

From Scenes to Scripts:
On the Relationship between Laboratory
Research and Published Paper in Science

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Research Memorandum No. 132

August 1978

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Paper presented at the Annual Meeting of the American Sociological
Association, San Francisco, September 4 - 9, 1978

S u m m a r y

Recent studies of the rhetoric of science have generally analyzed writings in the social sciences and in philosophy and they have restricted their inquiry to the published text. Based upon a one year observation study done in a major research institution in Berkeley, CA (1976-77), in the present paper the attempt is made a) to look at a scientific paper in a technological science specialty; and b) to analyze the relationship between the research process as observed in the laboratory and the scientific publication which originated from this research. More specifically, the origin and dynamics of a research effort in the laboratory are outlined and compared with the account given in the scientific publication as examined for its strategies of persuasion by using discourse analysis techniques. A discussion of the transformation-function between the written text and the research process shows that the link between the paper and the laboratory is provided by measurement traces, and that a conception of the scientific paper as a "relevant summary description" of what happened in the laboratory cannot be substantiated.

Z u s a m m e n f a s s u n g

Neuere Arbeiten zur Rhetorik der Wissenschaft haben sich im allgemeinen mit Texten aus den Sozialwissenschaften oder aus der Philosophie beschäftigt und sich auf veröffentlichte Texte konzentriert. Im folgenden wird auf der Basis einer einjährigen Beobachtungsstudie in Berkeley, CA (1976-77) der Versuch gemacht a) ein wissenschaftliches Papier in einer technologischen Disziplin zu analysieren; und b) die Beziehung zwischen dem im Labor beobachteten Forschungsprozeß und der daraus resultierenden wissenschaftlichen Publikation in die Analyse einzubeziehen. Dabei werden insbesondere der Ursprung und die dynamische Entwicklung eines Forschungsvorhabens mit der Darstellung im wissenschaftlichen Papier verglichen, das mit Diskursanalysetechniken auf seine Überzeugungsstrategien hin untersucht wird. Eine Diskussion der Transformationsfunktion zwischen Text und Forschungsprozeß zeigt, daß die Verbindung zwischen Text und Forschungspraxis durch Meßdaten hergestellt wird und daß die Vorstellung vom wissenschaftlichen Papier als eine "relevante Zusammenfassung" der Forschung nicht gerechtfertigt erscheint.

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INTRODUCTION

The scientific paper has long been a subject of analysis in the "context of justification" e.g. with a view to the structure of scientific explanation, scientific method, and rationality. Together with the general critique of such logical investigations, there developed an interest in studying the rhetorical properties of scientific discourse as manifested in conversations and written material drawn largely from the social sciences and philosophy.¹ As a result of these studies, language in science can no longer be regarded as a neutral medium through which technical results are reported.² Since most natural or technological science papers are rhetorically fairly standardized in terms of paragraph organization, choice of vocabulary and grammatical means of expression, rhetoric as defined in terms of individual variation or excellence of style must be considered poorly developed. On the other hand, if we define rhetoric in terms of a repertoire of techniques of persuasion, the very same features of the texts offer ample opportunities for identifying such techniques. It is by now a commonplace to say that scientists express their procedures, findings and generalizations in a language which is ostentatiously neutral. Studies of scientific texts reveal such common strategies as use of a simplistic language; separation of 'information' and 'interpretation'; use of the passive voice and of regal we; redoubling (offering both sides of an argument); and avoidance of explicit value statements.³ Manuals devoted to teaching the scientist the skills of concise 'scientific' writing ceaselessly censure the sorry result of some of these habits (like passivity), while reinforcing others (like brevity and straightforwardness).⁴

However, the persuasive effects of the scientific paper do not rest solely upon linguistic manipulation, but also upon the paper's institutionalized definition as a report of laboratory work addressed to a specialty field. Exclusive analysis of the paper may lead us to adopt a restrictive definition of persuasion as something evolved from the text, and therefore to neglect the link between the narrative of the paper and the discourse of the field. With Cicourel,⁵ we believe that understanding the formal properties of those texts classified as reports requires that we also study the relationship between the text and the reality from which they originate. As argued by Bourdieu with respect to philosophical discourse,⁶ the formal properties of a work are at the same time social strategies which cannot be grasped by a science of discourse considered in itself and for itself. In sum, we believe that an analysis of scientific texts which includes the mode of production of scientific findings in the laboratory will allow us to reconsider the authentic claim of the scientific paper as a research 'report', and to eventually understand the structure and function of the discourse found in these 'reports'. It is the purpose of the present paper to contrast a scientific text with an observation of the laboratory work on which it is based as a first step toward such an understanding.

DATA AND METHODOLOGY

The contrasts between scientific text and laboratory scene found in the present paper are drawn from an observational study conducted at a large research institution in northern California during 1976-77 by the first-named author of the present paper.⁷ The observations focused on plant protein research, a field which involves a variety of specialties and methodological approaches: generation and recovery, purification,

structure, texture, biological assays, protein additives, etc. For the present purpose, experiments on protein recovery were selected because the resulting paper was the first to be published out of all the research conducted during the period of observation, and because a complete set of all versions of the paper, from the first handwritten copy to the manuscript accepted for publication, was made available to us. The principles illustrated here exemplify a pattern which can also be found in other cases observed. The primary experiments and chemical analyses were conducted between November 1976 and April 1977; the first official draft is dated May 13, 1977; the final version was finished on September 14, submitted on October 2, and accepted (with the condition that a reference be completed) on October 28, 1977. All comparisons refer to the research process as reflected in the observer's notes and interview tapes, and to the published version of the paper.⁸ Since the paper only appeared in the spring of 1978, it is impossible to use citation rates as an indication of the quality of the work; however, the fact that the paper was quickly accepted without corrections suggests that peer evaluation of the work was high. Other indicators of quality may be gleaned from the fact that both senior authors of the paper are highly ranked in regard to journals and professional societies, that the oldest author has published more than 250 papers and acts as a government consultant, and that the scientist mainly responsible for the work had 40 publications to his credit by the age of 33.

Contrasting the published paper with the preceeding laboratory practice means confronting two narratives: one belonging to the authors of the work, and one drawn from the observer's tapes and protocols. Each purports to have the same referent (i.e., laboratory practice, scientific reality).

Obviously, this referent cannot be analyzed independently of the texts within which it is constructed. While the accuracy of the observer's data and interview transcripts have been verified by the scientists involved, the merit of these data cannot lie in their 'objectivity', but rather in the contrast they provide to the story presented by the scientists' in their publication. If we consider the scientific paper and the observer's field notes as two different texts about the laboratory, rather than text and factual observation, we should in principle be able to apply the same kind of analysis to each.

Given the purpose of the study and the volume of material, this analysis will have to focus on narrative macro-structure and neglect the linguistic micro-elaboration of the texts. A limited number of models of analysis are offered in relevant studies of discourse: the model of accounting; the dramaturgical model; and the structural model developed by Propp and modified by Greimas. The model of accounting conceives of speech and texts which precede, accompany and follow action as 'produced to ensure the twin goals of intelligibility and warrantability' (Harré).⁹ While we will retain an interest in how specific kinds of justification dominate the scientific paper analyzed, the issue of meaningfulness as such or of formal organization (e.g. turn taking) which are prominent with this model are not the main concern of the present undertaking. The dramaturgical model is best exemplified by Gusfield's¹⁰ study of a paper on alcoholic drivers which draws upon the techniques of literary criticism to analyze the action of a text in terms of the dramatic tension created by a plot and its dénouement and in terms of the dynamics of action expressed in the play. The dramaturgical model of literary criticism is obviously similar to the model of narrative structure developed by Propp¹¹ with respect to Russian fairy tales.

However, both the dramaturgical metaphor and the elaborate classification of functions and agents offered by Propp appear somewhat far-fetched when applied to the detached and dry descriptions of a paper on natural or technological science. Greimas reduced Propp's scheme to a core structure which consists of the transformation of a need through the transfer of a valued object from an 'addressor' to an 'addressee' by a 'subject' helped by an ally and hindered by an opponent.¹² Since the appropriate parts of the scientific paper analyzed here appear to be cast in terms of needs and supplies or problems and solutions, the basic function of need-transformation can be retained from Greimas' analysis. However, rather than force a close correspondence to Greimas' structural units, we will rely principally on a model abstracted from the scientific text — a model which is recurrent in both the narrative sections of the paper and the respective observation notes and interview transcripts. Before presenting this model, let us emphasize that the scientific paper is sharply subdivided into familiar units;¹³ of these we will retain the Introduction, the Materials and Methods, and the Results and Discussion as core elements to be analyzed here. Narrative structure (in the sense of the above model) will be found mainly in the Introduction. However, the latter is of particular importance because it defines the action of the paper and relates it to the context of the field. Consequently, the Introduction will be given special weight in the analysis to follow.

THE STORY OF THE INTRODUCTION

The argument of the Introduction can be subdivided into a series of textual units which do not necessarily coincide with subparagraph structure. These units describe a resource or object of supply held by a supplying actant¹⁴ which responds to a largely implicit need on the part of a demanding actant. The narrative unit also includes statements which qualify the supplying actant with respect to its paradigmatic alternatives by reducing the general form of the offer to the restricted form of a particular quantity, quality or named variety. The qualifications determine the modality of the supply, i.e. the logical status according to which the possibility, impossibility, contingency or necessity of the object as a supply of the demand is asserted or denied. In the Introduction analyzed here, the modality of contingency predominates: i.e., the transformation of a need depends upon the transformation of a further derived need. Or phrased differently, the status of certainty as a supply (or a solution) with respect to a demand (or a problem) can only be accorded to an object if a secondary demand (or a problem) generated by the previous supply (or solution) can be eliminated. In this way a closed - and hence a static - Demand - Supply unit appears to be transformed into a structure which allows for closure only through opening up secondary Demand - Supply units, a structure which is made inherently open and dynamic through potentially endless chaining operations.¹⁵

(Fig. 1 about here)

Let us illustrate this scheme with respect to the first paragraph of the Introduction (see App. 1). According to the analysis summarized in Fig. 2, the paragraph begins by instituting the potato tuber (A_{12}) as a provider of protein (O_1) to a world (A_{11}) which we must assume lacks protein in food systems. The actant is qualified with respect to its implicit, paradigmatic alternatives - such as other protein yielding plants (e.g. soy, alfalfa, rice) or proteins from animal sources (e.g. egg) - by the amount of protein it supplies. It will be qualified once more in a later textual unit with respect to its (protein) quality (TU_6).

We should not be worried by the fact that both the demand (for protein) and the paradigmatic alternatives of the potato tuber as a protein source remain unstated in TU_1 . First, the supply or resource character of the respective statements could not be understood without assuming some taken-for-granted need. Accordingly, the introduction to the first version (which is more explicit in many respects than the discrete final paper) begins by stating that the potato tuber 'provides the world with six millions metric tons of protein per year', and that it 'has potential as an egg white substitute in some food systems'. Moreover, the laboratory notes repeatedly suggest that the world food problem at that time was seen at least partly in terms of protein (although one of the co-authors referred, toward the end of the observations, to a rising controversy about this definition of the problem). And finally, the unstated paradigmatic alternatives of the potato tuber as a protein source are made more explicit in TU_6 , a brief paragraph which was originally part of the first paragraph. (It should also be noted that the experiments in question were also conducted with soy and rice protein, although for reasons related to publication policy the results were not reported in the text analyzed here).

In line 6 of the Introduction, we see that another actant is instituted as a potential supply of large amounts of protein: i.e., the potato processing waste effluent in paradigmatic contrast to the starch, flakes, granules, etc. mentioned. It appears that this new supply responds to a demand implied by the choice of the original actant, i.e., a demand that those parts of the potato tuber which have not as yet been utilized for nutrition of any sort be used as a source of protein. Phrased differently, the status of protein from potato plants is contingent upon establishing that the potential of this protein source has not as yet been exhausted by normal plant food consumption. - Fig. 2 presents a summary of this and the other textual units of the Introduction:

(Fig. 2 about here)

As indicated by Fig. 2, the waste effluents are qualified by the quantity of protein available from them (ll. 13-15), and by composition data which prove the actant's possession of the object (ll. 17-20). However, the ambiguity left between the demonstrated existence of protein recovery from waste effluents 'in various European countries' (1.13) and the non-existence ('potentially' available, 1.14) of the protein recovered precludes the premature conclusion that obtaining the protein is a matter of adopting existing recovery practice.

