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SEED QUALITY IN CHILLI INFLUENCED BY THE DIFFERENT TYPES OF DRYING METHODS

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ABSTRACT

Chilli drying methods were evaluated with respect to temperature and time combination and quality parameters, including physicochemical properties. Studies were carried out to find out the influence of different drying methods on seed quality, physical parameters of whole chilli and biochemical constituents in chilli seeds. PLR-1 variety chilli seeds were selected for this study. Chilli dried by sun and mechanical drying at 37^{0}C were recorded higher vigour index, Germination, Root length, Shoot length, seedling dry weight, and lower electrical conductivity, moisture content. The nutrient content also higher in this parameter (Sun, Mechanical drying) *viz.*, Capsaicin, ash content, protein, Ascorbic acid, Carbohydrate, Iron, but lower seed quality parameter and nutrient content were recorded in shade and in room drying methods. So seems to this results better quality found the Sun and Mechanical drying (oven) and low quality found in the shade and room drying methods.

INTRODUCTION

Chillies, come in all shapes, sizes and colours ranging from tiny pointed extremely hot, bird's eye chilli to the large mild fleshy peppers like the Anaheim. Chilli seeds are produced in the process of making dry chillies. Seed moisture plays major role in determining the longevity of seed in several vegetables, particularly in chilli. Most of the vegetable seeds can withstand drying to extend their storage life with low moisture content. All kinds of drying methods will not suit equally well under given set of conditions in retaining viability and vigour of seeds. Drying of chilli fruits too rapidly or with high air temperature is certainly cause injurious to seed Copeland (1976). After extraction of seeds from the fruits, seed moisture content varies generally from 40 to 45 per cent. It has to be reduced to safer level of 8 to 9 per cent by drying to preserve the quality of seed during storage (Rajkumar 1973; Javaregowda *et al.,* 1994; Gowda, 1997).

Chilli (*Capsicum annuum .L*) is a highly perishable crop after harvest in a ripened condition at moisture content of 310 % (d.b.) as against its safe moisture level of 8% (d.b.) Chandy (1992). Therefore, the produce is to be dried in a manner that it retains its physical characteristics with red colour and luster. Delay in drying results in growth of micro flora and subsequent loss of quality leading to total spoilage (Singh *et al.,* 1982). Drying is the process of thermally removing moisture to yield a dried solid product. It is a complex process due to a simultaneous heat and mass transfer (Ponting and McBean, 1970). The most important reasons for popularity of dried products are longer shelf-life, product diversification as well as substantial volume reduction to decrease transportation cost. This could be further expanded by improvements in product quality and process applications (Simal, Dey and Rosello, 1997). Roopa (2006) who had reported, seeds dried in oven at 40°C temperature recorded significantly higher speed of germination, germination, seedling length, seedling dry weight and vigour index with lower moisture content. Most have used air temperatures of between 50-80^{o}C. It has been found that the higher temperatures resulted in reduced drying time and an increase in the effective moisture diffusivity (Kaleemullah and Kailappan, 2005; Vega *et al.*, 2007; Di Scala and Crapiste, 2008). However, using high temperatures for drying produces a low quality of chilli, with losses of volatile compounds, nutrients and color (Di Scala and Crapiste, 2008; Kaleemullah and Kailappan, 2006).

Laul *et al.* (1970) have investigated ways of improving sun drying method for Indian chillies. The values of various quality attributes for all varieties at all the drying temperatures are compared with standard values of capsaicin content and colouring matter (Gurpreet Singh, 1997).

The present in work is conducted with the specific objective to find out the influence of different drying methods on seed quality and biochemical constituent of chilli seeds.

MATERIALS AND METHODS

All experiments were conducted in the Department of Microbiology, Annamalai University, Tamil Nadu, India. All the chemicals used were AR grade unless or otherwise stated as the double distilled water was used throughout the study. The PLR-1 variety chilli was obtained from Vegetable Research Station, Palur, Cuddalore,. The seeds were collected manually and red ripe chilli fruits were dried by different dying methods. Freshly harvested ripening chilli (PLR -1) were collected and subjected to different drying methods with five replication. The treatments details

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T_1 - Sun
T_2 - Shade
T_3 – On zinc sheet (0.8mm)
T_4 – Oven drying (37^0C)
T_5 – On Concrete tiles
T_6 – Room temperature.

