Iodine-Binding Capacity of some Native Starches of Indian Food Grains

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In recent times a number of studies have been made on the amylose and amylopectin contents of starches isolated from different plant materials. The main purpose of all these studies was to investigate the structure of the starch molecule and to correlate it with other physicochemical properties like viscosity, retrogradation, etc.

Of late, much interest has also centred round the potential industrial uses of the separated fractions. Analysis of the usual starch sources of industrial significance, such as potato, corn and tapioca, has revealed that they contain only 20–25 % of amylose, and it does not appear to be economically feasible to fractionate amylose from these materials. The search has therefore been directed for a high-amylose starch that can be economically produced in significant quantities. Furthermore, we were interested to find out whether the difference in the rate of digestibility of the various starches, observed by us, could in any way be explained by their amylose and amylopectin contents.

Most of the work so far has been done on cereals, tubers (Bates, French & Rundle, 1943; Lansky, Kooi & Schoch, 1949; Higginbotham & Morrison, 1949; Meyer & Gibbons, 1951), and to some extent also on fruits, e.g. apple (Potter, Hassid & Joslyn, 1949) and banana (Brown, Halsall, Hirst & Jones, 1948), but no work seems to have been carried out on the starches of pulses, beans or of certain tubers which are essential ingredients in the dietary of the people of India. The present paper reports a study of the amylose and amylopectin contents of the starches of eleven pulses and beans, a seed, two millets and two tubers. For comparison a study has also been made of the starches isolated from rice, wheat, millets, potato, sweet potato and a variety of smooth peas, all grown locally, and a sample of waxy maize starch.

The results in this paper are reported as percentage of bound iodine, because varying figures have been quoted for the iodine-binding capacity of pure amylose by various authors (Bates *et al.* 1943; Higginbotham & Morrison, 1949; Doremus, Crenshaw & Thurber, 1951; Lansky *et al.* 1949). The advantage of this form of presentation has been fully discussed by the last-named authors. However, for comparison, we have also calculated the

amylose contents of the starch samples, and have used Higginbotham's value of 21.2 % (mg. of I_2 /100 mg. of carbohydrate) as the iodine-binding capacity of pure amylose.

EXPERIMENTAL

Preparation of starches

Pulses and beans. The starches from various pulses were prepared according to the following general technique.

The best quality commercial split, dehusked and sound grains were selected for the starch preparation. They were well washed in water and then soaked in water for 3–4 hr. until they had imbibed enough to become fully turgid and fairly soft. A suspension of the swollen grains in water was disintegrated in a Waring Blendor. The resulting slurry was filtered through several folds of fine muslin and allowed to settle. The dark-coloured supernatant liquid was decanted off and the settled starch was resuspended in water. The suspension was stirred, filtered through several layers of fine muslin and allowed to settle. The supernatant liquid was poured off before complete sedimentation had occurred. This cycle was repeated four or five times to increase the purity of the starch. The purified starch was suspended in ethanol and collected on a Büchner funnel, washed well with further quantities of ethanol and finally air-dried at room temperature. The starch was powdered and bottled for analysis.

Bengal gram (*Cicer arietinum*, variety II, local name Kabli channa), cow pea (*Vigna sinensis*, varieties I and II, local names Rawan and Roonghi respectively), smooth pea (*Pisum sativum*, local name Mattar) were soaked overnight before working in the Blendor.

Cereal and millets. Starches from this group were isolated as is done commonly with wheat. Dough was made from their flours and starch separated as usual.

Seeds and tubers. They were peeled and sliced, and then worked up in the Blendor in the normal way. Preparation of starch from *Colocasia esculenta* (Arvi), however, was quite troublesome, as it formed an extremely stable emulsion, owing to the presence of mucilaginous impurities, and the starch did not settle down as in other cases. The complete removal of these materials was achieved by repeated washing of finely grated material, which had been soaked in 5 % NaCl solution overnight and scrubbed occasionally. In all, 48 hr. were necessary to free the sample completely from the mucilaginous material. The rest of the procedure was the same as described previously.

All samples were defatted by Soxhlet extraction with absolute ethanol for 24 hr. before determining their iodine-binding capacities.

Determinations of the content of ash and soluble matter, along with the usual hydrolytic studies, were carried out to check the purity of starch samples. All the starch samples studied were low in content of ash and soluble matter, and yielded on hydrolysis with acid 98–99% of the theoretically obtainable glucose.

Determination of the iodine-binding capacity of the starch samples

The iodine-binding capacity was determined by means of the iodine potentiometric titration method of Bates *et al.* (1943), as modified by Lansky *et al.* (1949). A Cambridge potentiometer reading to 0.1 mv was used, in conjunction with a sensitive spot galvanometer. The instrument was standardized by titrating 100 ml. of a solution 0.05N with respect to KCl and KI with a solution containing 0.2 mg. of iodine/ml. in 0.05N-KCl-KI. A calibration chart was made and the amount of free iodine calculated therefrom.

