BREEDING ON THE C and J and B LOCI FOR MODIFICATION OF BEAN SEEDCOAT FLAVONOIDS WITH THE OBJECTIVE OF IMPROVING FOOD ACCEPTABILITY

Colin L.A. Leakey. The Close, Girton, Cambridge England.

1. BASIS FOR BREEDING FOR DIGESTIBILITY BY MODIFYING "TANNINS".

In a recent review of flatulence and its causes in relation to diet PRICE et al.(1988) review previous discussions of the possibility of improvement of foods in this respect by breeding. However all the discussion had focussed on reduction of the oligosaccharides as the approach. There may be other directions of attack. MURPHY (1964) in a most interesting early discussion of the problem of flatulence factors in beans, suggested that an inhibitor of carbonic anhydrase in the bean digesta was likely to be a major factor contributing to flatulence induction by beans. However, since the recognition of the role of the oligosaccharides as bacterially fermentable substrates, Murphy's original hypothesis has been largely overlooked until quite recently. FENWICK et al.(1987) also pointed out that some natural plant phenolics might be effective in inhibiting flatulence although this had not been demonstrated in man.

During a visit to Chile in 1979 it became apparent that in that country the distinction between "ordinary beans" and "beans for the rich man's table" is one reflected in a large difference in market price, and that the beans of the latter group belong to two main market classes called Coscorrons and Mantecas. These are respectively pale lemon yellow and pale lemon yellow mottled or striped over white. The Coscorrons generally also have brilliant red pods. The rich man's beans are so called because they are reportedly non-flatulent.

Their similarity in genetic makeup in relation to the flavonoid controlling genes is interesting, being in particular CCjj types with C linked to Mt in Coscorrons but to mt in Mantecas. (LEAKEY 1988). They are also genetically quite close to Pintos and some Great Northerns which are also (mainly) jj genotypes, but differ from these in the lack of a dominant gene (probably B), which would convert the lemon (canary) yellow of the Chilean types to the brown (grey greenish brown) of the mottle colour of classic Pintos (both in gg).

Two questions arise for the geneticist/plant breeder. These are whether the unusual multiple recessive traits of the Mantecas and Coscorrons are of any direct significance to digestibility and whether the ccjj(dd) P-whites have any significant chemical difference from the p-whites. A practical approach to attempting to answer this question has been to breed new varieties with these various gene combinations and assess them for food use.

The hypothesis, now beginning to be substantiated, of significant physiological activity of proanthocyanidins and their condensation polymers, provides encouragement for investigating the J-gene and breeding on jj for the absence of pro-anthocyanidins in the expectation of improved digestibility and cooking quality.

Two quite different phenolics (flavonoids) of bean seed testas may have opposite effects. I postulate that kaempferol may be positively beneficial as an anti-flatulence factor, without reducing digestibility whereas one or more pro-antocyanidins and/or their condensation polymers may contribute both to indigestibility, hardness-to-cook and through indigestibility to flatulence.

The proanthocyanidins, and perhaps particularly procyanidin, are also enzyme inhibitors, and might well inhibit carbonic anydrase and thus also positively contribute to flatulence as well as indigestibility. This calls for investigation which happily is beginning to be undertaken in appropriately equipped laboratories .

In another paper (LEAKEY 1991 this conference) I have discussed the possible roles of "the tannins" in digestibility, and hard-to-cook phenomena.

2. BREEDING ccjjdd WHITES.

SMITH (1962) discussed the distinction between p-whites and P-whites, first due to LAMPRECHT (1936) but I believe not correctly interpreted by him, but by PRAKKEN (1970) as being ccjjdd. p-whites have no anthocyanin expression in any part of the plant, P-whites which may contain other colour genes may express these but not in the seed testa. ccjj whites may express pinkish, mauvish or purplish colours, due to anthocyanins, in other parts of the plant as well as carrying flavonoid modifying genes such as G and B cryptomerically.

J genotypes are usually shiney, due to reflection through the cells of the crystal pallisade, of light reflected off a layer of cells containing proanthocyanidins. jj genotypes on the other hand are usually more "matt" in sheen. ccjjD genotypes are matt grey white in colour and have a dark hilum ring.

OPAL, bred by the Clause seed company of France, is a backcross derivative incorporating Are (for anthracnose resistance) from the earlier similar seeded variety MISTRAL. Despite its D gene it proved a useful source for the cj combination since the plant type has an excellent tall determinate structure. It is however reportedly rather susceptible to halo blight.

RACHEL is a black-seeded "filet" bean and appears to be CmtJd.and was also reported to carry Are, resistance to at least one race of halo blight and "protected I gene" for bean common mosaic virus resistance. i.e. I gene with at least one of the bc recessives.

Although on the face of it OPAL X RACHEL is a "Wide" cross between a dry bean variety and a green podded high quality filet, the genes were present to transfer the crucial d and hopefully other useful disease resistance genes to produce white seeded ccjjdd's with as good a plant habit as OPAL. From this family CASA, OPERA and DORDOGNE have been provisionally selected from screening trials for futher evaluation, but more extensive material remains in store as backup or for other studies.

