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REVIEW

Histamine intolerance and dietary management: A complete review

I. San Mauro Martin*, S. Brachero, E. Garicano Vilar

* Corresponding author.
E-mail address: research@grupocinusa.com
(I. San Mauro Martin).

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Table 1 Comparison between reviews, table compilations and proposals of histamine content in food for the general population and food analytical studies and laboratory analysis.

Food group	Food	Food composition table, food analytical study and laboratory analysis			Compilations of laboratory analysis		Reviews, table compilations and proposals of content in food for the general population								
		Ref. 19,20	Ref. 21	Ref. 13	Ref. 22	Ref. 23	Ref. 24	Ref. 18	Ref. 25	Ref. 26	Ref. 7	Ref. 27	Ref. 28	Ref. 29	Ref. 30
Cereal and tuber	Barley											X (red)			X (green)
	Buckwheat											X (yellow)			X (green)
	Corn						X (green)					X (red)	X (green)		X (red)
	Malt						X (yellow)								X (green)
	Potato						X (green)						X (green)		X (green)
	Rice					X (green)	X (green)								X (green)
	Wheat					X (green)	X (yellow)	X (red)				X (red)			X (green)
	Yeast						X (red)	X (red)				X (yellow)	X (red)	X (red)	
Fruit	Avocado				X (yellow)	X (red)	X (red)			X (red)		X (yellow)	X (red)	X (red)	X (red)
	Banana				X (yellow)		X (red)					X (yellow)	X (red)		X (yellow)
	Cherry												X (green)	X (red)	X (red)
	Coconut												X (red)	X (red)	X (yellow)
	Dried figs											X (red)	X (red)		X (red)
	Grapefruit				X (red)							X (yellow)	X (green)		X (red)
	Guava						X (red)								X (green)
	Kiwi	X (green)			X (red)		X (red)	X (red)				X (yellow)	X (yellow)	X (red)	X (red)
	Lemon						X (red)	X (red)				X (yellow)	X (red)		X (red)
	Mandarin				X (red)								X (red)		X (red)
	Mango											X (red)			X (red)
	Olives					X (green)	X (red)					X (yellow)	X (yellow)	X (red)	X (red)
	Orange				X (red)		X (red)					X (green)	X (yellow)		X (red)
	Papaya				X (yellow)		X (red)	X (red)				X (yellow)	X (yellow)		X (red)
	Pear						X (red)					X (red)	X (green)		X (green)
	Pineapple				X (red)		X (red)	X (red)				X (yellow)	X (red)	X (red)	X (red)
	Plum							X (red)				X (yellow)	X (red)	X (red)	X (red)
	Raspberry						X (red)					X (yellow)	X (red)		X (red)
	Strawberry				X (yellow)		X (red)	X (red)				X (yellow)	X (green)	X (red)	X (green)
Vegetable	Broccoli												X (yellow)		X (red)
	Cabbage									X (red)		X (red)	X (green)		X (green)
	Capsicum												X (green)	X (red)	
	Cauliflower												X (yellow)		X (red)
	Cucumber				X (yellow)							X (yellow)	X (green)		X (green)
	Eggplant			X (green)	X (yellow)	X (red)	X (red)			X (red)		X (yellow)	X (red)	X (red)	X (red)
