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Grape antioxidant dietary fibre
A natural food additive and a dietary supplement

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ABSTRACT: Dietary fibre and antioxidants, particularly phenolic compounds, are natural constituents of plant foods which have shown several properties as food additives and as health-promoting agents. Grape Antioxidant Dietary Fibre (GADF) is a natural constituent obtained from red grape pomace, which combines in a single product a high content of DF and phenolic compounds. Addition of GADF to cooked chicken hamburgers significantly improved the oxidative stability and the free radicals scavenging activity. Similarly, white grape antioxidant pomace delayed lipid oxidation in minced fish muscle during three months of frozen storage. GADF has also shown in studies in rats and humans different health-promoting effects in relation to cardiovascular disease, antioxidant status and colonic health. Further research is needed to consider the possible synergistic effects that may take place in natural products rich in both DF and phenolic compounds, as well as their potential to be used as natural additives and/or as dietary supplements.

Keywords: antioxidant dietary fibre, dietary fibre, polyphenols, grape, food additive, dietary supplement.

CHARACTERISTICS OF GRAPE ANTIOXIDANT DIETARY FIBRE

Dietary fibre (DF) and natural antioxidants are two dietary factors involved in health-promoting. Natural antioxidants, and particularly phenolic compounds, have the capacity to act as powerful antioxidant by scavenging free radicals and terminating oxidative reactions (1, 2) and these properties have led to propose their use as useful natural food preservatives (3) as well as have related them with the prevention of several chronic diseases (4). On the other hand, DF has been considered as a functional ingredient, because of their healthy effects (5, 6). The inclusion of DF in food products improves texture, increases fat binding and the cooking yield, due to water-holding. Also, it improves physicochemical and sensory properties in processed foods (7). Grape pomace is a natural antioxidant obtained from concentrate of grape seeds, stems and peels, a wine by-product that accounts about the 20 percent of the weight of the grape processed into wine (8). Grape Antioxidant Dietary Fibre (GADF) is a natural product that combines high amounts of DF and phenolic antioxidants obtained by a patent procedure (9) from red grape pomace (*Vitis vinifera*, var Cencibel). Also, White Grape Antioxidant Pomace (WGAP) has been obtained from white grape (*Vitis vinifera*, var. Airén, Spain) pomace from wine production. The proximate composition of either GADF or WGAP might change slightly due to the vintage. DF and phenolic compounds are the main components of GADF and WGAP (Table 1). It is worth noting that the soluble DF content of both is relatively high. Polyphenols of both products are usually named extractable polyphenols, that is, phenolic compounds that can be extracted from the food matrix by aqueous-organic solvents and, from a physiological point of view, could be absorbed through the gastrointestinal tract. In WGAP the content of extractable polyphenols is of 7.85 percent and in GADF of 4.93 percent. In GADF these extractable polyphenols belong mainly to the groups of catechins (46.8 percent), benzoic acids (16 percent), flavonols (14 percent) and anthocyanidins (16.2 percent) (12). However, extractable polyphenols are only a 21 percent of total polyphenols in GADF, since the rest are non-extractable polyphenols (hydrolysable tannins and condensed tannins), compounds associated with the DF matrix and that, although not available in the gastrointestinal tract, when reaching the colon may be fermented by the colonic micro flora, releasing substances with specific health-related properties (13) Overall, this composition confers appreciable nutritional properties to the whole.

	GADF [a]	WGAP [b]
Protein	11.08 ± 0.46	7.31 ± 0.2
Fat	7.69 ± 0.49	5.50 ± 0.1
Ash	5.25 ± 0.19	3.50 ± 0.2
Fibre [c]		
Soluble DF	15.53 ± 0.11	23.01 ± 0.1
Insoluble DF	62.07 ± 3.01	53.36 ± 1.3
Polyphenols		
Extractable polyphenols	4.93 ± 0.03	7.85 ± 0.3
Condensed tannins	14.81 ± 0.19	nd
Hydrolizable tannins	2.70 ± 0.19	nd
Antioxidant capacity (*µmoL Trolox/g dm*)		
ABTS[b,d]	124.4 ± 0.3	284 ± 24
FRAP[d]		466 ± 43
ORAC[b]	214.2 ± 38	

[a] Ref. 10 [b] Ref. 11, [c] Residual polyphenolic contents may be included in this value. [d] Ref. 12

Table 1. Proximate composition of Grape antioxidant Dietary Fibre and White Grape Antioxidant Pomace (g / 100g dry matter).

