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Original Research Article

Quantification of Resistant starch, Non-Resistant Starch and Total Starch Content of Some Processed Foods Sold in Enugu Metropolis

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ABSTRACT

Resistant starch, which is produced by the interaction between starch, lipids and proteins, is an important part of diet due to its ability to escape digestion in the gut, thus reducing the blood glucose concentration. Resistant starch contents of some processed food products sold in Enugu Metropolis were quantified using Megazyme resistant starch kit (Megazyme Bray, Ireland). The processed foods were grouped into cereals (Oatmeal flours, basmati rice flours), Legumes (beans flour), Fruits (Unripe plantain flours) and Tubers (yam flours and potato starch flours). Mean values were determined with MegaCalc and data were expressed as percentage weight per weight. Among the processed food samples analyzed, plantain flour (82.314% Ayoola foods plantain flour, 82.757 % for naked amala plantain flour and 65.648% for deluxe plantain flour) contains the highest concentration of resistant starch. In descending order of resistant starch concentration is as follows; rice samples (lamis basmati rice, 43.427%, TBR basmati rice (39.268%). The resistant starch content of yam samples was 38.769% (Ayo ola poundo yam flour) and 28.354% for Ola ola yam flour respectively. The least resistant starch content was detected in beans sample; deluxe bean flour (~6.788%), Ayo ola bean flour (~3.481 %) and tasty pot bean flour (~4.345 %) and oat flour; lecker white oat 1.503%), health-wise oat meal (3.497%) and elkaris swallow oat (1.325%) respectively. Plantain and rice flours should be considered most for consumption, due to the high resistant starch content that confer many of health benefits.

Keywords: Resistant starch, processed food, Cereals, Legumes and Tubers

Introduction

Starch is an abundant carbohydrate found in plants, which serves as the major source of carbon and energy in plants.[1] It is stored and activated during seed germination and sprouting of tubers.[2] It is composed of two α-glucan fractions, that consist of amylose linked by α-1,4 glycosidic bonds and amylopectin, that is highly branched at the α-1,6 positions.[3] On ingestion, digestion of starch sets in, with α-amylase catalyzing the first step. The molecules available in food are quickly broken down by salivary α- amylase.[4] The digested starch is classified into non-digestible resistant starch (RS), rapidly digestible starch (RDS) and slowly digestible starch (SDS).[5]
Resistant starch is any starch product that cannot be digested by α-amylase found in the small intestine, however, degradable by intestinal microbiota to produce short chain fatty acids (SCFAs).[6-7]
It is found naturally in native foods such as fruits, legumes, vegetables, cereals and in some processed foods.[8] Water content, pH, temperature, heating time, the presence of lipids, proteins, minerals and inhibitors play significant roles in formation of resistant starch in foods.[9]
The resistant starch content in starch and starch-based foods has been categorized into four main groups and can be altered by different processing methods such as moist heating and chemical modification.[10-11]

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There is focus on the dietary relevance of resistant starch (RS), and this is as a result of its role in healthy nutrition.[12] In discouraging fat consumption as a risk factor in the development of obesity, carbohydrate consumption in form of starch is being considered. Since it is affordable, available and accessible, and has been established as staple food, especially in Africa.[13] However, this seems incompatible with healthy nutrition, as increased starch intake results in higher glycemic effects as found in starchy diets, making the search for better source of foods which are filling, yet, with lower glycemic effects and lower energy densities necessary.[14] Resistant starch improves gut health and insulin response, maintains blood glucose levels, exerts positive effects on some forms of cancer, cardiovascular diseases, obesity and osteoporosis and increases mineral absorption.[15-16]
Food processing involves the changing of food materials from their native state to better preserve them and meet the needs of consumers.[17] Owing to an increased demand for convenient, readily available foods, with increased shelf life and adequate nutritional benefits, the 21st century has recorded an increased global reliance on commercially processed foods.[18] Their contributions to health and nutrition are nourished by the aggregation of various components in their right proportions, one of which is the resistant starch component.[18] These processing methods trigger some physicochemical and functional alterations in starch granules, and sometimes, lead to a reduction in the resistant starch content (RS) of certain foods.[8] On account of this, quantification of resistant starch contents of processed foods sold in Enugu Metropolis of Nigeria becomes necessary.