RESULTS

Table 1 shows the iodine-binding capacities of various starches. These values were obtained by extrapolating the horizontal portion of the curve drawn by plotting mg. of bound iodine against mg. of free iodine in solution. Fig. 1 shows the typical curves of the representative starch samples of the various food grains. This includes curves of abnormal starches like those of *Colocasia* (varieties I

Fig. 1. Iodine affinities of various starches. Weights in brackets refer to dry material. ○, *Pisum sativum* L. (88.8 mg.); △, *Phaseolus mungo* L. (89.2 mg.); ×, *Colocasia esculenta* L., Schott et Endl, variety I (170 mg.); □, *Trapa bispinosa* Roxb. (86.4 mg.); ●, *Oryza sativa* L. (89.5 mg.); ○, *Colocasia esculenta* L., Schott et Endl, variety II (87.2 mg.); ▲, *Zea mays* L. (waxy maize) (170 mg.).

Table 1. Iodine-binding capacities of starches

Percentage amylose is expressed on a dry-matter basis.

Source of starch	Local name	Iodine-binding capacity (mg. of I ₂ /100 mg. of starch)	Percentage of amylose
Pulses and beans			
Black gram (<i>Phaseolus mungo</i> L.)	Urd	5.18	24.4
Green gram (<i>P. aureus</i> Roxb.)	Moong	5.38	25.4
Lentil (<i>Lens culinaris</i> Roxb.)	Masoor	6.00	28.3
Red gram [<i>Cajanus cajan</i> (L.) Millsp.]	Arhar	5.45	25.7
Moth bean (<i>Phaseolus aconitifolius</i> Jacq.)	Moth	5.58	26.3
Bengal gram, variety I (<i>Cicer arietinum</i> L.)	Channa	5.65	26.8
Bengal gram, variety II (<i>C. arietinum</i> L.)	Kabli channa	6.14	29.0
Red kidney bean (<i>Phaseolus vulgaris</i> L.)	Raj-mah	5.72	27.0
Cow pea, variety I (<i>Vigna sinensis</i> Savi.)	Rawan	5.48	25.8
Cow pea, variety II (<i>V. sinensis</i> Savi.)	Roonghi	5.47	25.8
Pea (smooth) (<i>Pisum sativum</i> L.)	Mattar	5.95	28.0
Millet and cereals			
Jowar (<i>Sorghum vulgare</i> Pers.)	Jowar	4.09	19.3
Bajra (<i>Pennisetum typhoides</i> Staff & Hubbard)	Bajra	4.44	21.0
Rice (<i>Oryza sativa</i> L.)	Chawal	3.18	15.0
Wheat (<i>Triticum aestivum</i> L.)	Gehun	3.91	18.4
Maize (yellow) (<i>Zea mays</i> L.)	Makki	4.28	20.2
Maize (waxy) (<i>Zea mays</i> L.)	Makki	0.1	0
Seeds and tubers			
Potato (<i>Solanum tuberosum</i> L.)	Alu	3.73	17.6
Sweet potato (<i>Ipomoea batatas</i> Lam.)	Shakarkandi	3.41	16.1
Colocasia, variety I [<i>Colocasia esculenta</i> (L.) Schott et Endl]	Arvi	1.87	8.8
Colocasia, variety II [<i>Colocasia esculenta</i> (L.) Schott et Endl]	Kachalu	1.35	6.4
Horn chestnut (<i>Trapa bispinosa</i> Roxb.)	Singhara	2.72	12.8

and II) and of waxy maize together with one curve each for normal starches as present in different groups of food grains like pulses and beans, millet and cereals and seeds and tubers.

DISCUSSION

The iodine-binding capacities of the starches vary from 2.72 to 6.14, except for those of the two varieties of *Colocasia esculenta*. Most of the values fall within the range of 20–30 % amylose content of normal cereal and tuber starches quoted by Peat, Bourne & Nicholls (1948). Furthermore, it will be observed that starches from pulses and beans have distinctly higher amylose contents than starches from the cereals, millets and tubers examined.

Starches from *Colocasia* contain appreciably less amylose than the other samples examined. It may be seen from Fig. 1 that their curves do not follow the conventional patterns. The break in the horizontal portion may be due to the presence of a large number of external branches in the amylopectin, sufficiently long to bind a considerable quantity of iodine at higher free iodine concentration, or it could also be attributed to the presence of small amounts of a fraction intermediate between amylose and amylopectin.

Our results are at variance with those of Fernandez (1948), who has reported the amylose content of a Spanish sample of *Colocasia* to be 17.5 %, determined by electro dialysis. Whether this discrepancy in the amylose content can be explained by the different experimental technique or the difference of the sample variety remains to be seen. The value of 12.8 % for horn chestnut is also an example of a low-amylose-bearing starch.

SUMMARY

1. The iodine-binding capacities of several native starches of Indian food grains are reported.
2. Most of the starches are normal, in that they absorb between 2.72 and 6.14 g. of iodine per 100 g. of carbohydrate.
3. *Colocasia* starch contains appreciably more amylopectin than the other starches.
4. Pulse and bean starches have distinctly higher amylose contents than the starches from cereals, millets and tubers examined.

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