USE OF GRAPE ANTIOXIDANT DIETARY FIBRE IN FOOD SYSTEMS

Antioxidant additives are added to fresh and further processed meats (poultry, fish, beef, pig, etc) to prevent oxidative rancidity, retard development of off-flavours

and improve colour stability (14). Synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been used to control lipid oxidation in meat. However, the use of these synthetic antioxidants is restricted in some countries because of their toxic or carcinogenic effects (15). The use of natural preservatives to increase the shelf life of meat products is a promising technology since many vegetal substances have antioxidant and antimicrobial properties.

GADF was used successfully in chicken breast hamburgers. Efficiency of two concentrations (1 and 2 percent) of GADF on susceptibility to lipid oxidation was investigated after 13 days of refrigerated storage at 4ºC. Addition of GADF significantly improved the oxidative stability and the radical scavenging activity in raw and cooked chicken hamburgers. The ability of GADF to prevent lipid oxidation was concentration-dependent. Acceptability of chicken meat was not affected by the addition of GADF (10). Similarly, WGAP (2 and 4 percent) delayed lipid oxidation in minced fish muscle during three months of frozen storage. TBA-index was lower in samples added with WGADF than control. Lipid oxidation and antioxidant capacity at 4 percent level was not significantly different than 2 percent for long term storage (15). WGAP was used on restructured fish products at two levels (2 y 4 percent). The lipid oxidation was inhibited in WGAP added samples being higher in vacuum-packing. The antioxidant capacity was lower during the long term storage (11).

The mechanism of the protective effect on lipid oxidation may be due the presence in GADF of a number of oligomer procyanidins such as catechin and epicatechin, compounds for which such an activity has been described (1) .The susceptibility of lipids in tissues to peroxidation depends on the proportion of PUFA's in lipid bilayers, the amount of reactive oxygen species produced, and the level of antioxidants of endogenous or nutritional origin. In both cases, phenols stabilized hydroperoxides preventing further degradation to more active oxidizing forms, such malonaldehyde (17).

GRAPE ANTIOXIDANT DIETARY FIBRE AS DIETARY SUPPLEMENT

There is growing scientific evidence that a sufficient daily intake of DF produces significant effects in the prevention of chronic diseases. Numerous clinical and epidemiological studies have addressed the role of DF in intestinal health, prevention of cardiovascular disease and cancer, obesity, and diabetes (5, 6). However, since the intake of DF in Western countries -around 20-g/person day- (18) is lower than the dietary recommendations -25 to 30 g/ day- (19), DF has been commonly added during last years to several foodstuffs as a functional ingredient and has also been included in several dietary supplements. Similarly, recent studies support the hypothesis that dietary antioxidants may be a critical mediator of the lower mortality associated with healthy diets such as the Mediterranean dietary pattern (4, 20-22), what has increased the research on natural antioxidants with possible health effects.

GADF has been tested as a possible dietary supplement in studies developed both in animals and in humans. Table 2 shows a summary of the observed effects in these studies. Unlike other dietary supplements, GADF combines naturally, as described above, DF and antioxidants in a single matrix, what may provide it specific healthy properties.

Studies in rats

The possible cholesterol-lowering effects of GADF were evaluated in rats fed either with a cholesterol-free diet or with a cholesterol-added diet (to induce hypercholesterolemia). A significant decrease in total and LDL cholesterol was observed in those rats fed with a cholesterol-added diet (23-24).

These reported effects would be due to a combined action of DF and polyphenols, having been described several hypocholesterolemic mechanisms for both. For DF, these mechanisms would imply a reduction in the absorption of triglycerides in the large intestine, an increase in the synthesis and excretion of bile acids, an inhibition of the synthesis of cholesterol by short-chain fatty acids generated during fermentation and modifications in the metabolism of lipoproteins through an increase in the amount of hepatic receptors of LDLs (25-28). Regarding polyphenols, a possible modifying effect of the lipoproteins metabolism through a hepatic removal of cholesterol, as well as an increase in faecal excretion of cholesterol, bile acids and other dietary lipids have been described as their main mechanisms of action in relation to lipid profile (29-31). An increase in fat excretion was actually observed in rats supplemented with GADF (24).