Thus, instead of an end to the chain, we have another demand-- that for suitable methods. Line 21 refers to this demand by asserting that 'there has been an interest in the recovery of potato protein during the past 60 years', a demand which is reinforced by durative aspectualization and followed by a responding supply ('several methods have been reported'). The providing actant implied by the last phrase is science; the bearer of 'interest' is industry which is obliged by law in some countries to remove protein from waste water for environmental reasons.

The fact that of the 8 methods mentioned to qualify the supplying actant, only 3 will ever be taken up again confirms that what is instituted here is not a particular way of handling the demand, but rather science as the general authority to solve the problem. The variety demands that a choice be made, as does the subtle ranking introduced by the formulation. 'proponents of heat coagulation ... most commonly use temperatures in excess of 90°C' (ll. 25-27), which inserts a distance between the authors and those who advocate the potentially negative use of 'excessive' temperature. The ranking is extended in ll.28-30 which classify FeCl₃ as 'comparing favorably' with another precipitant, and somewhat dissipated by lines 31-34 which report on two irrelevant methods.

Paragraph 4 responds to paragraph 3 by presenting the object of demand as chosen by commerce - in contrast to the choice to be made later on by science. What follows is the first de-institution of the Introduction: the offer (heat coagulation) is qualified by high costs and restrictive food applicability, which add up to a disqualification. As in paragraph 3, FeCl₃ is noted in passing as preferable with respect to protein quality. Dissipation is repeated by slipping in an alternative method of coagulation, followed by two small paragraphs which essentially repeat previous points.

TU₅ qualifies potato protein as equivalent or superior to other proteins, once more instituting the potato tuber as supplying actant. And TU₆ once more de-institutes heat coagulation by apparently attributing an earlier recommendation to the date of 'that time', as a supplying actant which automatically calls for an 'up-dating' of the analysis. The iterating links between TU₁ and TU₅ and between TU₄ and TU₆ account for the spiral-like paragraph structure of the Introduction and interrupt the flow of contingent modalities between textual units such that TU₇ responds to TU₄ rather than to TU₆. We can say it 'responds' because the comparative evaluation of 3 coagulation methods which TU₇ introduces as the purpose of the paper is presented in the imperfect tense, i.e. as a work already achieved. This comparative evaluation is at the same time instituted as the mandate¹⁶ which follows from the final demand for method selection.

The element of the mandate is nothing new: it is only an explicit version of the mandate to transform a need implied by each S - D structure. The final mandate gains special importance from the fact that the fulfillment of previous needs hinges upon its effective realization. Needless to say, the actants who are to carry through this mandate to supply the final object of demand (the best suited recovery method) are the authors of the paper.

THE ACTANT STRUCTURE OF THE STORY: RATIONALITY RESTORED

Let us look for a moment at the complete actant structure of the Introduction. For the sake of lucidity we have inserted Units 5 and 6 where they belong thematically. Since the supplying actants always appear to demonstrate their potential (through qualifying statements) not only in regard to the respective demands, but also

in regard to alternative resourceful actants, examples of the latter are included:

(Fig. 3 about here)

If we eliminate the productive system in TU_4 and the date in TU_6 , which are introduced only to be deinstitutioned, there are two classes of supplying actants represented in Fig. 4: products such as the potato tuber or waste effluents, and science in general and in specific (the authors of the paper). In the case of the demanding actants, there are again two classes: the public, as represented by the world, 'human adults', the US, or the system of social reproduction, and private interests, as referred to by commercial and economic needs. Since demanding and supplying actants cannot be considered as independent, there is an element of irrationality in the separation between demand and supply. Thus, it is not nature which confronts the world of human agents, but the potato tuber as a product of human agriculture; and the US is separated from the potential fruits of the enormous waste it produces. In TU_3 , it is commerce and science which confront each other, apparently because of the neglect on the part of the productive system toward what could be called public or social reproductive costs provoked by nutritional deficiencies, high energy consumption, and public water hazards. TU_6 confirms the irrationality of this neglect and separation by spelling out the disrespect for economy involved in the current practice of 'commercial' recovery which, it is implied, results from the insensitivity of business to change (i.e. the increasing importance of the above mentioned social reproductive costs). The fact that the supply side of the argument is emphasized in the text (supply of protein from potato and waste, of methods, of a potential alternative method, of protein quality), whereas the demand often remains implicit, sustains the connotation of an unnecessary separation. It is up to science to restore

rationality by providing the method(s) to bridge the gap. Without wanting to resort to the outworn image of science as the pillar of rationality in our culture, we cannot help thinking that the text actually reinvokes such an image.

If we allow for the fact that the ethics of the fairy tale (in which divine or human law is restored through punishment of villainy) are replaced by an ethic of restored rationality, we can give a summary description of the grand actant structure of the paper using Greimas' model: A demand on the part of the world or US system of reproduction (addressee) could potentially be eliminated by neglected (wasted!) products of the productive system (addressor), a fact which is uncovered by the authors of the study (subject) and effectuated with the help of methods provided by science in general (the magical agents of Propp's fairy tales) after discrediting the 'opponent' commerce (Propp's false hero). As mentioned, the opposition derives from the productive system's neglect of its own and society's costs, which results in the above multi-level separation.

(Fig. 4 about here)

It may be interesting to learn that the first draft of the 'Interpretative Summary' and Abstract rather exactly reproduce the above summary description (App. 2), while the final Abstract - with its extensive extracts from the Results and Discussion - lets the reader do part of the summarizing himself.¹⁷ The ease with which we can give a mythic reading to the paper as analyzed so far cannot be explained away by the general character of Greimas' scheme, which cannot be applied in an illuminating way to the structure of the Method and Results section, nor to the following scenes from the laboratory.

THE STORY OF THE LABORATORY

In the laboratory narrative, the part played by the Introduction corresponds to various quotes and references - spread throughout the story - as to how and why the scientists chose the respective research focus. When the period of observation began, the work was about to be started. We will put together relevant quotes from the author of the paper (W.), who originated the research,¹⁸ and summarize some of the observer's notes. To begin, let us quote W's response to the question as to whether or not the research had been planned:

'No. Originally, I did not want to do any recovery research. Rather, it turned out that I would have to generate the protein I needed (for another project) myself because I did not get it from (he mentioned the name of a laboratory). But originally I did not want to make a separate paper out of this work ... I wanted to finish it as quickly as possible, and thought about simply working together with F ...'.

F. was a colleague at the institution who had recently published a recovery method involving phosphoric acid. However, there were technical problems - principally, that the experiments needed to be done under nitrogen, which was difficult in the large scale laboratory which W. had to use (because he needed large quantities of protein). Furthermore, W. had discovered a paper which, for environmental reasons, recommended the use of hydrochloric acid in place of phosphoric acid. Finally, F.'s method was simply too expensive.

The opportunity which established protein recovery as a research effort in its own right was hit upon when W. happened to read that ferric chloride was used for protein precipitation:

'... I thought it must be cheap, otherwise, they would not use it. And I read that it can be done at low temperature without heat treatment ...'.

In the context of an energy crisis, the use of a protein coagulation method which worked at low temperature (thus, low energy consumption) and would probably result in a higher nitrogen solubility (implying better applicability) struck W. as an excellent solution:

'In Europe (where this sort of protein recovery was mainly done), everybody who recovers this protein uses heat coagulation. Since protein concentration is only 0.5%, one has to heat enormous quantities of a solution to get 1 kg of protein ... They realize that this is a problem and attempt to concentrate the liquid before heat coagulation - but this is expensive, too. And the result is an almost insoluble protein causing all kinds of problems!'

Later, he added:

'I was also already concerned about the fact that I had not covered any technological topics in my protein work up to then. ¹⁹ I thought that if I have to go into the large - scale laboratory anyway and generate the protein myself, I might as well make some comparisons and see whether the ferric chloride works. This would fill the gap...'

From the observer's notes, it appears that the above-mentioned large scale laboratory with its high cost equipment and well-trained staff was considered a highly appealing resource for the scientists, and one made even more attractive by the fact that access to the laboratory

was not easily granted by the head of the group to which it belonged. Thus, many conflicts evolved around the negotiations with the laboratory head for access,²⁰ and on several occasions it was made clear that any reason which would allow one to 'exploit' the potential of the equipment in one's own work was welcome.

The field notes also document that the main author of the paper was committed to do some protein work not clearly specified in return for funds received from a cooperative research institution to which he had to send regular reports. When this contract was discussed at a later date, it turned out that W. hoped to use part of the results of the recovery work in his reports: :

'... There is this contract I have (he talked about the financing institutions, and the problems with the protein they generated). I know that their (recovery) procedure is bad, and I know from pretests I did that the suitability of their protein is very low. They should be interested in this work ...'

When asked specifically whether he had searched for a method which would work at low temperature and thus meet the energy-reduction and nitrogen-solubility requirement outlined in the text, the scientist said:

'No. I think I was not clever enough originally to see that it would be better to recover protein without applying heat treatment. I probably first read about the ferric chloride. One needs stimulation to see ...'

(italics by the authors of this paper)

In sum, a series of personal advantages or 'solutions' thought to respond to some latent or apparent needs account for the existence of a research focus which had originated when W. routinely read a journal article. A representation of the 'text' supplied by the

laboratory notes in terms of the end points of the respective narrative units runs as follows:

(Fig. 5 about here)

There is no need to repeat a detailed description of the narrative units which branch out from these endpoints. Let us just briefly highlight the main differences between the observer's narrative and that of the Introduction. First, in the observer's text, there is a series of demands to which the discovery of FeCl_3 precipitation is said to provide a potential solution: W. needed to find a method to generate the large amounts of protein demanded by his bioassay and protein additive work; he needed to come up with some interesting results in return for the funds he received; he saw a need to research a technological topic in order to qualify for the kind of position he was seeking; he was interested in using the highly valued resource of the large scale laboratory; and he was aware of the demand for protein and of the fact that protein recovery as currently practised was unsatisfactory.

Thus, in regard to the raison d'être of the research, the observer's narrative offers an inventory of various demands, most of which are not elaborated in depth. Yet the story of the Introduction emphasizes one string of supplies related through progressive dependency. Of the demands referred to in the notes, all but the need for an improved recovery technology are absent from the Introduction; and not surprisingly, the major actant of all the demands most conspicuously absent is the scientist himself.

Most important, perhaps, is the fact that in the written Introduction the dynamics of the process are reversed when compared with the laboratory narrative: in the laboratory, it was the chance occurrence of what has

elsewhere been called an 'opportunity of success', ²¹ i.e. of a solution or a "supply" giving rise to (in the sense of actualizing) a series of latent and potential demands which henceforth 'sustained' the investment in this solution; whereas in the paper, it is the demand for a protein recovery technology which seems to necessitate the experimental comparative evaluation of several methods which the work is said to provide. In Greimas' terms, the 'pouvoir faire' (doing potential) generated in the laboratory by the discovery of FeCl_3 precipitation leads to the 'devoir faire' (mandatory doings) of the work, whereas in the Introduction it is the carefully derived mandate of the scientists to establish an alternative methodology which the rest of the paper documents as an achievement, i.e. as the author's - 'pouvoir faire'.

(Fig. 6 about here)

The fact that the scientist had searched for a method to generate the protein he needed should not delude us as to this reversal of dynamics. The crucial aspect is that there had been no purposeful search or research plan with respect to the demand for an alternative recovery technology described in the paper. Nor had there been a hypothesis as to how the existing recovery problems could be solved. In general, our observations suggest that new research efforts begin with such hit upon potentials to eliminate some demand(s); or, phrased differently, from a solution rather than from a hypothesis.

The difference is subtle but consequential, since it is the perceived solutions which push the research process forward, and they push it in whatever direction the potential may lie. In contrast to hypotheses, a "pouvoir faire" does not refer us to the imaginary world of tentative explanatory interpretations. It is linked instead to a

personal interest structure (exemplified in W.'s case), and rests upon a material core - e.g. a result which has been shown to work in another context or a highly suggestive experimental outcome. Furthermore, it implies feasibility under given instrumental and organizational conditions.