The seed quality parameters such as moisture content (%) and germination percentage were accessed by adapting ISTA procedure (Anonymous, 1996). About 5 gram of seed sample was surface sterilized with 0.1% $HgCl_2$ for 10 min followed by through washing with distilled water. The clean seed were immersed in 100 ml of water at 25 ± 1^0C temperature for 10-12 hours. After this the seeds were removed with a clean forceps. The steep water left was decanted and it was termed as leachate. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge with a cell constant 1.0 and the mean values were expressed in deci simons per meter (dSm^{-1}).

Hundred seeds each in each treatment were germinated in laboratory condition for germination test. While evaluating the number of normal seedlings at the time of final count, the seedling length of 5 randomly selected seedlings were measured. Seed vigour index is calculated by multiplying germination (%) and seedling length (cm).The seed lot showing the higher seed vigour index is considered to be more vigorous. The vigour index (VI) was calculated by adopting Abdul-Baki and Anderson (1973). The plant shoot length, root length, seedling dry weight and field emergence were observed as per standard methods.

Ascorbic acid content

Ascorbic acid content was analyzed according to the indophenol method (Harris and Ray, 1935). Ground chilli seed powder (5.0 g) was homogenized with acid mixture (15 g metaphosphoric acid in 40 ml glacial acetic acid and 450 ml water), and filtered through Whatman No.1 filter paper. Known volume of filtrate (25 ml) was titrated against indophenols (42 mg sodium bicarbonate was dissolved into a small volume of water followed by the addition of 52 mg 2,6-dichloro phenol indophenols and the volume was make up to 200 ml with distilled water). The standard graph was developed by using standard ascorbic acid solutions.

Carbohydrate content

Carbohydrate content was determined by phenol sulphuric acid method (Dubois *et al.* 1956). Ground chilli seeds (100 mg) were hydrolyzed by keeping in boiling water bath for 3 hours with 5.0 ml of 2.5 N HCl and cooled to room temperature. The solution was neutralized with solid Na_2CO_3 until the effervescence ceases and the volume was made up to 100 ml with distilled water. The contents were then centrifuged at 8000× g for 30 min at 27^0C. One ml of supernatant was diluted to 100 ml with distilled water. About 1.0 ml diluted sample was transferred into test tube and 1.0 ml of 5% phenol 5.0 ml of conc. H_2SO_4 was added. The mixture was shaken well and kept in water bath maintained at 30^0C for 20 min. The absorbance of the solution was measured at 490 nm in UV–VIS dual beam spectrophotometer (Labomed, Inc., USA). Carbohydrate concentration in test sample was calculated using standard graph prepared with standard solution of glucose.

Protein content

Protein content was estimated as per the method of Lowry *et al*. (1951). Seed powder (500 mg) was mixed thoroughly in 10 ml of phosphate buffer (pH 6.6). The contents were centrifuged at 4000 × g for 30 min at 4^0C in refrigerated centrifuge (Sigma 3K30, 230 V, 50 Hz). One ml of supernatant was taken in a volumetric flask and made up to 100 ml with distilled water and used for protein estimation. From this, 1.0 ml of sample was taken into a test tube, to which 5.0 ml of alkaline copper sulphate was added, shaken well, and incubated for 10 min at room temperature. Then 0.5 ml of Folin-Ciocalteau reagent was added with proper mixing and allowed for 10 min for color development. The absorbance of the solution was measured at 650 nm on UV–VIS dual beam spectrophotometer (Labomed, Inc.USA). The seed protein contents were estimated with standard graph prepared with Bovine serum Albumin.

Capsaicin content

The capsaicin content was estimated as per by Palacio (1977). About 2.0 grams of ground-dried chilli was passed through No.40 sieve (0.42 mm) and was placed in the 100 ml volumetric flask. The capsaicin was extracted by diluting with ethyl acetate up to 100 ml and allowed to stand for 24 hrs. One ml of the extract was taken and diluted with 5 ml of ethyl acetate just before reading, and then 0.5 ml of vanadium oxytrichloride ($VoCl_3$) solution (0.5% $VoCl_3$ in ethyl acetate) was added and shaken thoroughly. The absorbance of the solution was measured at 720 nm in UV–VIS dual beam spectrophotometer (Labomed, Inc., USA). Then reading was subtracted from the value obtained with 0.5 ml $VoCl_3$ added to 5 ml ethyl acetate (blank) and the reading was compared with the standard curve prepared for capsaicin. The amount of capsaicin in the samples were analysed and expressed in percentage.