	Green peas		X (green)									X (red)	X (green)		X (green)
	Leek											X (red)			X (green)
	Mushroom					X (green)	X (red)					X (red)	X (red)	X (red)	X (red)
	Onion											X (red)	X (green)	X (red)	
	Pickle											X (yellow)	X (yellow)	X (red)	X (red)
	Sauerkraut			X (green)	X (red)	X (red)	X (red)	X (red)		X (red)		X (green)	X (red)	X (red)	X (red)
	Spinach	X (red)	X (green)	X (green)	X (yellow)	X (red)	X (red)					X (yellow)	X (red)	X (red)	X (red)
	Tomato				X (yellow)		X (red)	X (red)		X (red)		X (yellow)	X (red)	X (red)	X (red)
	Turnip greens											X (red)	X (green)		X (green)
	Zucchini				X (yellow)								X (green)		X (green)
Dairy	Acidified whey						X (yellow)					X (red)			
	Butter				X (yellow)		X (green)	X (green)							X (green)
	Cheese (fresh)				X (green)		X (green)						X (green)		X (green)
	Cheese (semi/hard)				X (red)	X (red)	X (red)	X (red)		X (red)					
	Cheese Brie										X (green)	X (yellow)	X (red)	X (red)	X (red)
	Cheese Camembert			X (green)					X (yellow)		X (yellow)	X (yellow)	X (red)	X (red)	X (red)
	Cheese Cheddar	X (red)		X (green)					X (yellow)	X (red)	X (red)	X (yellow)	X (red)		X (red)
	Cheese Edam										X (yellow)		X (red)		
	Cheese Emmental			X (green)		X (red)			X (green)				X (green)		
	Cheese Feta						X (yellow)			X (red)					X (red)
	Cheese Gouda			X (green)					X (yellow)		X (yellow)		X (green)		
	Cheese Gruyere								X (yellow)			X (green)	X (green)		
	Cheese Parmesan			X (green)								X (green)	X (red)	X (red)	X (red)
	Cheese Raclette									X (red)		X (yellow)			
	Cheese Roquefort								X (yellow)	X (red)		x (green)	X (red)		
	Cheese Swiss	X (red)		X (green)							X (red)	X (green)	X (red)		X (red)
	Milk (fresh)				X (red)	X (red)	X (green)			X (green)			X (green)		X (green)
	Milk (pasteurised)					X (red)	X (green)	X (green)	X (green)				X (green)		
	Milk - Coconut							X (green)							X (red)
	Yoghurt				X (red)	X (yellow)	X (yellow)	X (yellow)		X (yellow)		X (red)	X (green)	X (red)	X (green)
Legume	Beans					X (yellow)	X (red)	X (red)				X (yellow)		X (red)	X (green)
	Chickpeas					X (yellow)	X (red)	X (red)				X (yellow)			X (green)
	Lentils					X (yellow)	X (red)	X (red)				X (yellow)			X (green)
	Soya beans											X (yellow)			X (green)
Fish	Canned anchovies				X (red)	X (red)	X (red)						X (red)	X (red)	X (red)
	Canned tuna	X (green)			X (red)		X (red)				X (green)		X (red)	X (red)	X (red)
	Crab									X (red)					X (green)
	Fresh blue				X (yellow)	X (yellow)	X (yellow)	X (green)							X (yellow)
	Fresh white				X (green)	X (red)	X (yellow)	X (green)		X (green)					X (green)
	Frozen blue				X (yellow)		X (green)						X (red)		X (red)