While such power with respect to some demand(s) may emerge unexpectedly, the occasions of emergence are bred²² by the mandatory doings of projects adopted earlier as exemplified by the reference to W.'s search for a method. Accordingly, the role of the above solutions or opportunities does not lie in the fact that they eliminate search processes from the laboratory, but rather in the dynamics of the problem shifts they introduce into the process. To return to our example, the differential importance of FeCl_3 precipitation with respect to the overall research process is not so much in eliminating the need for a method of protein generation in the context of the projected assay and additive work, as in its role in initiating a wholly new research focus. Let us not forget that the 'pouvoir faire' is always a potential, not only in the sense of a power to achieve something, but also in the sense of a not-yet-actual achievement. Thus the emergence of the potential is usually followed by often quite tedious 'make the stuff work' operations which are the enactment of investments made on the promise of high returns.²³

THE STORY OF THE LABORATORY CONTINUED

We have said that W.'s discovery of the potential of FeCl_3 precipitation generated the mandate to convert this potential into the actual achievement of a method that would work for the plant material chosen. In the story of the laboratory provided by the observer, this mandate was subsequently translated into a host of further tasks, such as convincing superiors of the significance of the research, obtaining money for buying the raw material, "borrowing" laboratory assistants to do routine experiments deemed necessary, gaining access to laboratories, etc. We could continue to describe the macro-structure of the laboratory narrative in terms of the S - D - S model used so far, of which the mandate forms part. Given the volume of material, however, it will be more effective to draw attention to the shift of focus which emerges from the narrative properties of the field notes when they are compared with the paper analyzed so far.

The difference can perhaps best be summarized as a shift from a state description to a fully blown action description. In the Introduction, a series of supplies and inferred demands delineate a state of affairs from which the need for change - presented in the imperfect tense as something already achieved - is derived logically in the final sentence. In the laboratory narrative, it is first and foremost the dynamic of tasks and doings which dominate the presentation. These tasks are rarely fully specified, as apparent from constant interpretations and negotiations. The space created by this indeterminacy is filled by statements of qualification, or phrased differently, by ad hoc modality work. Given indeterminacy, the tasks which flow from the original mandate present themselves in terms of what should be done and what could be done, rather than as what definitely had to be done in the sense of a

mandate. What should and what could be done is heavily influenced by conditions which hold at the site of the work, as related to the power and interest structure of particular actants. ²⁴ In other words, the happenings of the laboratory narrative are characterized by indexicality and actant particularization.

To illustrate this, let us confront the reader with another extract from the laboratory notes taken on February 9, 1977, one day before a second run of large - scale recovery experiments was begun:

While on the telephone (with T.), W. learns that K. has finally agreed to let him have the pilot plant, after making lots of difficulties. The date is to be tomorrow, Thursday. This puts them under considerable pressure ... Except in an extreme case, the date set by K. cannot be changed; besides, they should be glad to be able to use the lab at all.

According to W., the first thing to get is the adsorbent agent needed for the tests. W. searches for about two hours, but does not find any of it in the storage rooms, nor in some of the labs which usually use it. W. finally says he realizes that the adsorbent agent intended might be bound with the protein. They could risk it in this case, since the effect is pH dependent, but he does not like taking the risk.

The problem is discussed with different colleagues. A. suggests trying CaCO_3 (one of the most important adsorbents with respect to colour and smell). A. says that he had used it once when trying to separate protein from some other ingredients, and it worked perfectly. W. says they will have to try this tomorrow, as there is no other alternative. The major problem is that CaCO_3 will probably contaminate the protein.

They will see what the result looks like, and try to get rid of the CaCO_3 later.

The second problem is at what point in the process they should add the CaCO_3 ... If the CaCO_3 is added before they make the split into HCl and FeCl_3 treatments, they can compare the new HCl-precipitated protein with the old one (for which no adsorbent agent had been used) and see what they've gained - if anything. If the CaCO_3 is put in at the beginning, it will bound with the starch and be removed with it after centrifugation. To add it later in the process would better correspond to conditions as they hold in practice, but they have fears concerning colour in this case.

Furthermore it is questionable whether the CaCO_3 can be removed. In any case, it implies using the Sharpless (large-scale-high-speed centrifuge) a second time, and Ke. (the technician heading the pilot plant laboratory) must be persuaded to agree to this. If Ke. says this cannot be done, they will not be able to change his mind.

A third possibility consists in adding CaCO_3 after the split into different treatments, and to go into the Sharpless with only half the product. W. says he would not have dared to do this with Bentonite (the intended adsorbent agent). Since he had read that fractions of the protein are responsible for the volume decrease effect (obtained in another series of experiments under way) he thinks that Bentonite might have bound exactly with the inhibiting protein fractions, in which case they would have obtained artifacts ... etc.

The example need not be extended to illustrate the emphasis placed on tasks rather than on states of affairs, the play of reasons (modality work) in which this task structure is embedded, and the indexical dependency of what is being done upon the situation at the research site. The actant

structure is basically agonistic: it rests upon a generalized conflict which ranges from struggles over local resources to competing interests with respect to impact on the scriptures of the field (domains of scientific writings) and on practical domains - none of which is independent from the others. Thus, K.'s reluctance to grant access to 'his' highly expensive large scale laboratory, alluded to briefly in the beginning of the last example, exemplifies a strategy to monopolize organizational

resources which can significantly ease the production of results apt to leave an impact on the scriptures. Part of this agonistic structure can be seen when scientists elaborate on the significance of their products, as in the following extract (related to the previous example) from the notes of March 11, 1977.

.The protein which had been treated with CaCO_3 and filtered is brought from the freeze dryer. W. says he is very pleased with the fact that it is a white (purified) powder which should be completely soluble. He thinks that such excellent colour and solubility had not been achieved so far, even though protein recovery experiments (involving other source plants) had been done for 25 years.

W. talks with A. and shows him the white protein. He says that K.'s group (the other group working on protein recovery in the Institute, but with different source material) has a solubility of 5-10%, and they have worked on the problem for years. Their protein is greenish. Theoretically, a white product is thought to be possible, but not economical. In contrast, W.'s protein should be economically very interesting. W. says that this confirms his belief in the stupidity of the people at N., who had shown 'no interest' in his proposal to do the research...

Statements of qualification like the above determine the desired modality of the laboratory's products. They contrast with the paper in that they do not form a coherent, separate part of this narrative, and they contrast with the Introduction in that they qualify particular human actants in the field of interests which the scientists constantly (re)-construct as relevant to their concerns. In the above example, they qualify W. himself as the producer of a valued object (white protein) in contrast to K. who is disqualified — semiotically speaking — as a paradigmatic antagonist. Furthermore, they qualify 'the people at N.' as those who could profit from a supply to which they — stupidly — pay no attention. ²⁵

THE STORY OF THE PAPER CONTINUED: THE MANDATE ACCOMPLISHED

If we read the core elements of the paper which follow the Introduction, i.e. the Materials and Methods and the Results and Discussion (see App. 1), we find a series of striking characteristics. First, there is a thorough split into method and result sections which is not borne out in the story of the laboratory. Second, neither of these respective parts of the paper display a structure in terms of the narrative units employed so far. 'Method' in the paper seems to be a recitation of a formula or recipe, rather than a narrative discourse; it offers a laconic catalogue of 'doing' ingredients stripped of their context and rationale. Rather than tasks of laboratory narrative, we find strict doing descriptions; ²⁶ rather than actant particularization, we are confronted with particularization through proper names of instruments, materials, and authors of methods; and indexicality, along with indeterminacy, is eliminated from the picture.

This last aspect is perhaps the most surprising: while we would clearly not expect a scientist to detail his personal interests and organizational quarrels in a scientific publication, it is not obvious why the inclusion of a particular instrumentation, a composition formula, or a way of quantification and control should not be justified by technical reasons, or why a relevant problem encountered should be rigidly eliminated from a research 'report'. In the paragraph headed Materials and Methods, every reference to a device or a chemical substance, as well as every figure cited, represents the technically justifiable outcome of a choice. Only a few of these choices are standard preferences, such as the methods issued by the Association of Official Analytical Chemists which were used to determine chemical composition. Some involved several months of testing and modification, as in the case of adsorption where several adsorbent agents were examined between January 29 (first reference to 'the problem') and April 11 (final decision) and finally rejected in favor of a second run of centrifugation. Most of the procedures which lead up to the naked doing which appears in the paper leave their trace in official laboratory protocols, where technical rationales are often minutely documented. The following example is taken from the official protocol book of the technician who performed those chemical analyses of proteins not provided by service laboratories. The example refers to an HCl-hydrolysis method of lipid extraction which had to be modified. Needless to say, no rationale is given in the paper.

(Fig. 7 about here)

Clearly, it would not be possible to present in a scientific paper the full story of painful modality work which leads to a selection or modification. Rather, the point here is that technical qualifications which can account for a final choice and which are so prominent in the laboratory narrative and in the Introduction are rigidly avoided in the method section. The fact that the method section also presents the respective laboratory doings in a standardized, typified manner - that is as an average process which is strictly temporally organized - corresponds to this abstraction. As implied by previous examples, the same protein recovery experiments reported were performed three times, on 3 different days within a period of 5 month - each time under different environmental conditions and in response to different demands. Accordingly, different issues and relevancies characterized the respective laboratory scenes, and different problems were encountered and further responded to. To be sure, all 3 test series included a comparable procedure with respect to the protein recovery relevant here, and hence resulted in the 'same' protein. Yet typification with respect to the stated purpose of the work relates to the fact that the issue of adsorption which dominated two of the three test series is not even mentioned in the methods section. This purpose was described as the mandate necessitated by the final demand of the Introduction, and it is with respect to the bare accomplishment of this mandate that the method section appears to have been constructed ex post facto.

THE STORY OF THE PAPER COMPLETED: MODALITY WORK

In the results section of the paper, the structure of the narrative changes drastically once again. Rather than provide a doing-description or a narrative composed of S - D - S units, the Results and Discussion are couched in statements of similarity and difference mingled with occasional comparative evaluations provided by the authors (see App. 1). We have said that in the laboratory notes there is no sequentially separated part which corresponds to the Results and Discussion of the paper. However there is one aspect of the laboratory narrative which - selectively extracted - forms the core of the result section: the measurement traces. In the laboratory narrative, the official records of procedures, ²⁷ the diagrams issued by measurement instruments, the printouts or iconic representations were glossed over and scanned for their qualification. In the result section, a careful selection of these measurement traces is related to the final mandate of the Introduction, as in the statements

'Laboratory experiments showed that FeCl_3 compared favorably with HCl/heat treatment at pH 2-4 with respect to the amount of coagulable protein recovered from the protein water (Fig. 2)'.

(11. 3-5)

'Compositional differences among the PPC precipitated by various methods included higher crude protein in the HCl/heat precipitate, higher vitamin C and ash in those precipitated at ambient temperature (HCl, FeCl_3), and higher Fe values in the FeCl_3 precipitate ...'

(11. 89-93)

Or they are related to the results of predecessors in the area, in which case, characteristically, the conclusions are left open:

'Although laboratory experiments by the authors indicated that slightly less protein would be recovered at pH 4.0 (Fig. 2), Meister and Thompson (1976) showed that FeCl_3 precipitation produced maximum recovery at pH 4.0" (11. 32-35)

'The increased ash content associated with HCl precipitation at room temperature was also observed by Meister and Thompson (1976), who noted...' (11. 42-44)

The classifications of similarity or difference to which the 'Discussion' component announced in the title of the section seems to correspond is often indicated by adverbial phrases like 'compared favorably', 'more appropriate for', 'significantly higher in', 'equal or greater than', etc. Among the 101 lines of Results and Discussion, there is only one sentence which offers a tentative explanation, and one which refers to an influence pattern. In the final, summarizing paragraph each sentence except the very last contains a notion of similarity or difference. The last sentence relegates 'ultimate selection of a precipitation method' to a comparative analysis of a series of parameters, including those not discussed in the paper. In sum, the result section seems to concentrate exclusively on statements of qualification which credit - or discredit - the proteins which result from the different methods studied. If we allow for the quantitative (paragraph 'Protein Recovery') and qualitative ('Composition', 'Functional Properties', 'Amino Acid Analysis') dis-qualification of heat- and HCl- coagulation in most respects, it appears that the work of the Results and Discussion is to transform the original modality of FeCl_3 precipitation from a contingent possibility to a demonstrable potential.

THE TRANSFORMATION FUNCTION: ARE THERE RULES OF CORRESPONDENCE?

Let us summarize our results obtained up to now with a view toward the authentic claim of the scientific paper as a research 'report'. If the paper is called a report, the assumption is that there are transformation rules which link laboratory work to the written presentation. Since there can be no 'objective', independent account of laboratory work, we will have to search for such a link between the scientists representation of their work and what they 'report' in the paper.

