

Manteca Yellow Bean Pasta is a Naturally Rich Source of Bioavailable Iron

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Background: Dry bean consumption is low in the United States and development of new bean products offer an opportunity to increase demand. Milling whole beans into flours can expand their uses into products such as pastas, snacks and baked goods. Ideal beans for flours were found to have light seed coat colors and low off flavors. Manteca yellow beans are a market class of dry beans with a pale-yellow seed coat and many favorable end use quality characteristics, which makes them an ideal flour ingredient for food production. Manteca beans tend to have short cooking times, subtle flavor and high nutritional value. In addition, Manteca yellow beans have more bioavailable iron when compared to other market classes of dry beans, which makes them an ideal target for improved iron nutrition. USDA-ARS has an active Manteca breeding program, adapting them to commercial production with improved seed yield, maturity, harvest quality, cooking time, canning quality and iron bioavailability. There is currently no information on the nutritional properties of Manteca beans after being processed into flour, therefore, the goal of this research was to evaluate the nutritional attributes of Manteca bean pasta made from advanced breeding lines as compared to commercially available chickpea, wheat and gluten free pastas.

Methods: A composite flour was formulated with advanced breeding lines of Manteca yellow beans (Y1608-14, RRY1803-1-1 and Y1610-01) produced in Montcalm Township and Saginaw Valley, Michigan (field season 2022). To produce flour, Manteca yellow beans were first oven treated before milling into an ultra-fine powder using a commercially available compression-decompression mill (Enagon LLC, Saugatuck, Michigan). Bean flour was mixed with small amounts of cassava flour and xanthan gum before being extruded into rotini pasta and dried at West Michigan Pasta & Provisions LLC located near Kalamazoo, Michigan (**Table 1**). Chickpea, wheat and gluten free rotini was purchased at local grocery stores located in Ithaca, New York. Pasta was cooked in distilled water according to package instructions (**Table 1**); drained, cooled to room temperature and then stored at -80°C for 16 hours. Cooked pasta samples were freeze-dried and milled into powder (Kinematica Polymix® analytical hammer mill, Bohemia, NY) for ICP-AES mineral analysis and iron bioavailability according to the methods described in Glahn, 2022 (Glahn, 2022 *JoVE*, 182:e63859).

Results and Discussion: Cooking in only 5 minutes, Manteca yellow bean pasta had similar calories, total fat, total carbohydrates and potassium when compared to commercially available chickpea, wheat and gluten free pasta (**Table 2**). However, one serving of Manteca rotini provides more fiber, calcium and iron compared to rotini purchased at the supermarket (**Table 2**). The results in **Figure 1** show that Manteca yellow bean pasta has more than twice the iron content and 3x the iron bioavailability as chickpea, wheat and gluten free pasta. This research demonstrates that the unique iron nutrition of the Manteca yellow bean can be translated into a convenient food product, beating out the other supermarket brands for the delivery of iron, even fortified wheat

pasta. This research reveals that the use of other dry bean market classes, which demonstrate high iron bioavailability (i.e., slow-darkening Pinto) should also be considered for bean flour development; possibly creating a specialty market for convenient plant based foods, which can be gluten free and targets consumers interested in their dietary fiber or iron needs.

Table 1. Description of Manteca, chickpea, wheat and gluten free pastas.¹

Pasta Type	Cooking Time, Ingredients and Attributes
Manteca	5 min – bean flour (90%), cassava (5%) & xanthan gum (< 5%)
Chickpea	9 min – chickpea flour (100%); gluten free, high fiber
Enriched Wheat	8 min – fortified wheat (folate, thiamin, niacin, riboflavin and iron)
Whole Wheat	10 min – durum wheat (100%); rich texture, high fiber
Gluten Free	9 min – corn & rice flour, monoglycerides; gluten free

¹Descriptions based on packaging labels of dry rotini pasta.

Table 2. Food label comparisons of Manteca, chickpea, wheat and gluten free rotini pastas.¹

Pasta Type	Calories	Total Fat (g)	Total Carb. (g)	Fiber (g)	Protein (g)	Calcium (mg)	Potassium (mg)	Iron (mg)
Manteca ²	180	1.5	34	11*	7	80	380	5.7*
Chickpea	190	3.5	34	8	11	29	622	3.0
Enriched Wheat	200	1.0	42	3	7	12	118	2.0
Whole Wheat	180	1.5	39	7	8	17	274	2.0
Gluten Free ³	190	1.0	44	2	4	2	77	0

¹Serving size: 2 oz. (56 g of dry pasta). ²Food label generated by Great Lakes Scientific, Inc. (Stevensville, MI) ³Gluten free rotini is formulated with corn and rice flour. *Considered an excellent source (>30% Daily Value) of dietary fiber and iron with each serving.

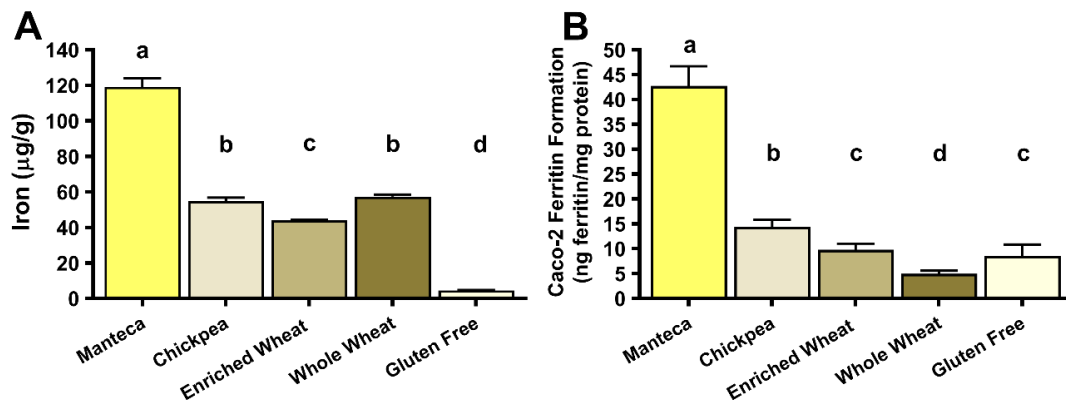


Figure 1. Iron concentrations (A) and iron bioavailability (B) of Manteca yellow bean rotini pasta compared to commercially available chickpea, wheat and gluten free rotini pasta. Values are means \pm standard deviations of six replicates from each pasta sample. Iron concentrations are measured as micrograms per gram of cooked, drained, lyophilized and milled pasta sample (dry weight). Iron bioavailability is measured as Caco-2 cell ferritin formation (ng ferritin / mg total cell protein) after exposure to an *in vitro* digestion of cooked, drained, lyophilized and milled pasta sample. Means sharing the same superscript are not significantly different at $P \leq 0.005$.