting and has a sugar content that prevents it from molding during the drying process. The fresh prune plum or sugar plum is slightly smaller than the more common varieties of fresh plums and has a lovely purple skin. It is rarely found in supermarkets or is in limited supply at farmer’s markets. Table 1 provides the highlights of dried plum nutrient content compared with their dietary reference intake (DRI), and Table 2 lists notable phenolic compounds thought to provide antioxidant properties and may be bioactive in bone and intestinal health.

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*Dried plums have a high antioxidant capacity due to high phenolic content.*

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†The CDPB has written guidelines on treatment of applications for funds from current NAP board members. The same criteria are used for evaluation as any other proposal and board members may not be present during evaluation nor may they communicate with current board members concerning their proposal. This also covers submissions of protégés or colleagues of the proposal-submitting board member. This governing document is signed by all members of board each time the NAP convenes.

**TABLE 1 Major Nutrients in Dried Plums and Juice and Percentage of DRI/Serving**

Nutrient	Dried Plums		Prune Juice	
	Content	% DRI	Content	% DRI
Serving, g	47.7 (~5 dried plums)		256 (~1 c)	
Moisture, g	14.7		208.0	
Energy, kcal	114		182	
Total CHO, g	30.3		44.7	
Glucose, g	25.5		14.1	
Fructose, g	5.9		20.2	
Sucrose, g	0.1		0.5	
Sorbitol, g	5.7		15.4	
Inositol, g	0.9		1.8	
Starch, g	2.4		–	
Total dietary fiber, g	3.4	18.7%	2.6	6.8%
Insoluble fiber, g	1.5		1.3	
Soluble fiber, g	1.9		1.3	
Pectin, g	1.1		–	
Protein, g	1.0		1.6	
Fat, g	0.2	0.1		
Vitamin K, mg	348	15.6%	707	15.0%
Vitamin K <sub>1</sub> , µg	28.3	49.6%	8.7	7.3%
Riboflavin, mg	0.1	14.3%	0.2	13.8%
Niacin, mg	0.9	11.8%	2.0	12.6%
Vitamin B <sub>6</sub> , mg	0.1	12.1%	0.6	32.8%
Fe, mg	0.4	5.2%	3.0	16.8%
Mg, mg	19.0	9.8%	36.0	8.6%
Cu, mg	0.13	31.2%	0.2	19.3%
Mn, mg	0.14	13.0%	0.4	16.8%
Boron, mg	1.1	100% <sup>a</sup>	0.6	52% <sup>a</sup>

No DRI: Based upon mean intake of US population. Derived from tables in Stacewicz-Sapuntzakis.<sup>6</sup>

Abbreviations: CHO, carbohydrates; DRI, dietary reference intake.

<sup>a</sup>No established DRI. Value is based on mean intake of US population.

A serving of dried plum (~5 plums/50 g) offers a complex of nutrients and other compounds, many of which provide more than 10% of the DRI. Especially notable are dietary fiber, vitamin K, copper, and boron. Its complex sugar

content with high amounts of sorbitol is probably the reason that its glycemic index (29 for a 60-g serving) is so low for such a sweet food.<sup>7</sup> Dried plums have a high antioxidant capacity compared to other fruits, dried or

**TABLE 2 Antioxidant Compounds and Major Secondary Metabolites in Dried Plums and Prune Juice**

	Dried Plum	Prune Juice
Serving size	100 g (~11 dried plums)	100 g (>1/3 cup)
Total carotenoids, mg	0.43	–
Total chlorogenic acids, mg	108–153	19–102
Neochlorogenic acid, mg	91–133	56
Cryptochlorogenic acid, mg	31–51	38
Chlorogenic acid, mg	7–10	8
Galic acid, mg	2	–
Caffeic acid, mg	2.6	–
Proanthocyanidins, mg	62	–
Cyanidin, mg	0–2.4	–
Delphinidin, mg	0–0.2	–
Quercetin, mg	0–4.0	–
Ascorbic acid, mg	0.3	10.5 <sup>a</sup>
Vitamin E, mg	0.2	0.3

From Stacewicz-Sapuntzakis.<sup>7</sup>  
<sup>a</sup>Ascorbic acid is added to prune juice.

not, depending upon the assay used. The low values of carotenoids, ascorbic acid, and vitamin E point to their high content of phenolic compounds as the contributing factor. Yet their phenolic content cannot explain all of their antioxidant capacity.