In order to pursue this question, let us treat for a moment the observer's story of the laboratory as the best approximation of the scientists' representation.²⁸ What can we then say about the relationship between the two kinds of representation? Since we cannot assume that the scientific paper purports to provide a complete²⁹ action description like that which predominates in the laboratory representation, it is tempting to suggest that the scientific paper provides a summary or 'relevant description', i.e. a description limited to supplying necessary information under some relevancy-criteria. But what are these criteria? When interpreting a piece of information, we generally supply propositions which are presupposed, entailed or a likely consequence of this information. Thus, a scientific report may be called a description which only contains propositions referring to those actions/events which are immediately relevant (necessary or sufficient) for obtaining the technical outcome presented. This eliminates the non-technical facets of the laboratory representation, and accounts for leaving out propositions which can be safely presupposed. For example, the scientist will not inform his audience of the fact that he had to order the source material and to fight for access to the large scale

laboratory before starting his experiments. Nor will he mention what belongs to the tacit knowledge of a field:

According to the laboratory narrative, a major problem of protein recovery in the large-scale laboratory was the development of foam mentioned previously. The problem was dealt with in ad hoc decisions — ignored, treated with water or sprayed with a foam detergent. Asked why the problem and the way it was solved were never mentioned in the paper, the answer was: 'Well, this is trivial .. because everyone working in the area knows about the problem ... only outsiders are baffled by it ...'

In order for the paper to provide a relevant summary, it is crucial that tacit knowledge be sufficiently defined within an area, and that the information contained in a paper correspond to this definition. However, the laboratory narrative suggests that both assumptions may be unwarranted. In the case of the above example, the scientist continued:

'On the other hand, uncontrolled losses (by throwing away the foam) may be high, and the composition of the lost part may be different from that of the remaining product. (He explained that foam might contain more solid particles.) ... Furthermore, people use different chemical foam detergents which can change the functional properties of a sample and then they proceed to measure functional properties without either taking into account or mentioning the detergent ...'

This example shows that, even if knowledge of a problem can be safely presupposed, how the problem is solved by different scientists may not be irrelevant for the kind of results obtained. Why, then, is such information not included in the paper? In a previous paragraph, we tried to illustrate the discrepancy between the tedious work often necessary to establish a choice in the laboratory, and the skeleton of typified doings which 'corresponds' to this work in the paper. Note that here we must address ourselves mainly to the method section of the paper. As implied earlier, Abstract and References refer to other parts of the paper itself from which they extract (Abstract) or to which they add proper names (References). The Introduction refers to a field of demands reconstructed from the literature; and in the Results and Discussion, measurement traces are qualified with respect to the Introduction and to predecessors in the area. If the methods section were a 'relevant summary' of the research, including all necessary information, would the problem of know-how which pervades many laboratory interactions persist ?

After the first series of protein recovery experiments, the head of the group whose laboratory had been used asked to have the experiments repeated under slightly changed conditions. This was interpreted to mean that K. wished to familiarize his staff and himself with the actual procedure so that he could work on the topic himself later on. The observer was surprised: 'But K. is your co-author, he got the paper and read the procedure!' The reply was: 'Yes, but this doesn't mean that they will be able to do the stuff themselves ... There is no other reason why he should suddenly want us to repeat the work (which would not have led to a separate paper, being, by K.'s wish, a repetition) after he read the paper and realized that the results were important...'

What do scientists say when directly confronted with the question of whether the paper includes all necessary information? When the laboratory notes described the replacement of an ether-extraction method of lipid determination by a HCl-hydrolysis method yielding significantly different results, while no reasons for such a choice were indicated in the paper, the observer asked whether a scientific reader working in the area could supply the reasons himself:

'He could, in principle ... but it would require a lot of thinking. And he would have to presuppose that I did a lot of thinking too ... In practice, he simply would not know ...'

When the scientists were asked whether there was any general problem in understanding how a previous author had proceeded, they repeatedly replied along the same lines:

'There is some informal communication between scientists in the US, which means that the reason for using a certain procedure can be discovered informally ... I do this myself - I call somebody, or write to him, or meet him at a conference ...'

'There is a problem if one wants to replicate a result or repeat a method. As a rule, however, one does something else anyway. Hence, it is not so interesting to know exactly why and how certain things were done ...'

(italics by authors of this paper)

Lack of journal space was often cited as the reason current scientific papers do not include sufficient information on how the results were achieved. However, the above remark suggests that there may be no need to supply all the information relevant to the technical success of an outcome. Scientific papers may not be simply summary descriptions, and our conception of the paper as a concise research "report" in the sense of such a description may be wrong.

THE LINK BETWEEN PAPER AND LABORATORY: MEASUREMENT TRACES

Not surprizingly, it is the representation of the laboratory itself which tells about the process of transformation; that is, of how the scientists actually proceed when writing the paper. From a summary of this procedure it appears that the order of events as presented in the paper is more or less reversed when a paper is written:

To write the paper, the scientists began by putting together a set of tables and figures (which come last in the paper) as the "core" around which the paper was to be constructed. In the present case, the first handwritten version of the paper consisted solely of comments on these tables and figures - comments which later became 'Results and Discussion'. In other cases, the tables and figures were first supplemented by the section on methods. The basic manuscript consisting of data, "Methods", and "Results" was usually written in 1-3 days, depending on available time. The Introduction originated from another pile of paper (the literature)

and was written at the end, as was sometimes the case with the concluding remarks of the Results and Discussion. It had to be adapted to that section of 'the paper' consisting of methods and results, and at times was written by a supervisory co-author. Abstract and References are based upon other parts of the paper and upon the literature, and came last.

Then from where do the core sections of the paper which cannot be derived from other parts of the text or from the literature of an area originate? As suggested above, they originate from a pile of measurement data and laboratory protocols, the traces of laboratory work. These traces are the writings the scientists constantly generate instrumentally in the form of printouts, graphs, figures and lists of numbers, and in the form of flow charts of which a cleaned and averaged version reappears in the method section of the present paper.

If the above argument is correct, the link between the laboratory and the scientific paper cannot be established by identifying some rules of cognitive transformation: Scientists writing a paper do not recall the research process and then proceed to summarize those recollections. Rather, the link between paper and laboratory is provided by measurement traces which are at the same time the product of the laboratory and the source material around which the paper is constructed. The gap which seems to exist between the dynamics of the research process and the dramatics of the paper disappears when we conceive of the latter as resulting from a double mode of 'writing' rather than of a cognitive transformation. The 'inscriptions' (Latour) of the laboratory may be more suggestively studied for the way they are instrumentally carved from the highly artificial reality of science

than for the way they summarize nature, ³⁰ and the writings of the paper may perhaps be more fruitfully searched for the way they provide the selected measurement inscriptions of the laboratory with a con-texture than for summarizing research. Through various comparisons between the narrative of the laboratory and the story of the paper, we have contrasted some features of the modes of writing. What can we conclude with respect to the global structure of the con-texture provided by the paper ?

THE CONSTRUCTION OF CONTEXTURE

In order to answer this question, let us first reconsider the global structure of the paper. We will perhaps recall that the method and result sections were classified as 'reified' and elaborate versions of the basic S - D - S structure, i.e. of the mandate prescribed by the final demand of the Introduction and of the qualifications of the solution proposed to meet this demand. The final narrative can thus be seen to consist of a chain of S - D - S units sequentially related through contingent modalities which imply mandatory doings. If we ignore for a moment the fact that the text consistently emphasized the 'supply' or solution side of the chain and if we choose a simplification proposed by Callon, ³¹ we can describe this chain as one of problematic statements (in this case, demands) linked through progressive translation. Thus the demand for protein pre-supposes a demand for more nutritional resources and is

in turn translated into a demand for potato protein, and subsequently into a demand for potato protein waste, for recovery of this protein, and for an alternative recovery method. The supply of such a method, which the work attempts to establish, generated further demands (e.g. of eliminating the solanine, of reducing the ash, of improving the colour) which appear in the laboratory narrative. They constitute the connecting links for further studies currently in progress, but fall beyond beyond the range of the story of the paper.

The first point to emphasize with respect to the paper is that the narrative does not leave it with a sequence of demands, but also implies their progressive elimination, beginning with the supply (of the method) provided by 'the study'. Given the sequential contingency of the narrative units, we must assume that the transformation effectuated by this supply is fed back to the other links of the chain. Phrased differently, we must assume that the transformation of the modality of FeCl_3 precipitation from a conceptual possibility to a proven potential - a transformation which hinged upon the success of 'the study' - leads to a corresponding transformation of all the other contingent modalities. Fig. 8 presents a simplified representation of this progress.

(Fig. 8 about here)

A more careful representation would give credit to the fact that a transformation of the modality of supplied objects at the same time transforms these objects into new semiotic objects, i.e. into new potential sources of demands. Thus, we should add a further link to the chain by including the demand for purification of the protein generated by FeCl_3 precipitation - a demand to

which current, although unpublished, work based upon chemical modification of the proteins is addressed. It is interesting to note that current analysis of a biological paper shows a similar emergence of new semiotic objects via progressive transformation of a biological phenomenon from the state of a conceptual possibility to the state of proven existence, from which the new demand to conceive of the mechanism which generates the phenomenon leads to a new conceptual possibility.³²

In the present case, the object is not a phenomenon, but a method, and the interest is not in the existence of the phenomenon, but in whether and by what means this method 'works' in comparison with other methods. If we consider that FeCl_3 has already been demonstrated to work 'effectively' with respect to the quantity of protein recovered on a small scale (see ll. 28-30 of the Introduction and ll. 14-15 of the Results and Discussion), that the quantitative and qualitative effectiveness (high Nitrogen-solubility of the resulting protein and nutritive value of Fe) on a large-scale was demonstrated in the paper analyzed here, and that the possibility of further purifying the resulting protein (to improve the qualitative effectiveness) is demonstrated in a paper yet to be published, we can provide a model of the progressive transformation of the mode of existence of this method. In accord with the subject of the paper, the progress specified is not a progress of knowledge, but a progress of technology, as manifested by progressive modality changes in subsequent papers:

(Fig. 9 about here)

In the present paper, the progress of technology via the works of science is linked to the progress of practical demands sketched in Fig. 8. Thus, the work of scientists whom the paper references is inserted into the double frame of technology and practice, of which the latter is much more elaborate. It also appears that the mandate for doing the work, i.e. the need to find an alternative recovery technology, is derived exclusively from the string of practical demands. The paper refuses to even hint at the problems raised by the earlier experiments, although these problems are discussed several times in the laboratory narrative. We suspect that this dominance of the 'practical' frame over the 'scientific' frame will be reversed in basic science papers.³³ In accord with an agonistic theory of scientific practice, we also suspect that the earlier work would have been accorded more mandatory impact on the work presented if it had been done by the same group or if there had been an overlap of authors.

The important point here is that the frames, independent of their syntactic and semantic agents, are constructions of contexture, and that this contexture has the properties of a field of demands or a market which will be elaborated in accord with the audience implied from the very beginning of the work (cf. Fig. 5, D₅). Unlike the demand of the fairy tale, the accomplishment of the paper relates not to personal lack or loss, but to a generalized demand from which the authors can draw symbolic capital if their product is frequently 'bought' by other scientists.³⁴ It is this market which appears to confer upon the paper the 'value' and 'success' which we tend to attribute to the inherent quality of scientific results. And it is due to its character as an object of value in this market of

demands that the paper apparently wants to persuade. It was with respect to this market that the authors were persuaded to invest in a new research focus, and it is in reconstructing this market that the persuasion of the paper is achieved. Thus we may come to understand why the paper does not build up the value of its product as an optimal creation through providing a relevant summary of all the trouble/some laboratory accomplishments which were necessary to arrive at the final results. If we add to this the fact that scientific products are rarely consumed in the sense of direct practical or scientific re-utilization, but rather serve as starting points for modification and negation through other scientists, for official standardization work (in the case of a method) or for work which leads to incorporation into industrial processes, we will also come to see why the paper need not provide a summary description relevant for technical replication of its results. In the present case of a technological science, we should also note that persuasion with respect to the audience of the journal in which the work is published is not accomplished by creating or addressing the 'real' market of demands, as it will generally not be the readers of the journal who need or want the recovery technology proposed. Rather it is through projecting a market which exist in practice that persuasion proceeds.

Let us conclude by emphasizing that the presence of these fields of demands in the text allows them to be analyzed as semiotic objects, much as, in following Greimas, we can analyze truth as the modality of an assertion, and much as, in redoubling the precedures of the laboratory through the narrative of an observer, we can analyze the two modes of writing specified above.

The thrust of the procedure clearly depends on the degree to which it allows us to pursue the construction of reality in both the natural and the social scientists texts, rather than analyze these texts as data which represent reality. Needless to say, it should be interesting - and necessary - to trace different modes of 'writing' and different fields of demands in other series of related texts, perhaps including this one. After all, it is a double-bound third-order representation of the observer's second order representation of the scientists first-order representation, of which the paper analyzed purports to be another second-order representation ...