Table 1 (*Continued*)

	Frozen white				X (green)	X (red)	X (green)			X (green)		X (red)		X (red)
	Oysters									X (red)				X (green)
	Prawns									X (red)			X (red)	X (red)
	Shellfish				X (red)		X (red)	X (red)		X (red)				
	Smoked salmon/fish				X (red)		X (red)			X (red)		X (red)	X (red)	X (red)
	Tuna									X (red)		X (yellow)	X (red)	X (yellow)
Meat	Bacon										X (green)	X (yellow)	X (red)	
	Chicken							X (green)		X (green)		X (green)		X (green)
	Cold meat				X (red)	X (red)	X (red)	X (red)						X (red)
	Duck									X (green)				X (yellow)
	Fresh meat				X (green)	X (green)	X (green)			X (green)		X (green)		X (green)
	Ham (cooked)			X (green)	X (yellow)	X (green)	X (red)	X (red)		X (red)	X (red)	X (red)	X (red)	X (red)
	Ham (Iberic)				X (yellow)		X (red)			X (red)	X (red)	X (red)		
	Rabbit										X (red)	X (green)		X (green)
	Salami			X (green)						X (red)	X (green)	X (red)	X (red)	X (red)
	Sausage	X (green)		X (green)		X (red)	X (red)	X (red)	X (red)	X (red)		X (red)	X (red)	X (red)
	Smoked meat									X (red)		X (red)	X (red)	X (red)
	Turkey				X (yellow)		X (red)			X (green)		X (green)		X (red)
Egg	Cooked egg (white)				X (yellow)		X (green)				X (yellow)			
	Raw egg (white)				X (red)		X (green)	X (red)						
	Yolk				X (green)		X (green)	X (green)				X (green)		X (green)
Nuts	Almond											X (green)	X (red)	X (red)
	Dried fruit and nuts				X (red)		X (red)	X (red)					X (red)	
	Peanut										X (yellow)	X (red)		
	Pistachio										X (red)	X (green)		
	Poppy										X (red)			X (green)
	Sesame seeds											X (yellow)	X (red)	X (red)
	Sunflower seeds										X (yellow)	X (yellow)		
Fats	Coconut oil				X (green)		X (green)							X (red)
	Margarine				X (green)		X (green)							X (red)
	Olive oil				X (green)		X (green)							X (red)
Sweets	Chocolate (milk/dark)	X (green)				X (green)	X (red)	X (red)			X (red)	X (red)	X (red)	X (red)
	Cocoa	X (green)			X (red)		X (red)	X (red)			X (red)	X (red)	X (red)	X (red)
	Honey						X (green)						X (red)	
	Jam				X (yellow)		X (green)				X (yellow)		X (red)	X (red)
Drinks	Coffee						X (green)					X (green)		X (green)
	Cola type drinks											X (red)		X (red)
	Fruit Juices					X (green)					X (red)	X (red)	X (red)	X (red)
	Green tea				X (green)		X (yellow)	X (red)				X (green)		X (green)
	Orange juice				X (yellow)						X (green)	X (red)		X (red)
	Red/Black tea				X (yellow)		X (yellow)	X (red)		X (red)		X (green)		X (green)
	Tomato juice				X (yellow)		X (red)				X (yellow)	X (red)		X (red)
	Vegetable drinks				X (green)									X (red)
Condiments	Baking powder										X (red)			X (green)
	Colorant/Preservative							X (red)						X (red)
	Curry				X (red)						X (yellow)			X (red)
	Ketchup		X (yellow)	X (green)							X (yellow)			X (red)
	Meat extract											X (red)		X (red)
	Mustard				X (red)					X (red)	X (yellow)		X (red)	X (red)
	Soy sauce				X (red)		X (red)					X (red)	X (red)	X (red)
	Tomato sauce		X (green)		X (red)	X (yellow)	X (red)				X (yellow)		X (red)	X (red)
	Vanilla										X (red)			X (green)
	Vinegar (balsamic)				X (red)	X (red)	X (red)			X (red)	X (green)		X (red)	
	Vinegar (white/red wine)			X (green)		X (red)	X (red)	X (red)		X (red)	X (green)	X (red)	X (red)	X (red)

* Red: high/very high (>20 mg/kg); yellow: moderate (5–20 mg/kg); green: low content (<5 mg/kg).

<5 mg/kg (green); moderate content 5–20 mg/kg (yellow); and >20 mg/kg as high content (red).

Results

Search results

A total of 23 references were retrieved in this review. After reading all the sources of information we were led to the exclusion of nine of them for not following the proposed criteria or being duplicated. Thus, only 14 studies were considered legible for review and have been included after a double revision. All studies reviewed have shown low-medium evidence as a whole.

Discussion

We found that histamine and other biogenic amines are present in a vast majority of foods. Available reference sources do not reflect a homogeneous consensus, and the variation between foods makes it impossible for dieticians to accurately estimate amines content to correctly advise patients.[33]

It has been shown how in the reviews, compilation tables and proposals of foods content for the overall population, three different recommendations (in response to high, moderate or low histamine content) were found for the same food. This was the case of strawberries, blue cheese, cooked ham, yoghourt, frozen blue fish or green tea.

It can also be seen, when comparing those compilation tables with laboratory analytical studies, how histamine content recommendations for the same food can be opposed (very high vs. very low content). Foods such as kiwi, spinach, canned tuna, sausages, cocoa and tomato sauce showed this contrast.

It may also occur that even laboratory analytical studies show opposite results, as with spinach, Cheddar and Swiss cheese and ketchup.