## TWO AREAS OF INVESTIGATION THAT HAVE BEEN A FOCUS OF CDPB FUNDING

The NAP recommended to the CDPB that they focus on particular areas of research and seek to develop the science in those areas. In retrospect, 2 areas have received the most intense funding. Gastrointestinal (GI) health, for obvious reasons, and bone health, which became an important area serendipitously. These studies are reviewed here with the objective that the reader sees the progression and type of studies funded, how other investigators not funded by CDPB become interested, and how paying close attention to the type of study needed as evidence leads to an official health claim.

### GI Effects

Dried plums/prunes have been the subject of many a joke, especially in the United States. Seeking to reposition the fruit away from the jokes and to younger consumers, the

CDPB applied to the FDA for a formal name change to dried plum in 2001, which was approved. Surprisingly little research has been published on the effect of dried plum or prune juice on GI function. There are 3 components of dried plum that could affect GI motility: sorbitol, dietary fiber, and phenolic compounds. The sorbitol content of dried plum (10–12 g/100 g or 2 servings) is uniquely high and is equivalent to consuming 12 sticks of sugarless gum or individual candies that can act as an osmotic laxative in high quantities.<sup>8</sup> Whether one is affected by consuming high levels of sorbitol is highly variable and seems to be related to the ability to absorb it. Breath hydrogen studies indicated that 71% of healthy adults showed malabsorption after consuming 10 g of sorbitol and 20% reported symptoms of bloating, flatulence, and abdominal pain.<sup>9</sup> However, a dose of pure sorbitol would enter the lower GI tract at a faster rate than found in an equivalent dose of whole dried plums.<sup>‡</sup> Those with irritable bowel syndrome have a greater likelihood of having a lower absorption potential.<sup>8</sup> Phenolic compounds are also thought to have an effect on GI motility.<sup>6</sup>

‡Sorbitol has Generally Recognized As Safe (GRAS) status and GRAS sets limits for percent that can be contained in specific food items but does not set a human limit. Very old references from 2 small studies find that ~20 g of pure sorbitol can produce diarrhea.

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## *High sorbitol content is likely reason for dried plum stool softening effect.*

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The CDPB funded a number of human studies that evaluated bowel habit with dried plum supplementation at various doses. With these data in hand, the CDPB applied for a health claim to the European Safety Authority.<sup>10</sup> After weighing the evidence on these studies and plausible mechanisms, the European Food Safety Authority stated “on the basis of the data presented, the Panel concludes that a cause and effect relationship has been established between consumption of dried plums of ‘prune’ cultivars (*Prunus domestica* L.) and maintenance of normal bowel function. In order to obtain the claimed effect, about 100 g (or about 2 US servings) of dried plums (prunes) should be consumed daily. The target population is the general population.”<sup>10</sup>

### **Details of Studies**

Most of the following studies were funded by CDPB but not all of them. Subjects (41 men with mild hypercholesterolemia or 40 chronically constipated men and women) consumed 12 dried plums a day for 8 and 3 weeks, respectively, in the 2 crossover studies. Psyllium was used as the control in the second study. There was a notable lack of adverse GI effects and no increase in the number of bowel movements or decreased transit time. However, stools were softer and there was an increase in fecal weight.<sup>11,12</sup> The study by Attaluri et al was the most impressive (not funded by CDPB). Forty constipated subjects consumed either 100 g (10–12) dried plums or 22 g of psyllium for 3 weeks in a crossover design with a 1-week washout. The number of complete spontaneous bowel movements per week and stool consistency scores improved significantly compared with psyllium.<sup>12</sup> A 3-month study of 58 postmenopausal women (38 completers) randomized to consume 100 g (10–12) of dried plum or 75 g of dried apple (1.2 g sorbitol/100 g fresh apple) not on hormone therapy (bone health the major outcome) was also submitted to the European Food Safety Authority. Both groups experienced the same mean number of spontaneous bowel movements with the sensation of complete evacuation.<sup>13</sup> Another study of 29 women consumed 84 g of dried plum or low-fat cookies for 2 weeks each in a crossover design. Notable was that during the dried plum intervention, subjects reported significantly softer stools.<sup>14</sup> A more extensive study of bowel health was subsequently funded by the CDPB in the United Kingdom. A total of 120 healthy subjects were randomized to control or 80 or 120 g of dried plum per day; 14 GI symptoms were tracked over the 4-week period. Of the 104 subjects completing the study, for both doses, dried plum significantly

increased stool weight and bowel movements but did not affect transit time. There was no reported diarrhea, but incidence of flatulence and/or reflux was higher in the dried plum groups compared with controls, but symptoms were rare and rated mild.<sup>15</sup>

We are beginning to explore the question, could dried plum consumption lower the risk of colon cancer by promoting a microbial population favorable to its prevention? We also would like to determine whether 1 serving (5 prunes) would also contribute to bowel health.