$$\text{Capsaicin (per cent)} = \frac{\mu\text{g capsaicin}}{1000 \times 1000} \times \frac{100}{1} \times \frac{100}{2}$$

Iron content

Iron content was analyzed according to the method of Wong (1928). Wherein, 0.2 g of chilli seeds was converted into ash in muffle furnace at 600^0C for 3 h. The ash was dissolved in 10 ml of 0.1 M HCl and the volume was made up to 50 ml with distilled water. 10 ml of solution was taken in a test tube, to which 1.0 ml of potassium per sulphate (7%) and 4.0 ml of potassium thiocyanate were added, mixed thoroughly and the absorbance of the solution was measured in UV–VIS dual beam spectrophotometer (Labomed, Inc., USA) at 540 nm. The iron content of the sample was determined by using standard curve.

STATISTICAL ANALYSIS

Differences among parameters were analyzed for seed quality and their nutrient content by standard deviation (±SD).

RESULTS AND DISCUSSION

Seed Quality parameter

The seed quality parameters such as Germination, vigour index, root length, shoot length, seedling dry weight, electrical conductivity and moisture content were presented in Table 1. Selvaraj (1988) reported the highest germination (75 %) of brinjal seed after ten days of drying under sun for 6 hours per day from 8 am to 11 am and from 2 pm to 5 pm on black polythene sheeted wire mesh held at 15 cm above floor level. Among the drying methods, the oven dying (T_4) at 37^0C recorded significantly higher germination (83.28 %) and Field emergence (79.81 %), the sun drying (T_1) also (82.80 %, 78.92 %) respectively. Drying the chilli on zinc sheet (T_3), concrete tiles (T_5) showed the low quality in germination (78.11 %, 74.45 %) and field emergence (72.17 %, 70.12 %) when compared to the shade (T_2), room drying (T_6) its improved results. Under the shade and room drying methods were showed very low results due to the moisture content, these methods took more time for dying chilli, the fungal infection also found in that. Similar report revealed by Harrington (1972), as if the moisture reduction takes place too slowly, then it may favour invasion of fungal pathogens. He also observed injury to the seed coat or cracking of endosperm or cotyledons as a result of rapid shrinkage of outer parts of the seed while, inner parts are still undried causing reduction in germination. Similar observations were also made by Kozlowaski (1972) who stated that due to rapid drying of seed, high temperature can seriously injure or kill the seed. However, for most of the vegetable seeds, 35- 40°C temperature is considered as safe.

Krishnamurthy (1995) while studying the different methods of fruit drying in chilli, he observed higher seed quality in sun drying among traditional methods (sun and shade), whereas, in mechanical drying at different air temperatures, seeds dried under 40°C temperature showed higher germination, field emergence and seedling vigour index. Sun (T_1) and oven (T_4) drying method showed high-quality vigour index (1946.4 % and 1950.0 %). Other methods had low vigour index (T_3 - 1733.1 %, T_5 - 1622.5 %, T_2 - 1532.2 %, and T_6 - 1500.3 %). Mini et al. (2003) reported that seeds of ashgourd when dried under shade gave maximum germination (77.29 %), speed of germination (16.28) and vigour index (563.15). While, the machine dried seeds showed lowest germination (71.63 %), speed of germination (15.88) and vigour index (518.82). Root length, shoot length, seedling dry weight and vigour index were varied.

Significantly high electrical conductivity of seed leachate (EC) was recorded inshade (T_2) (2.78 dSm^{-1}) and room ((T_6) (2.91dSm^{-1}) dying methods. Sun (T_1) and oven drying (T_4) methods showed low EC (0.81dSm^{-1}, 0.76 dSm^{-1}), when compared to the shade (T_2) and room drying (T_6) low EC for Zinc sheet (T_3) (1.56 dSm^{-1}) and concrete Tiles (T_5) (1.53 dSm^{-1}) dying methods. Significantly high moisture content was noted in the methods of room drying (T_6) (9.10 %) and low in oven drying (T_4) (7.40 %). These results are also in conformity with the reports of Harrington (1972), Ravi Hunje *et al*., (2007).