Even the European Rapid Alert system for Food and Feed database reports concentration ranges in different sub-samples of the same sample e.g. 50–500 mg/kg, 102–180 mg/kg, 27–152 mg/kg, of 147 mg/kg, below 5–208 and below 10–1000 mg/kg (for fish samples).[4]

Data from outbreaks show big variation in concentrations leading to adverse effects in the consumer. These uncertainties may lead either to an underestimation of the adverse effect to occur in sensitive people or to an overestimation of the risk in healthy people due to biogenic amines, since only the risk assessment of the individual biogenic amines is feasible at the moment.[4]

That situation can lead patients to assume erroneous or insufficiently verified information, and generates incomplete or ineffective treatments. This becomes disturbing when two-thirds of those using the internet to find health information claim it has some impact on their healthcare decisions,[34] and when searchers assure the internet information they obtain is, in most cases, trustworthy.[35]

The majority of health-related Internet searches by patients are for specific medical conditions.[36] Many concerns have been raised about the quality of online consumer health information, and the possibility that poor information has detrimental effects on health. A systematic review of 79 studies investigating the quality of online health information revealed that the methodology and rigour of these studies varies widely, as do the findings.[37] The information is often incomplete and sometimes inaccurate, although good quality material can be found.

Therefore, instructing patients with histamine intolerance, DAO deficit and mast cell diseases to limit their intake of histamine and other amines containing products would seem to be a reasonable recommendation. However, following such a recommendation will be challenging for several reasons. First, simply knowing that a product contains histamine or other amines does not allow an accurate estimate of its content. Second, ingredient lists are generally not present on fast food items, making it difficult to identify the

Table 2 Reviews, table compilations and proposals of other amines content in food for the general population.

Food group	Food	[25]		[7]	[28]	[31]	[26]	[30]	[32]	[29]
		Triptamine	Tiramine	Tiramine						
Cereal and tuber	Alfalfa					X (red)		X (green)		
	Kumara					X (yellow)		X (green)		
	Potato	0			X (green)	X (yellow)		X (green)		
Fruit	Apple	0.53			X (green)	X (yellow)	X (green)			
	Apricot				X (green)	X (red)		X (green)		
	Avocado		2.3		X (red)	X (red)		X (red)	X (red)	
	Banana	1.13	0.7		X (red)	X (red)	X (red)	X (yellow)	X (green)	
	Blackcurrant				X (green)	X (red)		X (red)		
	Cherry				X (green)	X (red)		X (red)		
	Coconut				X (red)			X (red)	X (yellow)	
	Dates				X (yellow)	X (red)		X (red)	X (red)	
	Dried figs				X (red)	X (red)		X (red)	X (yellow)	
	Grapefruit				X (green)	X (red)	X (red)	X (red)		
	Grapes				X (red)	X (red)		X (red)	X (red)	
	Kiwi				X (yellow)	X (red)		X (red)	X (red)	
	Lemon				X (red)	X (red)	X (red)	X (red)	X (yellow)	
	Mandarin				X (red)	X (red)		X (red)		
	Olives				X (yellow)	X (red)		X (red)	X (red)	X (red)
	Orange	0.1	1		X (yellow)	X (red)	X (red)	X (red)	X (red)	
	Papaya				X (yellow)	X (red)	X (red)	X (red)	X (green)	
	Passionfruit				X (yellow)	X (red)		X (red)	X (red)	
	Peach				X (green)	X (red)		X (green)		
	Pear				X (green)	X (yellow)	X (red)	X (green)		
	Persimmon					X (red)		X (green)		
	Pineapple	0.62			X (red)	X (red)	X (red)	X (red)	X (red)	
	Pomegranate	0.47				X (red)		X (green)		
	Plum				X (red)	X (red)		X (red)		
	Raspberry		5		X (red)	X (red)		X (red)		
	Rhubarb				X (green)	X (red)		X (green)		
	Rockmelon				X (green)	X (red)		X (green)		
	Strawberry	0.47			X (green)	X (red)	X (red)	X (green)		
Vegetables	Asparagus				X (green)	X (yellow)		X (green)		
	Broccoli				X (yellow)	X (red)		X (red)	X (yellow)	
	Cabbage	0.77			X (green)	X (green)		X (green)		
	Carrot	1.58			X (green)	X (yellow)				
	Cauliflower	1.98			X (yellow)	X (red)		X (red)	X (yellow)	
	Cucumber	1.28			X (green)	X (yellow)		X (green)		
	Eggplant				X (red)	X (red)		X (red)	X (red)	X (red)
	Green peas				X (green)	X (yellow)		X (green)		
	Lettuce				X (green)	X (yellow)		X (green)		
	Marrow					X (yellow)		X (green)		
	Mushroom					X (red)	X (yellow)	X (red)	X (yellow)	
	Onion	0.92			X (green)	X (red)				