Another preventive effect of GADF would be related to its action on colonic epithelium. The preventive role of DF on colorectal cancer has been widely described (32), but also polyphenols, in particular high molecular weight proanthocyanidins, which, as described above, are the major fraction of polyphenols in GADF, could play a similar role. These compounds would reach the colon intact, where they would be subjected by colonic micro flora to fermentation, giving place to absorbable metabolites (phenyl acetic, phenylpropionic, urolithin, etc) that may exert systemic effects (11). Also, non-absorbable metabolites and non-fermented antioxidants remain in the colonic lumen where they can provide an antioxidant environment that counteracts dietary pro-oxidants. In this way, rats supplemented with GADF exhibited shorter crypts than those non-supplemented and GADF showed an antiproliferative capacity in their colonic epithelium through a decrease in the total number of crypts per millilitre (33). Similarly, a higher caecal antioxidant capacity was found in rats supplemented with GADF in relation to those non-supplemented (34), what may be relevant for colonic health, since a more oxidant status in the colon has been observed in colorectal cancer patients (35). Further research is needed to establish properly the possible beneficial effects of GADF on colonic health, as well as its mechanisms of action.

Studies in humans

GADF was recently tested as a dietary supplement in effects in 43 normo- and hypercholesterolemic subjects (12), whose introduced in their usual diet 7.5 g/day of GADF for 3.5 months. Confirming results in rats, a significant reduction in total cholesterol and non significant reductions in LDL cholesterol and plasma triglycerides, took place in the supplemented group. Moreover, when the supplemented group was divided according to the initial concentration of plasma cholesterol, the decrease in these three parameters became significant in hypercholesterolemic subjects (with reductions of 14.2 percent, 11.6 percent and 18.2 percent, respectively).

GADF also had an effect on blood pressure, reducing significantly both systolic and diastolic pressures. This effect observed in subjects mostly normotensive should be confirmed in other studies with hypertensive subjects. The stimulation of the release of nitric oxide –with vasorelaxing and anti-aggregating properties- by the vascular endothelium observed after the intake of grape juice by humans (36) and the inhibition of the absorption of sodium ion in the large intestine after the supplementation of rats with psyllium, a soluble DF (37) have been suggested as the mechanisms by which polyphenols and DF, respectively, would exert their hypotensive effect.

This beneficial effect of GADF on cardiovascular disease risk factors would be due to a combined effect of DF and polyphenols. Although, as stated before, a major fraction of polyphenols in GADF would not be directly absorbable through the gut and could only exert their action after colonic fermentation, a fraction of polyphenols in GADF would be absorbed in the gastrointestinal tract, as shown by an increase in plasma antioxidant capacity (sum of the effects of all antioxidant substances present in plasma) after the intake of GADF, an increase that did not take place in a control group (38). Authors hypothesized that this combined action would explain the fact that the effects achieved by GADF in the reduction of total cholesterol, LDL cholesterol and blood pressure in humans were more pronounced than those attributed to different DF in several meta-analysis of the published clinical trials.

Parameters	Rats	Humans
Cardiovascular disease	Decrease in total cholesterol in rats fed a cholesterol-added diet Decrease in LDL cholesterol in rats fed a cholesterol-added diet	Decrease in total cholesterol in normo- and hypercholesterolemic subjects Decrease in blood pressure Decrease in LDL cholesterol in hypercholesterolemic subjects Decrease in triglycerides in hypercholesterolemic subjects Decrease in percentage body fat in females
Antioxidant status	Increase in caecal antioxidant capacity	Increase in plasma antioxidant capacity after an acute intake
Colonic health	Shorter colonic crypts Decrease in the total number of crypts per millilitre	Increase in the number of stool deposition per day

Table 2. Summary of effects observed after supplementation to rats with GADF and after the intake of GADF by humans.

CONCLUSIONS

GADF is a natural product containing high concentrations of both dietary fibre and phenolic compounds. It has shown promising resutls as food additve, preventing lipid oxidation in chicken hamburgers Similarly, white grape antioxiant pomace delayed lipid oxidation in minced fish muscle during three months of frozen storage. GADF has also shown a potential as dietary supplement; in studies in ratas and in humans a significant improvement of plasma lipid profile took place. A hypotensive effect was also observed in humans supplemented with GADF.

Further research is needed to consider the possible synergistic effects that may take place in natural products rich in both DF and phenolic compounds, as well as their potential to be used as natural additives and/or as dietary supplements.

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