### **Bone Health**

Exploring the role of dried plum on bone health seems to be an improbable leap. However, the scientific process is often serendipitous and personal. As I took on the role as NAP member for the CDPB, I noticed that dried plum had an unusually high boron content. I remembered that boron had been associated with strengthening bones in some early animal studies. A young faculty member, Bahram Arjmandi, in my department at the University of Illinois at Chicago had a model for ovariectomized animals to simulate osteoporosis, so I suggested that he put in a proposal to study dried plums with his animal model. The NAP advised the CDPB that the proposal was low cost and scientifically worthwhile and CDPB funded the animal project although there was no previous evidence of a dried plum bone connection. To Arjmandi’s surprise and ours, the dried plum-treated ovariectomized rats (a good model for postmenopausal osteoporosis) experienced less bone loss than their counterparts.<sup>16</sup> Since that first experiment, a number of animal studies using various models of bone loss have been performed funded by the CDPB (as reviewed<sup>17</sup>). Previous bone loss was somewhat restored in the femur and tibia at a low dose of 5% dried plum powder (w/w), but it took a 25% dose to improve lumbar vertebra. Immobilization leads to bone loss and a dried plum diet performed as well as parathyroid hormone injections to restore bone during the reambulation period in bone mineral density (BMD), bone strength and bone structure. A study in a rat male model of osteoporosis found that feeding 15% and 25% of the diet as dried plum powder (w/w) for 90 days postcastration prevented loss of BMD, whereas the 5% diet was effective only for the lumbar vertebra and femur. Again, male rats allowed to lose bone after castration showed reversal of that loss with either 25% dried plum or parathyroid hormone. Most interesting was a long-term study where adult (6 months) and old (18 months) mice were fed calorically adjusted diets of 15% and 25% dried plum (w/w) for 6 months. On the 25% diet, bone volume increased 50% in the adults and 40% in the old mice but the control groups lost 24% and 28% of their bone mass, respectively. The most recent study used lower doses (5%, 15%, and 25% w/w) of dried plum in growing mice and found increased cancellous bone of 12%, 36%, and 64%,

respectively.<sup>18</sup> These investigators observed the dried plum appears to disrupt the balance between resorption and formation with a net effect of more bone and this might be due to a suppression of proinflammatory cytokines.

Some of these studies have been funded by the CDPB and others have not. Almost all of them have used dried plum powder fed at 25% of the diet (w/w), a much higher dose than would be reasonable for human beings. Since these initial studies, efforts to find mechanism and the components of dried plum that are bioactive have led to understanding that dried plum phenolics are not the sole component<sup>19</sup> and that dried plum has unique properties compared with other dried fruits.<sup>20</sup>

Three human trials have been performed. Three months of 100 g of dried plums a day (10–12 dried plums) improved the biomarkers of bone formation in postmenopausal women.<sup>21</sup> A 12-month study showed that the same dose could prevent the normal loss of BMD in postmenopausal women. Dried apple had little effect. Both groups were supplemented with calcium and vitamin D.<sup>22</sup> The third study assigned 48 osteopenic women to 6 months of either 50, 100, or 0 g of dried plums per day. All were supplemented with calcium and vitamin D. Both doses of dried plum preserved BMD compared with the normal loss experienced by the control group. Bone resorption appeared to be inhibited.<sup>23</sup> The GI complaints of subjects were minimal in these studies. One study was funded by USDA, and the other 2, by CDPB. Because we want to be sure of the dried plum effect in humans, we have decided to fund a larger clinical trial by a different set of investigators, using a standard serving size (4–5 dried plums) and higher dose (10–12 dried plums) to characterize the effects on bone mass in this older population of women.