Table 2 (*Continued*)

	Pickle				X (yellow)	X (red)		X (red)		
	Sauerkraut		2		X (red)	X (red)		X (red)		
	Spinach				X (red)	X (red)		X (red)	X (yellow)	
	Tomato	0.93	0.4		X (red)	X (red)				
	Turnip greens	2.12			X (green)	X (yellow)		X (green)		
	Zucchini				X (green)	X (yellow)		X (green)		
Dairy	Cheese Brie		26	39.8	X (red)			X (red)		X (red)
	Cheese Camembert	2	12	Trace	X (red)			X (red)		X (red)
	Cheese Cheddar	0.1	21-27	24-108.	X (red)		X (red)	X (red)		
	Cheese Edam	8	31	Trace	X (red)					
	Cheese Gouda	7	29	29	X (green)					
	Cheese Limburger	16	12		X (red)					
	Cheese Roquefort	20	36		X (red)		X (red)			
	Cheese Swiss	19	41		X (red)			X (red)		
	Mozzarella	10	16		X (red)					
	Yoghurt		0.13		X (green)			X (green)		
Legume	Broad beans					X (red)		X (red)	X (red)	
	Tofu/Tempeh				X (green)			X (yellow)		X (red)
Fish	Canned tuna	0.1	0		X (red)			X (red)		
	Fresh white				X (green)		X (green)	X (green)		
	Frozen				X (red)		X (green)	X (red)		
	Sardine				X (red)			X (red)		
	Smoked salmon/fish				X (red)			X (red)		X (red)
	Tuna				X (yellow)		X (red)	X (yellow)		X (red)
Meat	Bacon				X (red)					X (red)
	Ham (cooked)						X (red)	X (red)		X (red)
	Pork (fresh/untreated)				X (red)			X (red)		
	Sausages	36	12		X (red)			X (red)		
	Turkey				X (yellow)			X (red)		
Nuts	Almonds				X (green)			X (red)	X (red)	
	Cashew nuts				X (green)		X (yellow)	X (green)		
	Macadamia nuts				X (green)			X (red)	X (yellow)	
	Peanut				X (red)			X (red)	X (yellow)	
	Pecan				X (red)			X (red)		
	Pine nuts				X (green)			X (red)	X (yellow)	
	Pistachios				X (green)			X (red)	X (yellow)	
	Sesame seeds				X (yellow)			X (red)	X (yellow)	
	Sunflower seeds				X (yellow)			X (red)	X (yellow)	
	Walnut				X (yellow)		X (red)	X (red)	X (yellow)	
Sweets	Chocolate (dark)		0.07			X (red)	X (red)	X (red)		X (red)
	Cocoa				X (red)		X (red)		X (green)	
	Maple syrup				X (green)			X (green)		
	Sugar				X (green)			X (green)		
Drinks	Coffee				X (green)			X (green)		
	Cola type drinks				X (red)			X (red)		
	Pear juice					X (red)		X (green)		
	Tomato juice				X (red)	X (red)		X (red)	X (red)	X (red)
	Vegetable drinks				X (red)	X (red)		X (red)		
Condiments	Basil					X (red)		X (green)		
	Soy		0.18		X (red)			X (red)	X (green)	X (red)
	Vinegar (white/red wine)				X (red)			X (red)		

* Content (mg/kg).
* Red: high/very high; yellow: moderate; green: low content.