Materials and Methods

Sample collection

Processed food samples including; plantain flour, oat meal, yam flour, potato flour, basmati rice, beans flour was purchased on March 22,

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2022, from different shopping malls around Enugu metropolis, Enugu state and transported to the postgraduate laboratory of Biochemistry Department, University of Nigeria Nsukka for analysis.

Quantification of Resistant starch and Non-resistant starch contents of the samples

A sample, 50 g of each of the samples was ground to pass a 1.0 mm sieve, and transferred to a plastic jar and mix properly. The resistant starch, non-resistant starch and total starch contents were quantified using the Megazyme resistant starch assay kit (Megazyme International Ireland Ltd,Bray, Ireland)[19].

Statistical analysis

All samples were analyzed in triplicates and the data expressed as percentage weight per weight (%w/w). The data obtained were analyzed and the mean values were determined using Mega-Calc™ Resistant Starch (K-RSTAR 09/16).

Results and Discussion

This study investigated the resistant starch (RS) content of 15 different processed food samples (Plantain flour, oat meal, yam flour, potato flour, basmati rice, beans flour) sold in Enugu metropolis of Nigeria. These products were grouped into cereals, legumes, fruits and tubers, and every product in each class had three (3) brands from different companies. Cereals are essential part of food, being staple food for humans and livestock.[20]

The study evaluated the concentration of resistant starch content of industrially processed foods. The concentration of resistant starch (w/w) in various processed food samples analyzed is shown in Figure 1. Plantain flour showed the highest value of RS % content (65.65 - 82. 76 %) when compared to the RS control (41.22 %). Among the Cereals, the RS of Lamis Basmati rice was higher (43.43 %), however Maharani Basmati rice RS (3.73 %) was relatively low when compared to the other rice flours. Oat meal had the least RS content (1.32% - 3.49 %) among the cereals. Among Tubers, yam flour RS was moderately high (38.76 %) while potato starch showed the least RS percentage (5.36 %) when compared to RS control (41.217 %). Legumes when compared to other food samples showed a lower RS content (>7.00 %). On the NRS content, Yam flour showed the highest non-resistant starch (NRS) content when compared to the control (7.45 %) followed by Basmati rice. On the other hand, plantain flour, beans flour, oatmeal flour and potato starches were the least on the average.

Similarly, Figure 2 represents the percentage weight/weight resistant starch, non-resistant starch and total starch in the different brands of beans flour. The RS content of beans samples were between 3.48-6.78 %, the RS content of beans flour is low, when compared to the standard (41.21%).

Beans are classified under grain legumes and they possess a nutritional profile that suits all ages, providing cholesterol-free protein and phyto-nutrients.[21] The beans samples, DBF, TPF and ABF, had low total starch contents (15.92 %, 8.40 % and 13.07 %), when compared to the control. In addition, the total starch of beans flour samples in this study were lower than results recorded in previous studies.[22] The reason behind this deficit in total starch content could depend on the variety or specie of the beans used. Also, chemical composition may vary according to the planting location, the cultivation process and environmental factors.[23] The RS content of the 3 beans flour samples were similar and low when compared to the RS content of raw bean flour of 55.6%, reported by García-Alonso *et al.*[24] Retrograded and reheated (processed) bean flour samples had lower resistant starch contents of 14.10 % and 12.20 %, which were closer to the RS contents of the samples (6.78 %, 4.34 % and 3.48 %), when compared to that in the raw flour sample. Processing methods such as heating reduce the RS content of beans flour. Kaur *et al.*[25] reported that cooked and autoclaved Mung bean was digested more rapidly than soaked and germinated counterpart samples. The thermal treatment reduces RS content is of food samples.[24]

Similarly, the RS and TS of the three different unripe plantain flour samples were significantly higher that of the control. However, DPF showed a significant lower RS content when compared to the other plantain flour samples (Figure 3).