Ravi Hunje *et al.,* (2007) has revealed drying the fruits on red tiles, zinc sheet and tarpaulin caused slow drying compared to fruits dried on concrete floor under sun. Hence, these methods recorded comparatively less germination and field emergence compared to fruits dried on concrete floor under sun. Root length, shoot length, seedling dry weight and vigour index were varied significantly due to drying methods. Consequently, in the present study obviously revealed higher root length, shoot length and seedling dry weight were recorded in sun (T_1) and oven (T_4) drying methods.

Biochemical Analysis

Using high temperatures for drying, produces a low quality of chilli, with losses of volatile compounds, nutrients and color (Di Scala and Crapiste, 2008; Kaleemullah and Kailappan, 2006). The seed nutrient content such as ash content (%), capsaicin (%), protein (mg/g), carbohydrate (mg/g), ascorbic (mg/g), and iron content (mg/g) were presented in Table 2. The ash content was higher in oven (T_4) and sun (T_1) (3.00 %, 2.80 %) drying methods other methods showed slightly variation *viz.*, T_2- 2.30 %, T_3 -2.55 %,T_5 - 2.50 %, T_6 - 2.38 %. The important reactions occurring during drying are enzymatic and nonenzymic browning reaction. Enzymatic browning reaction can be prevented by pretreatment methods, such as blanching and chemical treatment, that bring about inactivated enzyme activity. (Gupta *et al.,* 2002; Hossain and Bala, 2002). On the other hand, the nonenzymatic reactions increase in rate at higher temperatures and at intermediate levels of moisture content in the fruit Manzocco *et al.,* (2001). This reaction is a diffusion-controlled binary reaction between amino acid and reducing sugar, namely the Maillard reaction. It produces color and flavor, which are features of quality change in a food product (Miao and Roos, 2006). Not only do Maillard reactions cause brown or dark colors in dried food product, other reactions may also be involved such as pigment degradation, chemical oxidation of phenols and ascorbic acid (Manzocco *et al.,* 2001; Sigge *et al.,* 1999).

The Capsaicin and Ascorbic acid content were lower in T_2 (0.23 %, 32.10 mg), T_5 (0.25 %, 38.12 mg), T_6 (0.27 %, 31.40 mg), due to the fungal invasion. Fasoyiro *et al.* (2005) indicated that the method of process-sing seeds has large effect on the nutrient and antinutrients content of three varieties of pigeon pea (*Cajanus cajan*). Singh Oberoi *et al.* (2006) revealed there was no difference in the oleoresin content, but capsaicin content was lower in chillies dried under hot sun. There was nearly a 2-log (cfu/g) reduction in total bacterial counts in dryer dried chillies as compared to sun dried ones, although no difference could be observed in the Lactobacilli colonies. A marked reduction in yeast and fungal colonies in dryer dried samples as compared to sun dried samples could be seen. *Escherichia coli* and *Salmonella* were not observed in dried chilli samples using either of the drying methods. The higher Protein (73.20 mg, 74.65 mg), Iron (1.2 mg, 1.3 mg), Carbohydrate (350 mg, 360 mg), content were recorded in T_1 and T_4 drying methods.

Table 1 Influence of different drying methods on seed quality parameters of chilli (PLR-1)

Drying methods (T)	Electrical conductivity (dSm^{-1})	Moisture content (%)	Germination (%)	Vigour index	Root length (cm)	Shoot length (cm)	Seedling dry weight (gm)	Field emergence (%)
T_1	0.81±0.040	7.54±0.377	82.80±4.14	1946.4±97.32	8.45±0.422	7.95±0.397	18.20±0.91	78.92±3.946
T_2	2.78±0.139	9.00±0.450	73.23±3.66	1532.2±76.61	6.81±0.340	7.25±0.362	13.90±0.69	60.48±3.024
T_3	1.56±0.078	8.52±0.426	78.11±3.90	1733.1±86.65	7.64±0.382	6.81±0.340	14.50±0.72	72.17±3.608
T_4	0.76±0.038	7.40±0.370	83.28±4.16	1950.0±97.50	8.59±0.429	8.36±0.418	18.40±0.92	79.81±3.990
T_5	1.53±0.076	8.60±0.430	74.45±3.72	1622.5±81.12	7.54±0.377	7.00±0.350	15.70±0.78	70.12±3.506
T_6	2.91±0.145	9.10±0.455	71.38±3.56	1500.3±75.01	6.45±0.322	6.88±0.344	14.90±0.74	53.18±2.659

T_1- Sun, T_2- Shade, T_3- Zinc sheet, T_4- Oven, T_5- Concrete tiles, T_6- Room temperature
The values are mean ± SD for five samples in each group.