NOTES

We are heavily indebted to the scientists at the observed institution who willingly served as informants and discussants of the data collected; to Aaron V. Cicourel who first set us thinking on issues like the present; to Bruno Latour for insisting on a structural rather than dramaturgical model; to Francoise Bastide, Roy MacLeod and Richard Ogar for their comments and suggestions; and to the Institute for the Study of Social Change, University of California, Berkeley, which facilitated the research.

1. Cf. P. Bourdieu, 'La lecture de Marx: quelques remarques critiques a propos de 'Lire le capital'' and 'L'ontologie politique de Martin Heidegger', Actes de la Recherche, Vol. 5/6 (1975), 65-79 and 109-156; D. Silverman, 'Speaking Seriously: The Language of Grading' Theory and Society, Vol. 1 (1974), 1-15 and 341-359; J. Gusfield, 'The Literary Rhetoric of Science' American Sociological Review, Vol. 41 (1976), 16-34. See also more general R. Harré and P. Secord, The Explanation of Social Behavior (Oxford: Basil Blackwell, 1972) Chs. 8-10. A rare analysis of a natural science paper was recently offered by B. Latour and P. Fabbri, 'La rhetorique du discours scientifique', Actes de la Recherche, Vol. 13 (1977), 81-95. N. Mullins summarized some Rhetorical Resources in Natural Science Papers (unpubl. manuscript, Princeton: Institute for Advanced Studies, 1977). G. Böhme, K. Knorr and N. Stehr deal with the structure of scientific discourse on a more general level. See G. Böhme 'The Social Function of Cognitive Structures: A Concept of the Scientific Community within a Theory of Action' and K. Knorr 'The Nature of Scientific Consensus and the Case of the Social Sciences', both in K. Knorr et al., (eds), Determinants and Controls of Scientific Development (Dordrecht: Reidel, 1975) 205-256; N. Stehr and A. Simmons, The Diversity of Modes of Discourse and the Development of Sociological Knowledge, (unpubl. manuscript, The University of Alberta, 1978). The only attempt to deal with the relationship between research and publication I am aware of is by N. Gilbert, 'The Transformation of Research Findings into Scientific Knowledge', Social Studies of Science, Vol. 6 (1976), 281-306.

2. As claimed, for instance by Hofstadter who developed the difference between scientific and artistic uses of language. See A. Hofstadter, 'The Scientific and Literary Uses of Language', in L. Bryson et al. (eds), Symbols and Society (New York: Conference on Science, Philosophy and Religion in their Relation to the Democratic Way of Life, Inc., 1955), 291-335

3. While the institutionalization of publishing scientific work in journals began some 300 years ago when the Journal des Sçavans and the Philosophical Transactions were founded in 1665, the standardization of certain features of scientific papers according to Roy MacLeod (written communication) dates back only to the end of last century. The question left open is of course why and how such standardization came about, and what it means. Clearly standardization which is often interpreted as conveying persuasion effects with respect to the 'objectivity' of science does not preclude scientists from identifying different journals with different expectations regarding representation and argument within the grid of formal structure and expression, as obvious from hot debates and lengthy reasoning processes which often precede the selection of a journal.

4. See for example S. Aaronson, "Style in Scientific Writing", Current Contents, Life Sciences, Vol. 20 (1977), 6-15

5. Cicourel repeatedly showed the importance of this point with a view to sociological 'reports' (i.e. interview and questionnaire data). See A. Cicourel, 'Interviewing and Memory', in C. Cherry (ed), Pragmatics of Communication (Dordrecht: Reidel, 1974). See also the points made in his 'Discourse and Text: Cognitive and Linguistic Processes in Studies of Social Structure' Versus (1975) and his 'Discourse, Autonomous Grammars and Contextualized Processing of Information' (Bonn: Institut für Kommunikationsforschung und Phonetik, 1976)

6. See P. Bourdieu, 'La critique du discours lettré', Actes de la Recherche, Vol. 5-6 (1975), 4-8

7. According to its official directory, the institution employs more than 300 scientists (along with the technical and service staff) working on basic and applied topics in chemical, physical, microbiological, toxicological, technological and economic research. Most of the scientists hold degrees in a branch of chemistry or biochemistry and in one of the other above mentioned areas.

8. For reasons of space a full analysis of the difference between first and final version cannot be included. Occasional references to the first draft will be made where appropriate.

9. The properties of 'accounts' and the method of account analysis as an essential tool of the social sciences are discussed by R. Harré, 'The Ethogenic Approach: Theory and Practice', in Berkowitz (ed), Advances in Experimental Social Psychology (New York: Academic Press, 1977), ch. 8. The quote is taken from page 291.

10. Cf. Gusfield, op.cit.

11. Cf. V. Propp, Morphology of the Folktale, revised edition, (Austin: University of Texas Press, 1968). Propp's inventory of folktale agents comprises a 'villain', a 'donor', a 'helper', a 'sought-for-person', a 'dispatcher', a 'hero' and a 'false hero'. His functions include events such as 'interdiction' and 'violation', 'fraud' and 'villainry', or 'marriage'.

12. See A.J. Greimas, Semantique Structurale. Recherche de Méthode (Paris: Librairie Larousse, 1966) and Semiotique et Sciences Sociales (Paris: Librairie Larousse, 1975).

13. I.e. Abstract, Introduction, Method-section, Result-section, evtl. Summary and Acknowledgements, and finally References. It is only when we consider subparagraph headings that the substantial topic of the paper is touched upon.

14. We have retained the notions of an actant and the role attributed to modalities from Greimas' analyses. An 'actant' is a semantic agent determined by his function in the narrative (i.e. supplying a wanted object) and not by the syntactic position in a sentence. In accordance with this definition the actant - in contrast to the various agents appearing in the text - may remain implicit. See Greimas, Semantique Structurale, op.cit., 173ff. In his Semiotique et Sciences Sociales, op. cit. 26ff. Greimas proposes a semiotic definition of truth as the modality of an assertion in accordance with a semiotic definition of a referent as internal to the text. This definition is adopted here.

15. A chaining of 'problem statements' through translation to which we will briefly refer later was recently described by M. Callon, 'L'Operation de Traduction comme Relation Symbolique', paper presented at the conference 'Nouvelles Methodes d'Analyse des Contenus Scientifiques' (Paris: Maison des Sciences de l' Homme, May 1978).

16. The 'devoir faire' of Greimas. Cf. Semiotique et Sciences Sociales, op.cit., 34ff.

17. These results allow for the speculation that Greimas model may actually be a model of summarizing procedures with respect to certain types of discourse.

18. W's co-authors agreed on the relevance of the work with respect to the field; their personal reasons for accepting to cooperate - though obviously different from those cited in the following - do not in principle add anything new to the argument.

19. W. had worked on biological assays, texture and protein additives and planned to continue working on these topics. Lack of technological work would have been problem considering the kind of university career he intended to make.

20. For a brief summary of one such conflict related to the recovery work see K.D. Knorr 'Tinkering of Success: A Prelude for a Theory of Scientific Practice', Theory and Society (1978, forthcoming).

21. Cf. K.D. Knorr, 'Producing and Reproducing Knowledge: Descriptive or Constructive?', Social Science Information, Vol. 16/6 (1977), 677ff.

22. When we say breed we actually mean breed: we believe that it is the effort and interest sustained by mandatory doings from which the power to do new work under conditions of high probability of success predominantly emerge.

23. Misjudgements of the promise of a work on the part of the scientists are of course not excluded, and there are many historical examples for misjudgements of great consequentiality. People, and conditions, obviously differ with respect to the degree of which they succeed in - or allow for-perceiving and seizing of opportunities.

24. The inherent relationship between scientific action and interest is expounded in detail in Knorr, 'Producing and Reproducing Knowledge: Descriptive or Constructive?', op.cit., 669ff.

25. If this interpretation seems far-fetched, let me stress that the scientists repeatedly referred to the stupidity of the respective "group" who would not recognize the economic potential of the recovery technology developed.

26. In his theory of narrative structure, T.van Dijk calls an "action (doing) description" any description in which all sentences/propositions refer to the doings of a course of action. See T.van Dijk, Philosophy of Action and Theory of Narrative (University of Amsterdam, Department of General Literary Studies 1974), 29.

27. In the institution observed, procedures and results had to be recorded in official protocol books which remained a property of the institution.

28. Obviously this is a strong assumption even if we add that representations of what was going on were constantly elicited from the scientists, and that accounts given by scientists do in fact constitute the main body of our data. Since the scientists' representations will depend on the audience to which they are communicated, even strict adherence to unedited transcripts would not save us from the trap. For the sake of the argument, let us nevertheless pursue this fiction.

29. 'Complete' here means including intentions, purposes, reasoning, procedures etc. Cf. van Dijk, op.cit., 41

30. B. Latour and S. Woolgar call the laboratory an 'inscription' device with respect to the fabrication of measurement traces. Cf. Science in the Making (Beverly Hills: Sage, 1979) ch. 5

We refer to the reality of science as highly artificial because even the source material for experiments usually consists of highly purified substances, specially bred animals or organisms, selectively grown plant material etc., all products of science rather than of 'nature'.

31. Cf. Callon, op.cit., 16ff.

32. Cf. Bastide, op.cit., 15ff.

33. This seems to be the case in the biological paper referred to earlier, in which it is difficult to see the practical relevance of the work if we exclusively rely on the text.

34. For an attempt to conceive of scientific fields as the locus of accumulation of symbolic capital, credit or credibility see P. Bourdieu, 'The Specificity of the Scientific Field and the Social Conditions of the Progress of Reason', Social Science Information, Vol. 14/6 (1975), Knorr, 'Producing and Reproducing Knowledge: Descriptive or Constructive', op.cit., and Latour and Woolgar, op.cit., ch. 4

Figure 1. The core unit of the Demand-Supply chain

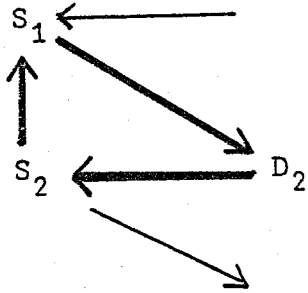


Figure 2. Chain of S-D-S units in the Introduction
(terms chosen such as to approach vocabulary of Introduction)