presence of amines. Third, amine-free products may require more effort to identify.[33]

To achieve the goal of collecting reliable information, all the methods and tools should be standardised.[38] Standardisation is a *sine qua non* of information pooling. However, scientific, and other constraints make it difficult to impose uniform procedures across studies.[39] In this case, each assessed nutrient must be defined in the same way, the units of measurement must be comparable, and the methods used to assess nutrient value must be the same or comparable.[38] It is important to recognise that it is not always necessary to use precisely the same methods and tools for data collection in order to achieve valid data integration across studies. Rather, what is crucial is that the information conveyed by each data set is 'inferentially equivalent'.[39]

Nutrient values in the food composition databases must be updated frequently and new foods and recipes need to be added promptly so that the results are precise and accurate also over time.[38] We recommend that manufacturers analyse their products for amines content and make these data available for incorporation into nutrient databases. Food manufacturers should also lower amines content of popular products. We also recommend that policymakers mandate that amines content of foods be included on the

Table 3 Foods excluded from Tables 1 and 2.

	Two green recommendations	Two yellow or red recommendations	One green and one yellow/red recommendations
Food excluded from Table 1	Apricot, Peach, Asparagus, Carrot, Celery, Lettuce, Rice milk, Soy milk, Lamb, Sunflower oil, Sweetener, Pepper.	Bread crumbs/cubes, Dates, Grapes, Lime, Passion fruit, Cream Tilsit, Sour cream, Yoghurt (fruit), Broad beans, Surimi, Calf liver, Chicken liver, Duck liver, Foie gras, Pork (fresh/untreated), Venison, Viscera, Hazelnut, Almond oil, Avocado oil, Peanut butter, Sesame oil, Walnut oil, Chocolate (white), Energetic drinks, Flavour enhancer, Ginger, Miso.	Rye, Pumpkin, Cream, Yoghurt (soy/rice), Split peas, Tofu/Tempeh, Sardine, Frozen meat, Cashew nuts, Caramels, Maple syrup, Lemonade.
Food excluded from Table 2	Barley, Rice, Chayote (choko), Bamboo shoots, Brussel sprouts, Celery, Chives, Garlic, Leek, Shallot, Swede, Cheese (fresh), Cheese Emmental, Milk, Sour cream, Beans, Mung Bean sprouts, Soya beans, Beef, Lamb, Rabbit, Veal, Cooked egg (white), Yolk, Green tea,	Corn, Lime, Arugula, Radicchio, Truffles, Cheese Feta, Cheese Fontina, Cheese Muenster, Cheese Parmesan, Cheese Port-Salut, Canned anchovies, Prawns, Surimi, Chicken liver, Offal, Salami, Smoked meat, Hazelnut, Chocolate (milk), Fruit Jam, Orange juice,	Durian, Guava, Longan, Loquat, Lychee, Nectarine, Rambutan, Redcurrant, Starfruit, Watermelon, Artichoke, Beetroot, Bok choy, Capsicum, Endive, Fennel, Parsnip, Pumpkin, Radish, Water chestnut, Watercress, Cheese Gruyere,

Low content <5 mg/kg (green); moderate content 5–20 mg/kg (yellow); and high content >20 mg/kg (red).

nutrition facts label. These actions by manufacturers and policymakers will help patients limit their amines intake, will help providers to better instruct patients, and will help researchers to accurately assess dietary intake.[33]

Conclusion

A valid risk assessment requires data on exposure, and thus on the contents of contaminants in foods. However, these data are highly variable and may significantly differ even within narrowly confined regions. In this regard, more attention should be paid to the preparation, extension and maintenance of food composition databases.

Further studies are necessary to establish safety limits for bioactive amines in food, and the intolerance they may cause.

Ethical disclosures

Confidentiality of data. The authors declare that no patient data appears in this article.

Right to privacy and informed consent. The authors declare that no patient data appears in this article.

Protection of human subjects and animals in research. The authors declare that no experiments were performed on humans or animals for this investigation.

Conflicts of interest and source of funding

The authors have disclosed that they have no significant relationships with, or financial interest in, any commercial companies pertaining to this article.

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