Figure 1: Resistant and Non-resistant starch contents in the various food samples

n = 3 Key: TBR – TRS Basmati Rice, LBR – Lamis Basmati Rice, AFPF – Ayoola Foods Plantain Flour, NAPF – Naked Amala Plantain Flour, DPF – Deluxe Plantain Flour, OYF – Ola-ola Yam Flour, APYF – AyoolaPoundo Yam Flour, DBF – Deluxe Beans Flour, LWO – Lecker White Oats, ABF – Ayoola Beans Flour, TPB – Tasty Pot Bean Flour, HWO – Healthwise Oat Meal, ESO – Elkaris Swallow Oat Meal, MBR – Maharani Basmati Rice, PSF – Potato Starch Flour, CON RS – Resistant Starch (Control)

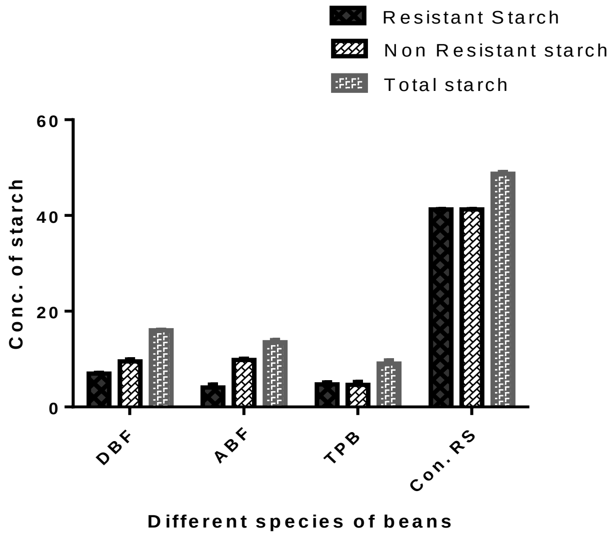

Figure 2: RS, NRS and TS Contents among Bean Flour

Key: DBF – Deluxe Beans Flour, ABF – Ayoola Beans Flour, TPF – Tasty Pot Bean Flour

Plantain fruit constitutes an important source of energy in the tropics.[26-27] The resistant starch levels of the three samples of unripe plantain flour investigated, DFP (65.648 %), AFPF (82.364 %) and NAPF (82.757 %), were significantly higher than that of the RS control (41.217%). However, DPF showed low RS content when compared with AFPF and NAPF. This indicates the effect of different processing methods on the total starch content of plantain fruit[28] improved the resistant starch content. Also, these unripe plantain flour

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products showed the highest RS content (65 to 82 %) when compared to other products investigated. Unripe plantain flour presents high RS content; however, the RS content of unripe plantain flour reportedly decreases during thermal treatment of food products, especially those with high water content.[29] This could be the reason behind the reduced RS content observed in DPF. Contrastingly, the RS content of the three unripe plantain samples were higher than the RS content reported by Adamu *et al*.[28] This variation in TS content could be attributed to varied proximate and functional contents exhibited by different cultivars of plantain. This agrees with the report of Oko *et al*.,[29] showing a TS content range of 69.96 % - 81% between 8 cultivars of plantain.

The RS content of the three Oat meal flours assayed were low (1.32 – 3.47 %) when compared to the RS (41.21 %) control (Figure 4). Also, the Oatmeal flours showed low total Starch and non-resistant starch contents respectively.

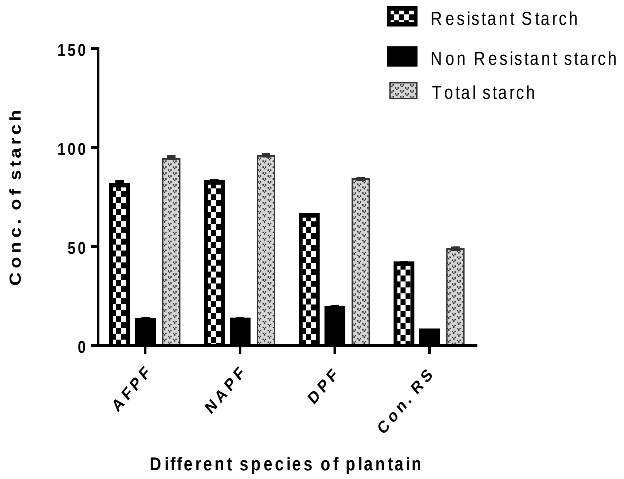

Figure 3: RS, NRS and TS Contents among Plantain Flours
Key: AFPF – Ayoola Foods Plantain Flour, NAPF – Naked Amala Plantain Flour, DPF – Deluxe Plantain Flour