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### *Human studies also show dried plum reduces bone loss.*

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The most interesting effect of a dried plum diet was recently published. Bone loss caused by ionizing radiation is a health concern for radiotherapy patients, radiation workers, and astronauts. Animals exposed to such radiation experience skeletal damage and an imbalance between bone building and bone loss. They rapidly lose bone mass. Mice were divided into groups and given a selection of antioxidant and anti-inflammatory candidates (antioxidant cocktail, dihydropyridic acid, ibuprofen, or dried plum 25% diet w/w). Various groups were exposed to gamma rays or simulated space radiation. Dried plum was the most effective in reducing expression of genes related to bone resorption and the prevention of cancellous bone loss. The authors concluded that “dietary supplementation

with dried plum may prevent the skeletal effects of radiation exposures either in space or on Earth.”<sup>24</sup>

The effect of whole dried plum on various dynamics of bone growth and resorption is certainly intriguing and worthy of further research and holds great promise as a dietary component that may promote bone health, not only in the elderly but throughout the life cycle.

## **CONCLUSION**

The experience of scientists with the CDPB may be informative in how such commodity boards listen to scientific panels and determine how to fund and promote scientific studies. Although there are grounds for concern when commodity boards and self-interested groups fund and then promote research that benefits the marketing of their products, great gains can be made with industry/academic partnerships that aid health and well-being. (1) Young faculty may find financial support for their first projects which then form the preliminary studies that aid in successful applications for National Institutes of Health or USDA grants. (2) Studies using whole foods are more difficult to control because of their variable and complex composition. Commodity board funding is essential to clarify the epidemiological findings that point to single foods or food groups as beneficial. (3) All academic institutions decline to enter into financial obligations with industry sponsors that do not allow their faculty to publish results from industry-sponsored research. Investigators are free to publish negative results. (4) The existence of independent scientific panels who direct the research programs of commodity boards is essential to guide commodity boards in the efficient and ethical use of funds set aside for research.

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## LESS THAN ONE-QUARTER OF US CHILDREN MEET PHYSICAL ACTIVITY GUIDELINES

Three-quarters of children in the United States currently fail to meet physical activity recommendations, putting them at an increased risk for future obesity, diabetes, and related chronic illness, according to a recent report issued by researchers from Louisiana State University’s Pennington Biomedical Research Center and health experts from across the country, assembled by the National Physical Activity Plan Alliance (NPAPA). The 2016 US Report Card on Physical Activity for Children and Youth shows that only 22% of children aged 6 to 19 years meet US physical activity guidelines. Furthermore, nearly 63% of children are exceeding sedentary behavior guidelines, which suggest no more than 2 hours of screen time per day. Less than 13% of children walk or ride their bike to school, a habit that has been associated with lower odds of obesity among children. The good news is that the report does show an improvement in the number of youth who are participating on at least 1 sports team—half of America’s children—since the 1970s, but there is still a significant gender gap with more boys participating than girls. Health professionals agree that physical activity plays a major role in promoting child health. The World Health Organization and the US Department of Health and Human Services recommend that children and adolescents engage in a minimum of 60 minutes of moderate to vigorous physical activity daily, including vigorous-intensity activity at least 3 days per week. Each organization involved in supporting the National Physical Activity Plan has already made a commitment to take substantial steps toward encouraging greater physical activity for US children and is trying to galvanize other organizations to take action. The 4 key messages and recommendations to increase physical activity included in the report were the following:

- Schools should work to increase physical activity opportunities among youth and should be a key part of a national strategy to increase physical activity.
- Preschool and childcare centers should enhance physical activity.
- Changes involving the built environment (such as safe outdoor and indoor recreation spaces) and similar sectors are promising but need additional work.
- Key research gaps in advancing efforts to increase physical activity among youth should be addressed.

The Report Card assessed data from multiple nationally representative surveys to evaluate levels of physical activity and sedentary behavior in American children and youth, facilitators and barriers for physical activity, and health outcomes related to physical activity, among 10 key indicators: overall physical activity levels, sedentary behaviors, active transportation, organized sport participation, active play, health-related fitness, family and peers, schools, community and the built environment, and government strategies and investments. The 2016 US Report Card is the second comprehensive assessment of physical activity in US children and youth, updating the first Report Card released in 2014. The US Report Card produced by the NPAPA US Report Card Research Advisory Committee can be downloaded from the NPAPA Web site at [www.physicalactivityplan.org](http://www.physicalactivityplan.org). Further information about the international release of the Report Card can be obtained from the Active Healthy Kids Global Alliance Web site ([www.activehealthykids.org](http://www.activehealthykids.org)).

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