Cooking parameters affect the sodium content of prepared pasta

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ABSTRACT

The quantitative effect of different preparation variables on the sodium content of cooked dry pasta was evaluated. Semolina spaghetti (< 5 mg sodium/100 g) was cooked by a typical method (454 g, 5.68 L water, 36 g salt, al dente, no rinsing) and after systematic variation of amount of salt, water:pasta ratio, cooking volume and time, rinsing, pasta shape, whole grain. Sodium was assayed by ICP-MS, including rigorous quality control. Pasta cooked without salt had < 5 mg sodium/140 g serving, and 247–490 mg/serving when cooked in salted water by the different variations. Rinsing reduced sodium by 34%. There was a linear relationship between salt concentration in cooking water and sodium in cooked pasta; doubling the concentration increased sodium by 243 mg/serving (> 10% of 2300 mg/day), relative to the reference method. No other variables affected sodium. Results allow more accurate estimation of sodium intake from cooked pasta, since food composition tables that do not reflect variations in cooking parameters.

1. Introduction

High sodium intake can have serious health repercussions, including increased risk of hypertension and cardiovascular disease (Mozaffarian, 2016). Cardiovascular disease (CVD) is responsible for approximately 801,000 deaths each year in the U.S. and is the leading cause of death for both men and women (Mozaffarian et al., 2016). Hypertension, defined as blood pressure ≥140 systolic and ≥90 diastolic, has an estimated prevalence of 29% of the adult population based on the 2009–2012 National Health and Nutrition Examination Survey (Jackson, King, Zhao, & Cogswell, 2016). Reducing dietary sodium can improve blood pressure (Cook, Appel, & Whelton, 2016; He & MacGregor, 2002; Strazzullo, D'Elia, Kandala, & Cappuccio, 2009; Vollmer et al., 2001). The Adequate Intake (AI) for sodium for young adults is 1500 mg/d and for older adults (50–70 years old) is 1300 mg/day (Institute of Medicine, 2006), and the American Heart Association Diet and Lifestyle Recommendations, revised in 2006 (Lichtenstein et al., 2006), include limiting sodium intake to 2300 mg/day [equivalent to 6 g salt (~1 tsp)]. The Daily Value for sodium used on food labels in the U.S. is 2300 mg (U.S. Department of Health and Human Services, 2007). However, individuals within the U.S. and other industrialized countries consume 6–12 g of salt per day (Brown, Tzoulaki, Candeias, & Elliott, 2009; Moshfegh et al., 2012).

The predominant sources of dietary sodium include processed foods and salt added during meal preparation and at the table (Anderson et al., 2010; Brown et al., 2009; Moshfegh et al., 2012; Quader et al., 2017; World Health Organisation, 2012). While most natural food sources, including unprocessed fruits and vegetables, meats, dairy products, grains, and legumes are low in sodium (US Department of Agriculture, 2016; World Health Organisation, 2012), the sodium content of these foods increases significantly when salt is added during processing, cooking, preparation, and at the table (Moshfegh et al., 2012). The What We Eat In America (WWEA) National Health and Nutrition Examination Survey (NHANES) has estimated that 11% of sodium intake is from discretionary use of salt during home cooking and at the table (Sebastian, Wilkinson Enns, Steinfeldt, Goldman, & Moshfegh, 2013).

Pasta is a food to which salt is often added during preparation, and it is in the top 12 foods contributing to sodium intake in the home (Quader et al., 2017). In the NHANES, 40% of respondents indicated they use salt "very often" in cooking, with pasta being one of the top five foods to which salt is added in home meal preparation (Sebastian

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Table 1

Some culinary recommendations for cooking dry semolina spaghetti, methods used to cook pasta analyzed for the USDA National Nutrient Database for Standard Reference (US Department of Agriculture, 2016), and package instructions from different brands.

Source	Amount of Pasta and Water		Salt		Boiling time/ Firmness	Rinsing
	Volume water/ weight pasta[a]	Calculated mL water/g pasta	Specified	Calculated g salt/L water[b]		
Culinary methods:						
McGee (2009)	4–6 qt/lb	8.3–12.5	not specified	n/a	not specified	not specified
Smithonian.com (Esposito, 2013)	4–5 qt/1 lb	8.3–10.4	1 Tbsp/qt	19	al dente	no
International Pasta Organisation (Organisation, 2016)	1 L/100 g	10.0	2 tsp/qt	12.7	al dente	not specified
The Food Network ("The Food Network. How to cook Italian pasta: A step by step guide," 2014)	6 qt/1 lb	12.5	0.5 Tbsp qt	9.5	al dente	not specified
Jenkins (Jenkins, 1997)	≥5 qt/1lb	≥ 10.4	2 Tbsp/5qt	7.6	al dente	no
Joy of Cooking (Rombauer, Rombauer Becker, & Becker, 2006)	6 qt/1 lb	12.5	1 Tbsp/3 qt	6.3	al dente	no
The Best Recipe ("Editors of Cook's Illustrated. *The Best Recipe.* Revised Edition," 2004)	≥4 qt/lb	≥8.3	1 Tbsp/4 qt	4.8	al dente	no
USDA National Nutrient Database for Standard Reference ("USDA National Nutrient Database for Standard Reference. Release 28," 2016):						
Pasta cooked without salt[c]	3.7–5.5 qt/1.3–1.8 lb	4.3–8.4	none	0	10–14 min	no
Pasta cooked with salt[d]	3.7–5.5qt/1.3–1.8 lb	4.3–8.4	0.19–0.36 Tbsp/qt	3.6–6.8	10–14 min	no
Package instructions for different brands[e,f]:						
Barilla® [f]	4–6 qt/1 lb	8.3–12.5	to taste	varies	9 min (al dente)	no
Mueller's	4 qt/1 lb	8.3	to taste	varies	10–11 min	no
San Giorgio	5 qt/1 lb	10.4	1 Tbsp/5 qt	3.8	9 min (al dente)	no
Ronzoni®: 1 serving	2 qt/0.25 lb	16.7	1 tsp/2 qt	3.2	10 min (al dente)	no
2 servings	3 qt/0.5 lb	12.5	2 tsp/3 qt	4.2	10 min (al dente)	no
4 servings	5 qt/1 lb	10.4	1 Tbsp/5 qt	3.8	10 min (al dente)	no
Pastifico G. DiMarlino	5 L/500 g	10.0	"slightly salted"	Varies	8 min	no