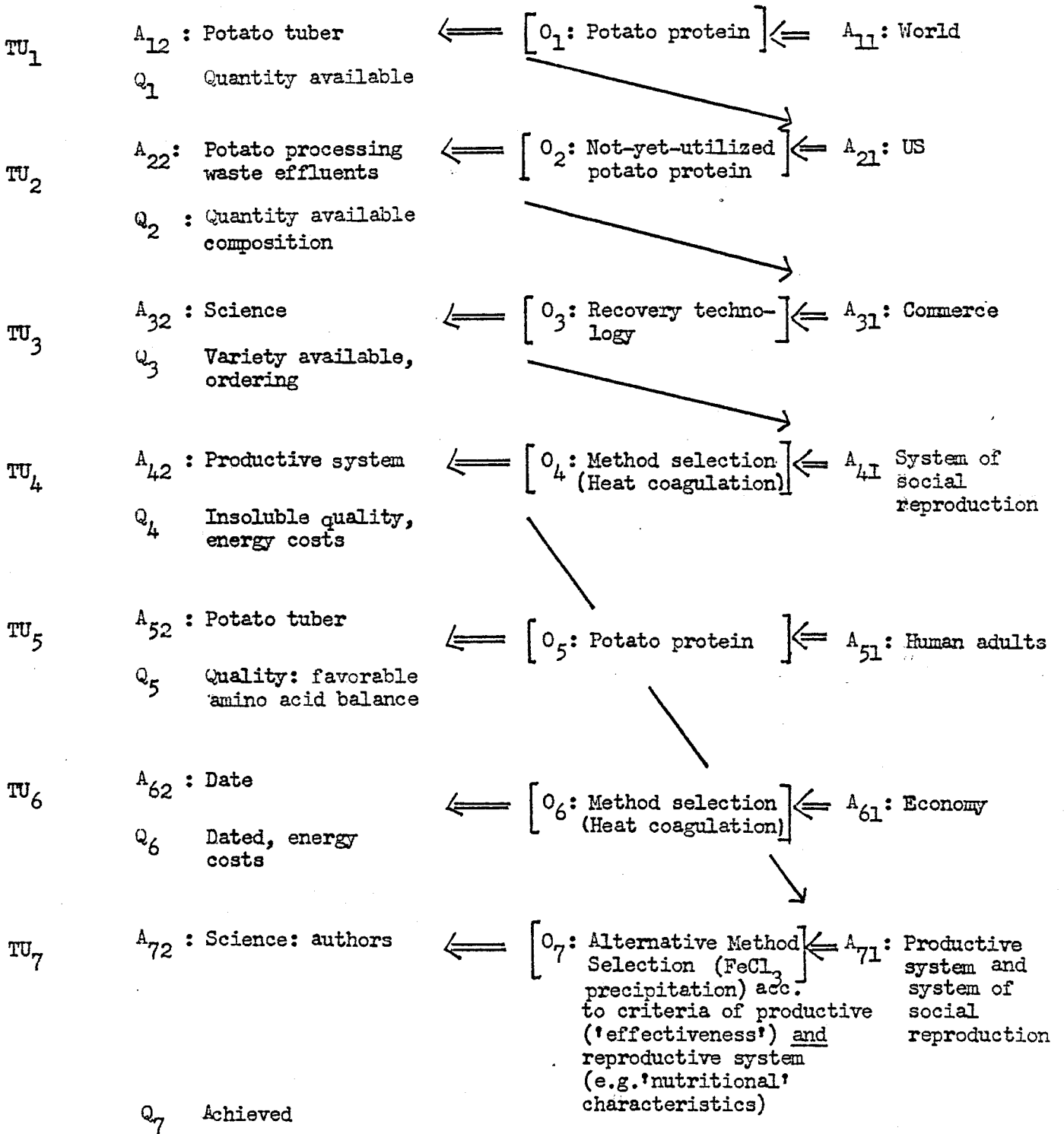


Figure 3. Actant structure of the Introduction

Text	<u>Supplying Actant</u>	:	:	Demanding Actant
Unit	Paradigmatic Alternative(s)			
TU ₁	<u>Potato tuber</u> Plant proteins, egg	:	:	World
TU ₅	<u>Potato tuber</u> Other plant proteins, egg	:	:	Human adults
TU ₂	<u>Potato processing waste effluents</u> Processed potato	:	:	US
TU ₃	<u>Science</u> Commerce etc.	:	:	Commerce
TU ₄	<u>Productive system</u> Science	:	:	System of social reproduction
TU ₆	<u>Date</u> Other dates	:	:	Economy
TU ₇	<u>Science : Authors</u> Other scientists	:	:	Productive system and system of social reproduction

Figure 4. Global actant structure in terms of the fairy tale model

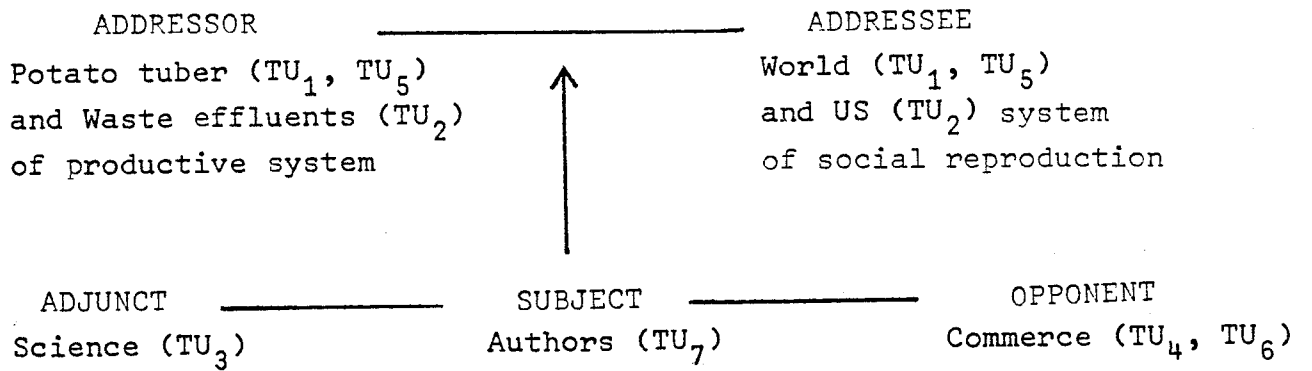


Figure 5. Simplified demand structure with respect to the origin of FeCl_3 precipitation in the laboratory narrative (actants in brackets)

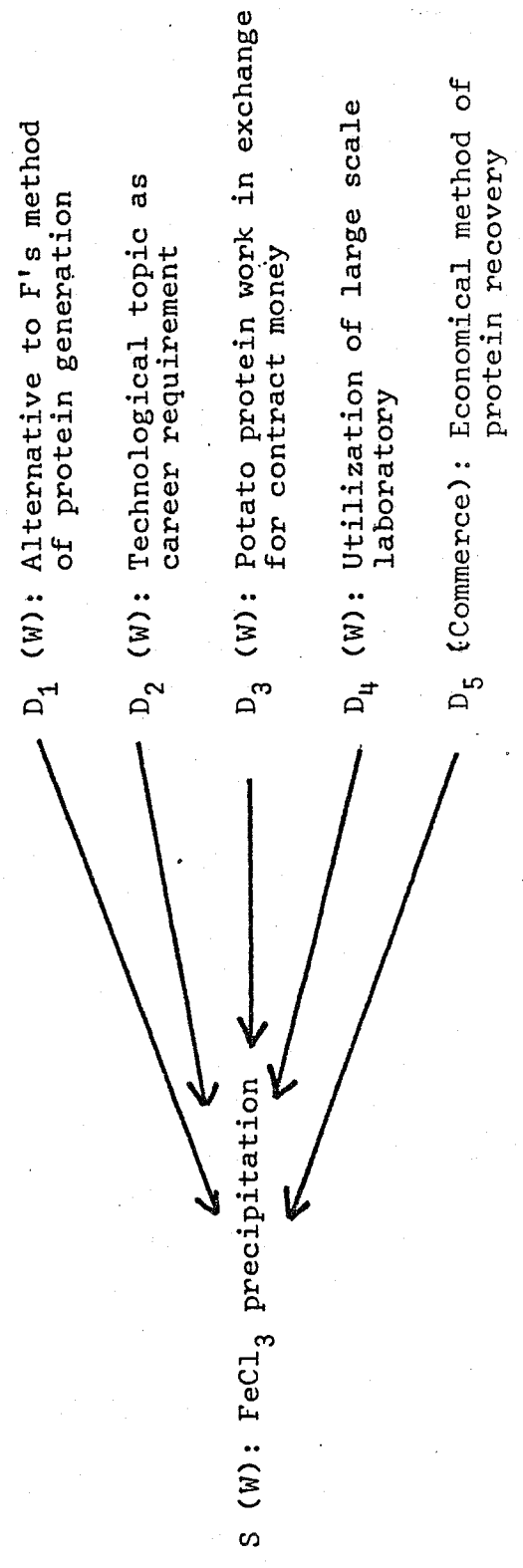


Figure 6. The origin of the research effort according to the Introduction and the observer's story

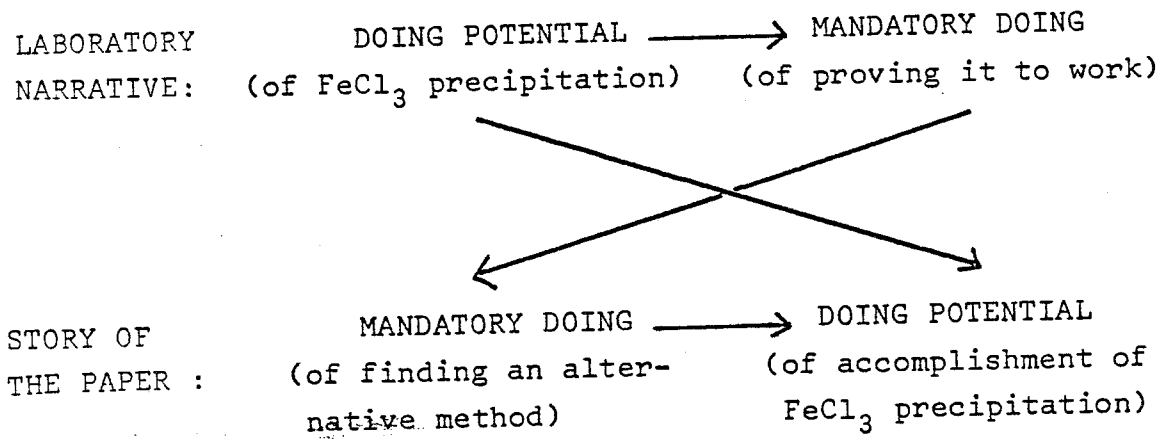


Figure 7. Rationale for amending a method taken from official laboratory protocol book

* Rationale:

A dry run using reagents only and the sep funnel, proceeded smoothly, However, problems were encountered when the first material, 286-6A (rice) ^{also 6B,C} was attempted. A murky, possibly imaginary interface appeared only after ~1 1/2 hrs., separating an opaque purplish upper layer which did not clear, from a blackish lower layer. Further, the "interface" could not be seen moving when the outlet was opened to drain off the lower fraction. Lastly, filtration of the extract (drawn from the top of the sep funnel) proved impractical: the cotton plug was overloaded with particulate matter almost immediately. The same occurred with potato products, ^{on occasion} though not with soy. In the latter case, the clear ether fraction which separated did so incompletely, for the volume recovered appeared far less than the 50 or 30 mls added. ∴ Centrifugation seemed appropriate to recover maximally the ether fraction in all three materials.

(Transcript:

* Rationale:

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Figure 8. Transformation of demands in the story of the paper

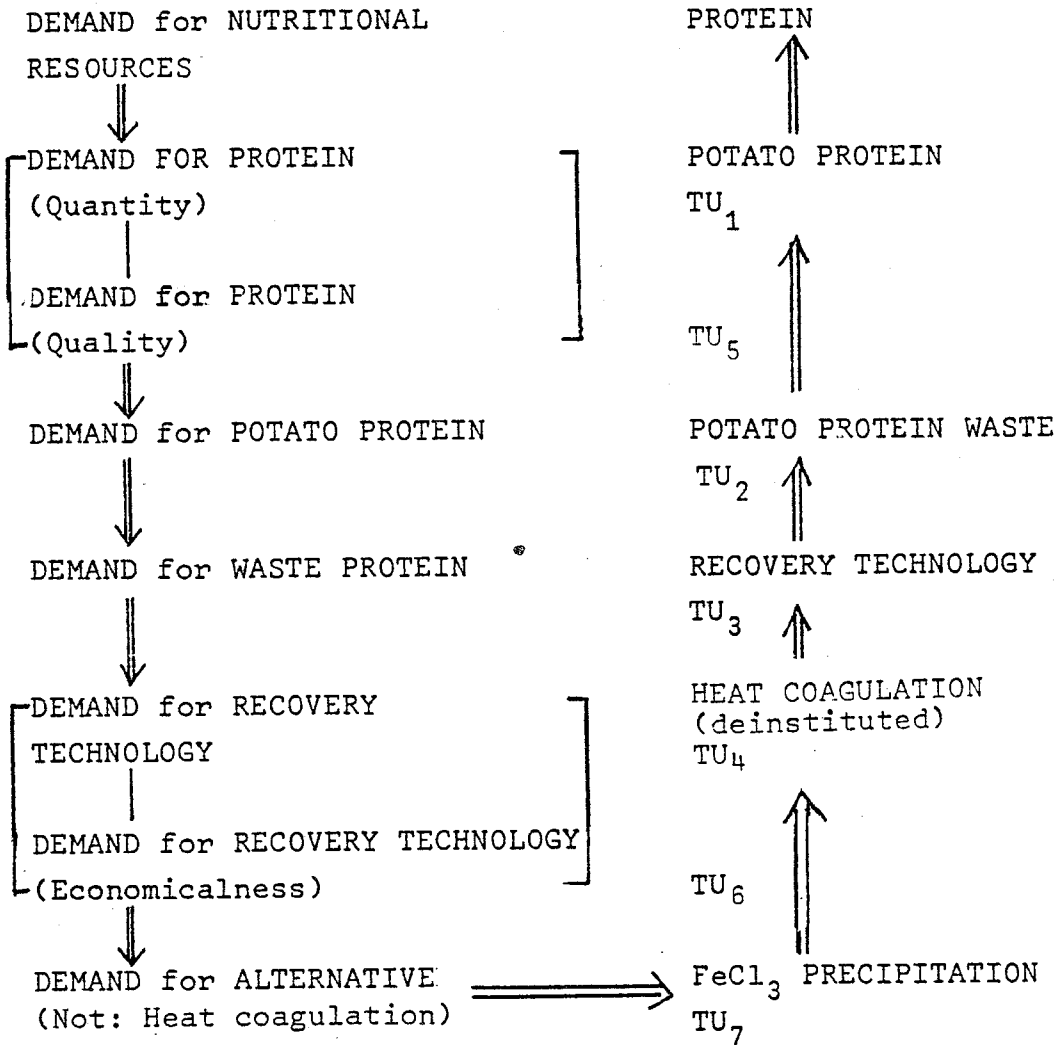
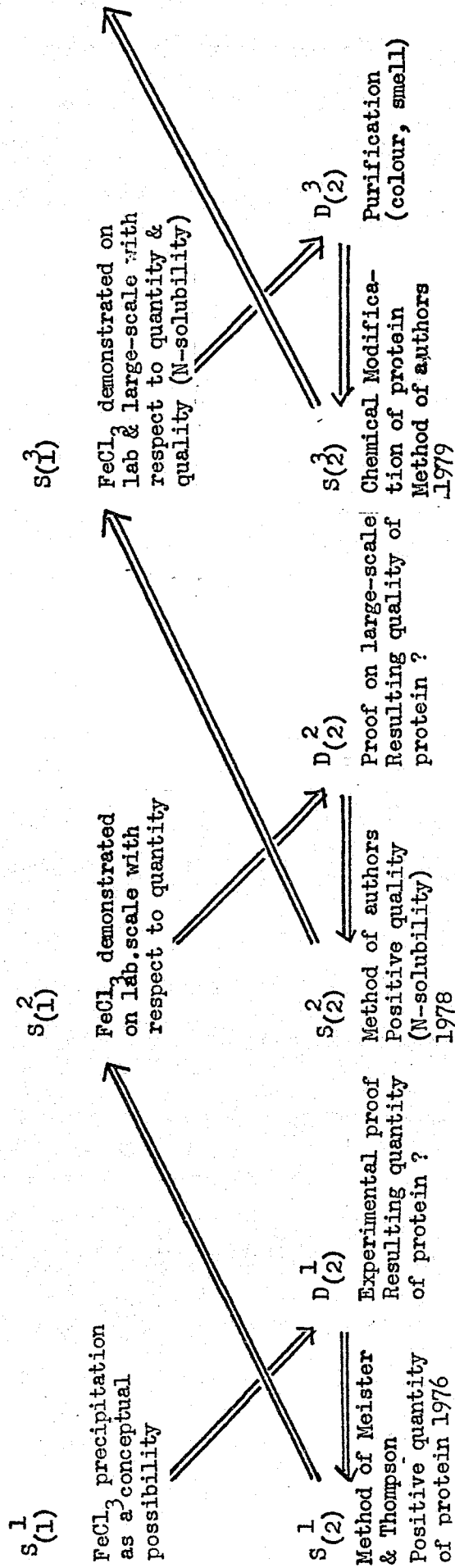