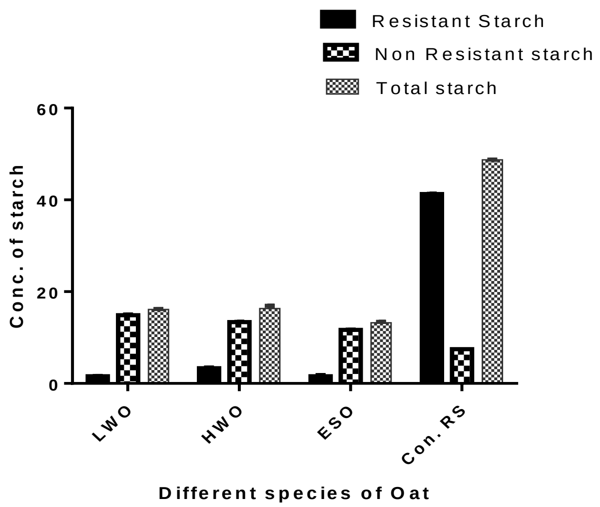

Figure 4: RS, NRS and TS Contents among Oat meal Flour
Key: LWO: Lecker White Oats; HWO: Healthwise Oat Meal; ESO: Elkaris Swallow Oat Meal

Oats contain important nutritional substances such as unsaturated fatty acids, essential amino acids and soluble dietary fibre. Hence, there are used producing breads, flakes and infant food.[30] As shown in Figure 4, the resistant starch contents of the three oat flour product samples, HWO (3.497%), ESO (1.326%) and LWO (1.504%), were low, when compared with the control (41.217 %). However, the resistant starch content of these oat flour samples was similar to the resistant starch content in oat flour (3.7 %) reported by Beloshapka *et al*.[31] Also, there was no significant difference in RS content between the oat meal flour samples and the RS content of oats (3.9 %) in previous reports.[31] RS doses of 20–30 g/day are required to observe physiological effects of RS consumption.

Furthermore, the percentage weight/weight resistant starch, non-resistant starch and total starch in the tubers (yam flours and potato starch flour) were evaluated. The RS contents of yam flours were high (28.35-38.76 %), with high total starch content as shown in Figure 5. However, potato flour showed RS content of 5.36%.

The tuber flour samples investigated were two yam flours and one potato flour. Of the three flour samples, yam flour samples recorded high total starch (TS) content of 84% and 86%. However, the resistant starch content of the two-yam flour, were 28 and 39 % respectively, were lower than that of the RS control, while the resistant starch content of potato starch flour was significantly lower than that of the control and the yam flour samples, as shown in Figure 5. This result is in line with the reports of Aprianita *et al*,.[32] who recorded a resistant starch content of about 22% in yam flour and approximately 1% in potato flour. Starch-protein interaction is believed to reduce the RS content in potato starch flour[33] and this could be the reason behind the low RS content in potato starch flour. The structure of the starch in these species of tuber may also account for the differences in the degree of digestibility. According to Aprianita *et al*.[32] there is an inverse relationship between RS content and digestibility of food. Thus, foods with high RS content have low starch and vice versa.

Basmati rice from three different manufacturers was assayed in this study. The total starch (TS) content of two brands of the rice variety, TBR and LBR (94.02 % and 87.39%) were significantly higher than Total starch of the control. However, MBR showed a low content of RS, NRS and TS respectively as sown in Figure 6.