3. ccjjdd GREAT NORTHERNS.

In the late 1970' the desirability of combining the very early maturity and stiff erect type 1 determinate habit and disease resistances of HORSEHEAD with a Great Northern type of white seed became apparent. A number of University of Nebraska Great Northerns were kindly supplied by Professor Dermot Coyne,(STAR, HARRIS,JULES, TARA and EMERSON). We also used GN1140 which was already under study and trials. These Great Northerns were crossed with HORSEHEAD. The development of these families was difficult because of extensive infertility among the segregates. It became apparent that the combination of determinate plant type combined with flattish white seed was being eliminated by whatever breeding barrier was operating between the genomes of the two very contrasting parents. We were not concerned, as an academic excercise, to study this barrier in detail, but from a practical standpoint to break it. There was also apparent elimination of flat seededness in combination with determinacy but plenty of reasonable (but unwanted at the time) indeterminate Pintos and Great Northerns). Fortunately, occasional determinate Pintos were able to be found and from these a small number of Great Northerns eventually segregated. Only from the EMERSON, HARRIS and STAR crosses were lines obtained that were worth carrying forward. So far one useful candidate has emerged from the EMERSON X HORSEHEAD cross but early maturing Pintos still segregating whites (segregation in C because the Pintos are matt) are still turning up where heterozygous pinto descent is being maintained for this purpose.

4. NEW MANTECA BEANS OF EARLY DETERMINATE HABIT.

A programme has been undertaken to breed new cultivars with erect plant type and early maturity adaptation for North temperate climatic production which also have the same colour genes (C,mtmt,jj,dd,gg,bb,blbl,vv) as the "Manteca" market class of Chilean beans. This has been achieved through a cross involving two parents repectively with presumptive genotypes as follows:

Female parent cc,??,jj,DD,gg,bb,blbl,VV cv OPAL of Clause
Male parent CC,mtmt,JJ,dd,gg,BB,blbl,?? cv SURVIVAL.
SURVIVAL is a "Swedish Brown" type.

The cross segregated as expected. Simultaneous selection pressure was able to be applied for agronomic characteristics of quantitative inheritance while progressively accumulating the required combination of recessive major genes.

4. BREEDING FOR "NEW" DETERMINATE COSCORRONES.

Initial attempts to breed determinate erect Coscorron beans, with mottled or striped yellow on white seeds, by crossing Chilean indeterminate Coscorrons with HORSEHEAD were just not successful. The project was undertaken on a smaller scale than for the determinate Great Northerns and the two families created were not persevered with in the face of apparent recombinational barriers.

More recently new crosses have been made between our determinate Mantecas (at F6) and two Coscorrons. From one of these families promising determinate Coscorrons are segregating.

5. DO YELLOW COLOURED BEANS HAVE INTRINSIC GENETIC WEAKNESS?

There is now accumulating evidence suggesting pleiotropic association between seed colour and susceptibility to bean common mosaic virus.

Yellows, as opposed to closely related greys and browns, tend to be susceptible as do red mottled beans in comparison with closely related purple or mauve mottled ones.(TEMPLE 1984. PARK & TU (1986) reported the same phenomenon in relation to the eye colour of Steuben yellow eye bean.

In Chile the price of yellow (Manteca) and yellow and white mottled (Coscorron) beans remains high despite popularity. They are reputed to be difficult and delicate to grow compared with other coloured types. It is possible, and I consider likely, that the same biochemical consitiution that favours digestibility also prevents the plants from having the same resistance to virus, and perhaps other diseases, of their less digestible relatives.

6. TESTS OF THE COOKING AND PROCESSING QUALITIES OF MANTECA BEANS.

Until 1991 such small quantities of primrose yellow "Manteca" beans were available that only very small scale preliminary evaluation was possible. At the Processors and Growers Research Organisation in November 1989 canned samples were prepared and sampled. The beans proccess (in brine) to a near white colour of warm but not yellow tone. The texture was considered good and there was a very low level of splitting and no serious problem of gellification. Recently we have been fortunate to be obtain the services of an organoleptic study laboratory where we shall undertake more searching tests. Some of our new beans will also be entering commercial test laboratories for screening for processing quality. How much I may be free to publish is presently unclear.

7. DISCUSSION.

There are quite other possible genetically determined differences between bean genotypes that might be associated with flatus, and particularly with production of unpleasantly aromatic flatus. The most important of these deserving attention is in differences in the content of non protein sulphur containing amino acids the catabolism of which must be expected to produce mercaptonoid volatiles.(MURPHY, HORSLEY &

BURR(1972). There would be no expectation of any pleiotropic association of these with the control of testa colour. However the non protein sulphur containing amino acids are able to be assessed in laboratory conditions fairly easily and evaluating these in a range of germplasm opens another obvious route that would facilitate a breeding approach to a solution.

Acknowledgement. I wish to thank Jean-Claude GARNIER for technical and field assistance in relation to the work on Great Northern beans. I earlier thought that the OPAL X SURVIVAL cross was probably segregating in G rather than B and I am grateful to Dr M.Bassett for suggesting that I was wrong.

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