Figure 9. The progress of FeCl₃ precipitation as a method for protein recovery



Received for Publication October 4, 1977

ABSTRACT

Potato processing effluents represent a potential source of valuable protein as well as a major waste disposal problem. Potato protein is commonly recovered by heat (in excess of 90°C) with pH adjustment between 3.5 and 5.5. The present study compared yield, and some compositional, and functional characteristics of potato protein concentrate (PPC) recovered with either HCl or FeCl₃ (pH 3.0, 20–22°C), or HCl/heat (pH 4.8, 98–99°C). Under pilot plant conditions, recoveries of 22.7, 36.7, and 37.5% of the crude protein (N X 6.25) were obtained with HCl, FeCl₃, and HCl/heat, respectively. Crude protein content of the PPC precipitated by HCl, FeCl₃, and HCl/heat were 65.6, 57.5, and 78.2% respectively. Ash and vitamin C values were higher in those PPC recovered at room temperature, with Fe content being highest in the PPC recovered with FeCl₃. The nitrogen solubility of the FeCl₃ precipitate, at pH 7.0, was 1.5 and more than 7 times that of the HCl, and HCl/heat precipitates, respectively. Whipping capacity of PPC was not influenced by precipitation method. The most favorable fat absorption and water absorption capacities were exhibited by the HCl and HCl/heat precipitates, respectively.

INTRODUCTION

Potato tuber(s), henceforth termed potato(es), contain an average of 2.1% crude protein on a fresh weight basis. Annual, world-wide production of potato protein is = 6 million metric tons (Markakis 1975). In the U.S., approximately 268,000 metric tons of crude potato protein

(N X 6.25) are available annually (U.S. Dept. of Agr. 1976). A portion of this potato protein is in the form of processing waste effluents resulting from the manufacture of potato starch, flakes, granules, chips and french fries. Approximately one-third of the crude protein in the waste effluent (potato juice) may be recovered with heat or a trichloroacetic acid/heat treatment.

Potato protein is recovered from the effluents of potato starch manufacture in various European countries. Quantities such as 2,000 and 25,000 metric tons of potato protein are potentially available annually in Austria and The Netherlands, respectively (De Noord 1975; Huchette and Fleche 1976; Vlasblom and Peters 1958; and Wohlmeier 1974). The waste effluent from potato starch plants contains 2–5% solids, and accounts for = 55% of the BOD leaving the plant. A typical composition of the soluble solids is: 35% crude protein, 35% total sugars, 20% minerals, 4% organic acids, and 6% others.

There has been interest in the recovery of potato protein during the past 60 years, and several methods have been reported. Generally, these methods consist of heat coagulation, heat coagulation with pH adjustment, pH adjustment alone with HCl, H₃PO₄, FeCl₃, or H₂SO₄, ion exchange chromatography, and reverse osmosis. Proponents of heat coagulation (Strolle *et al.* 1973; Vlasblom and Peters 1957; and Xander and Hoover 1959) most commonly use temperatures in excess of 90°C. When pH adjustment is used, it is usually between 3.5 and 5.5. Meisler and Thompson (1976) demonstrated, in laboratory experiments, that FeCl₃ compared favorably with HCl as a precipitant of potato protein. Ion exchange chromatography has been used to recover protein, amino acids and potassium from potato waste streams (Heisler *et al.* 1972), and Porter *et al.* (1970) studied the use of reverse osmosis for potato protein recovery.

Heat coagulation is the most commonly used method to commercially recover potato protein. The energy costs of concentrating and heating the dilute waste effluent are a disadvantage of this method. In addition, heat coagulated protein is, generally, quite insoluble, which could limit some potential food applications. Of those acids used for pH adjustment, HCl is preferred in terms of cost and potential hazards to the public water supply. With the use of FeCl₃ as the precipitant, any Fe recovered with the protein could add to the nutritional value of the final product.

The amino acid balance of potato protein is quite favorable. Nitrogen balance studies with human adults have shown potato protein to be superior to most major plant protein, with its nutritive value approaching that of whole egg (Kofranyi and Jekat 1965; Jekat and Kofranyi

49 An economic analysis of alternative methods for processing potato
50 starch effluents was conducted by Stabile *et al.* (1970). At that time,
51 the authors concluded that concentration of effluents by evaporation
52 appeared to be the only economically feasible method. An up-dated
53 economic analysis may be warranted in light of increased energy costs.
54 The purpose of this study was to compare the effectiveness of HCl,
55 FeCl₃, and HCl combined with heat, as precipitants of potato protein
56 in the laboratory, as well as under pilot plant conditions, and to evalu-
57 ate some compositional, nutritional and functional characteristics of
58 the protein concentrates recovered by these three methods.

1 MATERIALS AND METHODS

2 Preparation of Potato Protein Concentrate

3 Potato processing water was simulated in the pilot plant. Washed
4 Russet Burbank potatoes (1.1 metric tons), containing 2.5% crude pro-
5 tein (N X 6.25) and 23% total solids, were used. The potatoes were
6 loaded into a modified drag chain feeder (Model A 632-44, Arnold
7 Dryer Co., Milwaukee, Wisc.) where 0.2% (w/w) NaHSO₃ was added to
8 inhibit darkening of the potatoes. The potatoes were then metered into
9 a 98 cm diameter vertical hammermill with swinging hammer (Owens
10 Mfg. Co., Verdon, Neb.) followed by a Morehouse Mill (Model 350,
11 Morehouse Ind. Inc., Los Angeles, CA). The slurry was diluted with
12 water (≈ 1:1 v/v) and insoluble solids were removed by centrifugation
13 at 3,200 G in a horizontal flow, decanter type centrifuge (Type P-3000
14 S, Sharples Co., Philadelphia, Penn.). The resulting supernatant, pH 5.6
15 contained 1.2 and 2.2% crude protein and total solid, respectively.

16 The aqueous solution containing the soluble protein (protein water)
17 was equally divided into three portions and processed as outlined in
18 Fig. 1. Two batches were adjusted to pH 3.0 and 4.8, respectively, with
19 2N HCl. The third was adjusted to pH 3.0 with a 28% (w/w) aqueous
20 solution of FeCl₃·6H₂O. The two batches at pH 3.0 were stirred
21 (Model Ag 100, Mixing Equipment Co. Inc., Rochester, N.Y.) in a
22 holding tank for 1 hr at 20-22°C. The precipitates were recovered by
23 using a high speed, disk-type solids discharging centrifuge, with 31 cm
24 bowl diameter and a RCF_{max} of 14,500 G (Model BRPX-207 S, De
25 Laval Separator Co., Poughkeepsie, N.J.). The batch adjusted to pH 4.8
26 was stirred for 15 min and then heated by steam injection to 98-99°C
27 (McDaniel Suction Tec, Dairy Industries Inc., Foster City, CA) as des-
28 cribed by Edwards *et al.* (1975) The heated coagulum was then pumped

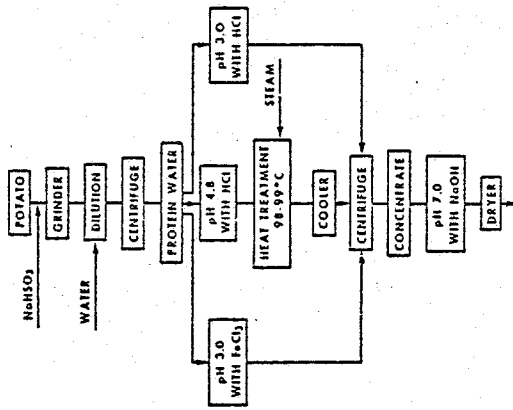


FIG. 1. SIMPLIFIED FLOW DIAGRAM FOR THE RECOVERY OF POTATO PROTEIN CONCENTRATES IN THE PILOT PLANT PROCESS

(Moyno pump type 380, Robbins & Myers Inc., Springfield, Ohio) through a plate type heat exchanger (Model Sc-3196, Creamery Package Co., Chicago, Ill.) where it was cooled to 24-26°C. The solids discharging centrifuge was used for the collection of this precipitate.

After collection by centrifugation the total weight of the concentrates was determined and samples were taken for Kjeldahl analysis. The yield was calculated as the amount of crude protein in the concentrates as a percent of the total amount in the protein water (see Table 1). The pH of each of the precipitated protein concentrates was adjusted to pH 7 with 2N NaOH. The concentrates were then sprayed at an air inlet temperature of 200-210°C and an outlet temperature of 105-110°C (Conical-type, laboratory model, Bowen Engineering Inc., North Branch, N.J.).

One experiment was conducted in the pilot plant on "potato cut water" obtained from a commercial potato chip processing plant. The effectiveness of the three precipitation methods, i.e. HCl, FeCl₃ and HCl/heat, was evaluated.

Table 1. Recovery of potato protein concentrates in the pilot plant by various methods

	Precipitation Method		
	HCl at RT pH 3.0	FeCl ₃ at RT pH 3.0	HCl/Heat pH 4.8
Recovery of Crude Protein	22.7	36.7	37.5
Recovery of TCA/heat Insoluble Protein	61.5	99.4	102.0

Methods for Analysis and Functional Properties

The standard AOAC methods (AOAC 1975) were used for the determination of total solids, nitrogen, crude fat, ash and vitamin C. Total sugars were determined by the method of Pottler *et al.* (1968) and total carbohydrates (in terms of glucose) were assayed according to the procedure of Dubois *et al.* (1956). The method of Kohler and Paller (1967) was followed for determining amino acid composition. Procedures outlined in Analytical Methods for Atomic Absorption Spectroscopy (Analytical Methods 1973) were used for the determination of calcium, iron, magnesium and sodium. Trichloroacetic acid (TCA)/heat treatment, as reported by Finley and Hautala (1976), was employed to determine TCA coagulable protein of the protein water. For the determination of coagulable protein of the protein water at different pH levels (see Fig. 2) the pH was adjusted with 2N HCl and 28% (w/w) FeCl₃·6H₂O solution at room temperature and filtered after 60 minutes through an S & S 576 filter paper. The nitrogen content of the filtrate was determined by Kjeldahl analysis. In the case of HCl/heat treatment the pH was adjusted and then the protein water was heated to 95°C for 10 min, cooled to room temperature and filtered after 50 min. A previously described method was used to evaluate nitrogen solubility (Betschart 1974). Water absorption capacity, fat absorption capacity, and whipping capacity were determined using minor modifications of the methods of Sosulski (1962), Lin *et al.* (1974) and Lawhon *et al.* (1972), respectively, as described by Betschart and Kohler (1975).