Results from different Basmati rice products showed that two brands of this rice variety, (TBR and LBR) had total starch contents of 94.024 and 87.39 % respectively (Figure 6). These were significantly higher than the total starch of the control (48.676%). This is in line with earlier reports that rice major source of caloric energy in the human diet, with about 90% of the dry weight of milled rice being starch.[34] Among rice flour samples, MBR, with a total starch content of 18.213 % had the least content of total starch. This could be as a result of the degree of milling and other processing steps. However, LBR rice which had highest total starch content of 87.39 % when compared with TBR, recorded the highest resistant starch content (43.427%) when compared with TBR and MBR, which had 39.268% and 3.73 % respectively. Some factors climates and locations affect starch properties.[35] The types of crop also play an important role in determining the digestibility of starch and its glycemic index (GI). Processing methods impact on the structural composition of starch, which affects its digestibility in foods. In rice starch, digestibility is partly attributed to its crystallinity, granular structure and amylose/amylopectin ratio.[36] However, different processing methods by different product manufacturing companies can influence the starch structure in rice, which leads to an increased or decreased starch digestibility. Also, Post-harvest processes such as milling, parboiling, and pressure parboiling, quick-cooking and drying can also affect the crystallinity of rice starch.[37] The individual or combined effects of these processing methods may account for the differences in the resistant and non-resistant starch contents recorded by the 3 brands of basmati rice.

Conclusion

Resistant starch content of the processed food samples grouped into cereals, fruit, tubers and legumes were investigated. Processed plantain and rice flour products had high resistant starch contents more than other samples. Therefore, these food products should be considered efficient for consumption as they are capable of giving both filling satisfaction and health benefits. Foods with high RS have

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shown low digestibility, enhancing the prevention of diabetes and other health related problems.

Conflict of Interest

The authors declare no conflict of interest.

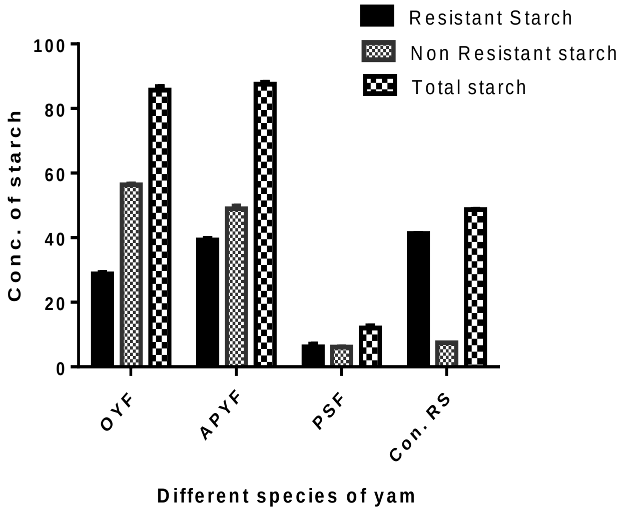

Figure 5: RS, NRS and TS Contents among Yam Flour.
Key: OYF – Ola-ola Yam Flour; APYF – Ayoola Poundo Yam Flour; PSF –Potato Starch

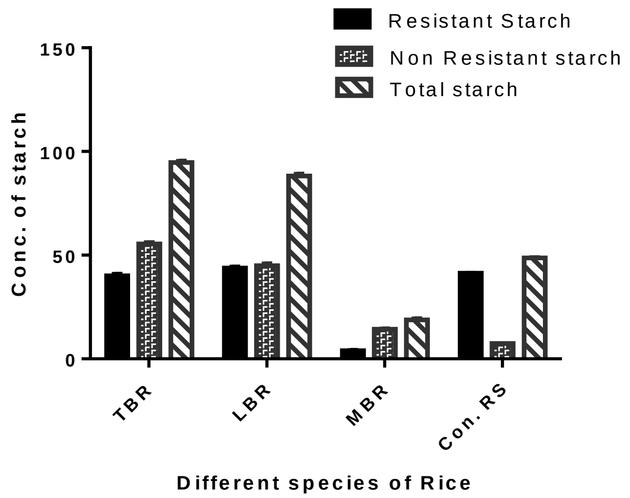

Figure 6: RS, NRS and TS Contents among Basmati Rice
Key; TBR – TRS Basmati Rice; LBR – Lamis Basmati Rice; MBR – Maharani Basmati Rice.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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