[a] 1 lb = 454 g; 1 qt = 0.946 L.

[b] 18 g per tablespoon (Tbsp), 6 g per teaspoon (tsp), per USDA National Nutrient Database for Standard Reference (US Department of Agriculture, 2016).

[c] NDB number 20121, "Pasta, cooked, enriched, without added salt" (US Department of Agriculture, 2016).

[d] NDB number 20,321 "Pasta, cooked, enriched, with added salt" (various brands, cooked according to package instructions) (US Department of Agriculture, 2016).

[e] Semolina spaghetti. Package instructions obtained 14 May 2017.

[f] Used for this study.

et al., 2013). The estimated annual per capita pasta consumption in the US is approximately 8.8 kg (19.36 lb) (International Pasta Organisation, 2013). Pasta is a broad food category that generally describes an unleavened dough containing milled durum wheat and water that is extruded in sheets and cut to make noodles and a myriad of other shapes (Potter & Hotchkis, 1998). Wheat that is milled such that the particles are coarse is referred to as semolina. To create a shelf stable product, the extruded dough is oven dried to specific moisture content of 12% (Potter & Hotchkis, 1998), and the dried pasta is prepared for consumption by cooking in boiling water. Recommended cooking parameters for dry pasta vary widely within the culinary community and among manufacturers, with varying water to pasta ratios and amount of salt added to the cooking water, as illustrated by the examples in Table 1.

The sodium content of packaged dry pasta is minimal [< 2 mg per 57 g (2 oz.) portion], but the addition of salt during cooking can result in a substantial increase. The mean value in the USDA National Nutrient Database for Standard Reference (SR) for sodium in pasta cooked with salt is 131 mg/100 g (183 g per 140 g standard serving) (US Department of Agriculture, 2016). There are limited reports on sodium in pasta cooked with different amounts of salt and none on quantitative uptake with home cooking conditions and varying pasta type, water to pasta ratio, amount of salt in the cooking water, and other factors that might differ within recommended and customary practices (Albrecht, Asp, & Buzzard, 1987; Antonelli & Colwell, 2006). Quantifying the impact of different cooking parameters would help guide the consumer to practices with concrete impact on dietary sodium, as well as allow researchers to estimate sodium in cooked pasta consumed by a given population or individual based on cooking methods used, given that the value in SR is an average. Studies relating different cooking parameters

to sodium in cooked pasta are limited. In one report, deionized water was used, without added salt, to assess sodium retention, not uptake (Albrecht et al., 1987). In another investigation (Albrecht et al., 1987), different types of pasta were evaluated (macaroni, egg noodles, spaghetti), but the amounts were small [38–71 g (1.3–2.5 oz)] and the water to pasta ratio and amount of salt varied between pasta types, so that sodium in the cooked pasta could not be related to particular cooking parameters. In another study (Antonelli & Colwell, 2006), pasta (semolina spaghetti and penne, whole wheat spaghetti, and white rice based pasta) was cooked with and without salt. However, cooking was done on a commercial food service scale, many details about the cooking method were not included, parameters other than the amount of salt were not varied, and only two levels of salt were tested. Thus, it was not possible to establish how different parameters affected the sodium content of pasta, or pasta cooked on a home preparation scale.

The objective of this study was to quantify the effect of different variables, including the amount of salt added to the cooking water, the water to pasta ratio, rinsing the pasta after cooking, different pasta shapes, and whole grain pasta, on the sodium content of pasta cooked on a home preparation scale, and to provide results in a manner that can be utilized by health care and public health professionals to educate consumers on dietary sodium.

2. Materials and methods

2.1. Experimental design

A typical consumer-scale cooking procedure for semolina spaghetti was chosen as the "reference method": 454 g pasta (1 lb), 5.68 L (6 qt) boiling water (12.5 mL/g water to pasta ratio), 36 g (2 Tbsp) table salt