All experiments, with the exception of nitrogen solubility, were conducted at the initial pH attained. The means of laboratory experiments are the result of from 2 to 5 replications. Pilot plant data are based upon a single run with analyses of these samples carried out in from 2 to 5 replications.

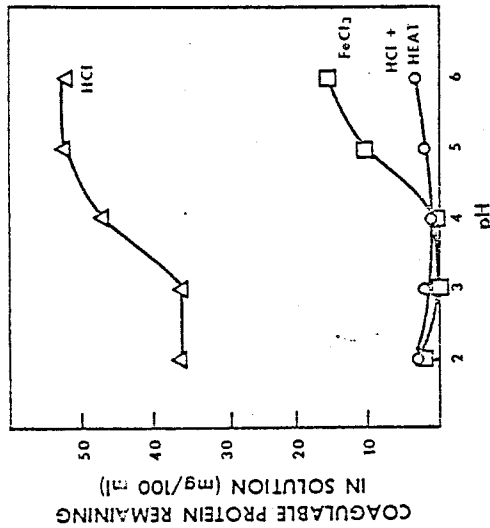


FIG. 2. RELATIONSHIP BETWEEN TCA HEAT INSOLUBLE PROTEIN REMAINING IN SOLUTION AND pH FOR THE DIFFERENT PRECIPITATION METHODS

RESULTS AND DISCUSSION

Protein Recovery

Laboratory experiments showed that FeCl₃ compared favorably with HCl/heat treatment at pH 2-4 with respect to the amount of coagulable protein recovered from the protein water (Fig. 2). At pH 5 and 6 HCl/heat was the most effective precipitation method studied.

By the use of TCA/heat, in combination, 37 ± 2% of the crude protein in the protein water was recovered (termed coagulable protein). Recoveries of crude protein by HCl, FeCl₃, and HCl/heat precipitation methods were 23 ± 1, 40 ± 1, and 35 ± 2%, respectively. These recoveries represented 62, 108, and 95% of the coagulable protein by HCl, FeCl₃, and HCl/heat precipitation, respectively. Thus, at pH 3.0 FeCl₃ was more effective than HCl in recovering potato protein concentrate (PPC). Meister and Thompson (1976) also found FeCl₃ to be more effective than HCl as a precipitant of potato protein. They reported that, at pH 3.0, 31 and 36% of the crude protein were recovered by HCl and FeCl₃ precipitation, respectively. From these data it is also apparent that Meister and Thompson achieved more effective results

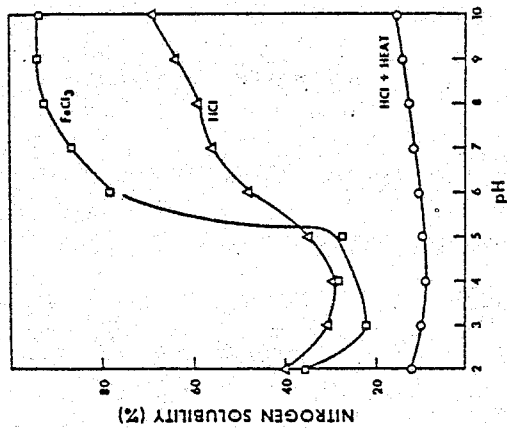


FIG. 3. RELATIONSHIP BETWEEN NITROGEN SOLUBILITY AND PH-OF DIFFERENT POTATO PROTEIN CONCENTRATES

Amino Acid Analyses

With the exception of arginine, aspartic and glutamic acids, the amino acid composition of the HCl/heat treatment PPC was equal or greater than that reported by FAO (1972) for potato protein (Table 3). The higher levels of methionine and cystine in PPC are of interest since these amino acids were previously reported to be low in potato protein (Scrimshaw and Young 1976). When compared with FAO (1973) Provisional Amino Acid Scoring Pattern, the PPC contain quantities of amino acids equal to or greater than the suggested levels for all the essential amino acids (except tryptophan which was not determined).

In summary, FeCl₃ and HCl/heat treatment recovered similar quantities of potato protein, whereas HCl at room temperature was the least effective method. Differences between these precipitation methods include the energy input required for steam (HCl/heat) and ingredient costs (HCl, FeCl₃). Compositional differences among the PPC precipitated by various methods included higher crude protein in the HCl/heat precipitate, higher vitamin C and ash in those PPC precipi-

Table 3. Amino acid analyses of potato protein concentrates recovered by various methods

Amino Acid	Precipitation Method			
	HCl	FeCl ₃	HCl/Heat	Potato Protein FAO (1972)
	g/16 g N			
Lysine	6.02	6.46	6.79	5.28
Histidine	2.04	2.03	2.11	1.76
Arginine	4.40	4.76	4.74	5.28
Aspartic Acid	12.83	13.37	11.08	13.12
Threonine	4.27	4.43	4.86	3.84
Serine	4.15	4.49	4.90	3.52
Glutamic Acid	11.67	11.58	10.47	17.60
Proline	3.35	3.70	4.11	3.84
Glycine	3.51	3.86	4.14	3.52
Alanine	4.01	3.91	4.41	4.00
Cystine	1.41	1.74	1.47	0.94
Valine	5.50	5.89	6.24	5.76
Methionine	2.09	1.96	2.70	1.12
Isoleucine	4.53	4.76	5.20	3.84
Leucine	7.20	7.41	8.53	6.24
Tyrosine	4.17	4.30	4.74	2.72
Phenylalanine	4.67	4.82	5.34	3.36

tated at ambient temperatures (HCl, FeCl₃) and higher Fe values in the FeCl₃ precipitate. In terms of functionality, PPC precipitated by all three methods possessed similar whipping capacity. Differences included greater nitrogen solubility for the FeCl₃ precipitate, with the highest water absorption capacity and fat absorption capacity exhibited by the HCl/heat and HCl precipitates, respectively. The ultimate selection of a precipitation method for potato protein will depend upon an analysis of the nutritional and antinutritional, economic, engineering, compositional and functional parameters, within the constraints of the end product use of the PPC.

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POTATO PROTEIN RECOVERY

with HCl and somewhat less effective results with FeCl₃ when compared with results reported in the present study.

Results obtained in the pilot plant with simulated waste effluent indicated that FeCl₃ and HCl/heat were equally effective in recovering protein (Table 1), with HCl recovering significantly less crude protein. Quantities of protein recovered by HCl and FeCl₃ were 62 and 99%, respectively, of the TCA/heat coagulable protein. The recovery of PPC by various methods was also studied in the pilot plant with commercial "potato cut water." Thus, results were similar to those obtained with simulated potato processing water. By using FeCl₃ as a coagulant, 97% of the TCA/heat coagulable protein could be recovered.

The quantity of FeCl₃·6H₂O required to precipitate PPC was 1.6 kg per kg protein (dm). By raising the precipitation pH to 4.0, 0.9 kg FeCl₃·H₂O would be needed per kg protein. Although laboratory experiments by the authors indicated that slightly less protein would be recovered at pH 4.0 (Fig. 2), Meister and Thompson (1976) showed that FeCl₃ precipitation produced maximum recovery at pH 4.0.

Composition

Proximate analyses of the spray dried PPC revealed that the crude protein contents of the HCl, FeCl₃, and HCl/heat precipitates were 65.6, 57.5, and 78.2%, respectively. In addition to the differences in protein content of the PPC recovered by various methods, major compositional differences were observed for ash, vitamin C, iron and sodium (Table 2). The increased ash content associated with HCl precipitation at room temperature was also observed by Meister and Thompson (1976), who noted that HCl recovered more total solids from the effluent than does precipitation by HCl/heat. The PPC precipitated at ambient temperatures with HCl and FeCl₃ would be more appropriate for human consumption if ash values were reduced. Vitamin C content (15-18 mg/100 g) was significantly higher in those PPC recovered at room temperature, whereas the FeCl₃ precipitate was markedly higher in iron than the other two precipitates.

Functional Properties

With the exception of whipping capacity, those functional properties of PPC evaluated were markedly influenced by method of precipitation. Nitrogen solubility of PPC recovered at room temperature was much higher than that of the HCl/heat precipitate (Fig. 3). At pH 6 and above, the nitrogen solubility of FeCl₃ precipitate was superior to that precipitated by HCl; at pH 7, it was >7 times that of the HCl/heat

Table 2. Analyses and select functional properties of potato protein concentrates^a

Composition/Property	Precipitation method		
	HCl at RT	FeCl ₃ at RT	
		HCl/heat	
		% Dry matter ^b	
Total solids (%)	93.7	94.7	95.4
Nitrogen	10.5	9.2	12.5
Crude fat	2.3	1.3	2.4
Ash	24.5	25.1	7.2
Total sugars	3.6	2.6	1.3
Total Carbohydrates	7.2	7.1	7.1
Total Vitamin C (mg/100 g)	18.1	14.9	0.01
Calcium	0.14	0.04	0.14
Iron	0.10	4.32	0.12
Magnesium	0.20	0.11	0.10
Sodium	4.25	3.85	1.53
Functional Properties		Percent	
Nitrogen solubility (pH 7)	56.0 ± 0.1 ^c	87.5 ± 2.1	11.5 ± 0.7
Water absorption capacity (pH 7)	214 ± 3	86 ± 5	273 ± 6
Fat absorption capacity (pH 7)	234 ± 16	188 ± 10	110 ± 10
Whipping Capacity Foam			
(% Volume increase pH 7)	568 ± 40	524 ± 9	523 ± 9

^aMeans of 2 to 5 replications

^b% dry matter unless otherwise indicated

^cMeans ± standard deviation

precipitated PPC (Table 2). Increased nitrogen solubility indicates that the PPC were less severely denatured during processing, and would more likely be functionally active in food systems in which protein solubility was a prerequisite.

Water absorption capacity was highest in the HCl/heat precipitate which had been most severely heated during precipitation, whereas fat absorption capacity was the lowest in this precipitate (Table 2). The high water absorption of heat precipitated plant proteins vs those recovered with HCl at room temperature has also been reported for alfalfa leaf protein concentrate (Betschart and Kohler 1975). HCl precipitation produced the PPC with the most favorable fat absorption capacity. The spray dried PPC precipitated by HCl were light and fluffy, with greyish beige overtones. That precipitated at room temperature was the lightest in color, whereas the FeCl₃ precipitate had a light green cast.

These data on functional properties within simple, model systems provide an indication of potential functionality in food systems.

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APPENDIX 2

Interpretive Summary

About $12,760 \times 10^3$ metric tons of potatoes (containing 263,000 metric tons crude protein) are utilized in the USA for food processing every year. Only 20-30% of the vegetable plants in the USA is utilized directly for human consumption. ^{For this reason} $\sqrt{\quad}$ the potato processing plant (potato chips, flakes, granules, french fries, starch, etc.) effluents are a major protein source as well as a major waste disposal problem.

The commonly used recovery process for potato proteins is acid/heat precipitation. This heat treatment leads to protein concentrates with low solubility which is a limiting factor for their use in food systems. Another disadvantage of the heat treatment are the energy costs $\sqrt{\quad}$ ^{to} heat the protein water up to the precipitation temperature.

The present study shows a way to precipitate all of the coagulable protein of the waste effluents at room temperature. The resulting potato protein concentrate has a nitrogen solubility 7.5 times higher than the solubility of the acid/heat precipitated concentrates.

Abstract^s

Potato processing waste effluents represent a potential source of valuable protein as well as a major waste disposal problem. The most common way to coagulate potato protein is by heat precipitation (mainly 95-100°C) combined with an adjustment of the pH (pH 3.5 - 5.5). An important disadvantage of the heat coagulation are energy costs for heating the protein water (about 2-5% solids; the solids contain about 35% crude protein). Another common occurrence of heat coagulated potato proteins is the low solubility which is limiting for the potential application of these proteins in human foods.

The results of the present study show that protein precipitation by using iron(III) chloride at room temperature is equal to acid/heat precipitation with respect to the yield of protein to the protein quality recovered, and to some functional properties. The nitrogen solubility of the protein concentrate recovered with iron(III) chloride is about 7.5 times higher than that of the acid/heat precipitated product.