Table 2 Influence of different drying methods on biochemical parameters of chilli seeds (PLR-1)

Treatments	Ash content (%)	Capsaicin content (%)	Protein content (mg/g)	Carbohydrate content (mg/g)	Ascorbic acid content (mg/g)	Iron (mg/g)
T_1	2.80±0.14	0.36±0.019	73.20±3.66	350±17.50	40.31±2.01	1.2±0.06
T_2	2.30±0.11	0.23±0.011	59.78±2.98	235±11.75	32.10±1.60	0.5±0.02
T_3	2.55±0.12	0.28±0.014	68.40±3.42	275±13.75	39.32±1.96	0.7±0.03
T_4	3.00±0.15	0.37±0.018	74.65±3.73	360±18.00	41.56±2.07	1.3±0.06
T_5	2.50±0.12	0.25±0.015	69.70±3.48	247±12.35	38.12±1.90	0.9±0.04
T_6	2.38±0.11	0.27±0.013	58.18±2.90	212±10.60	31.40±1.57	0.3±0.01

T_1- Sun, T_2- Shade, T_3- Zinc sheet, T_4- Oven, T_5- Concrete tiles, T_6- Room temperature
The values are mean ± SD for five samples in each group

CONCLUSION

This study was conducted with the main objective of determining the influence of seed quality and nutrient content on chilli by different drying methods. Seed metabolic activities commonly increase with temperature and moisture content. Simultaneously, high moisture content reduced seed germination, and its leads to the seed spoilages. The seeds quality and nutrient content were good in sun and oven drying methods. Low content was found in other methods *viz.*, Shade, Concrete tiles, Zinc sheet, and Room temperature due to the fungal attack. Seed deterioration is an unalterable process. Therefore the drying methods can protect from seed deterioration for particular period of dried seed.

References

Abdul-Baki, A. A. and Anderson, J. D. 1973. Vigour determination in soybean seeds by multiple criteria, Crop Sci, 13: 630-633.

Anonymous, 1996. International Rules for seed testing, Seed Science and Technology, 29 (Suppl):1-335.

Chandy, 1992. Effects of some physical treatments on drying characteristics of red chillies, Proceedings of International Agricultural Engineering Conference held at Bangkok, Thailand, pp. 492-498.

Copeland, L.O. 1976. Principles of Seed Science and Technology, Burgers Publication Co., Minnessoe.

Di Scala, K. and Crapiste, G. 2008. Drying kinetics and quality changes during drying of red pepper. LWT-Food Science and Technology 41(5): 789- 795.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers. P.A. and Smith, F. 1956. Anal. Chem., 26, p. 350.

Fasoyiro, A., Saka, A., Obatolu, F., Afolabi, A. 2005. Physical characteristics and effects of processing methods on pigeon pea varieties, J. Food Agric. Environ. On line. WFL vol. 3.

Gowda, H.G. 1997. Effects of stages of harvesting and drying methods on seed quality in onion. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Gupta, P., Ahmed, J., Shivhare, U.S. and Raghavan, G.S.V. 2002. Drying Characteristics of Red Chilli. Drying Technology 20(10): 1975-1987.

Gurpreet Singh, 1997. Evaluation of chilli genotypes for yield and processing Unpublished MSc. Thesis, Punjab Agricultural University, Ludhiana, Punjab.

Harrington, J.F. 1972, Seed storage and longevity. In: Seed Biology, 3: 145-245.

Harris L.J. and Ray S.N. 1935. Biochemical methods. Lancet 1:462–463.

Hossain, M.A. and Bala, B.K. 2002. Thin- Layer Drying Characteristics for Green Chilli. Drying Technology, 20(2): 489-505.

Javaregowda, S., Mahboob Ali Khan and Jagadish, G.V. 1994. Effect of drying methods on seed quality in brinjal (*Solanum melangena L.*). Seed Tech News, 24: 101-102.

Kaleemullah, S. and Kailappan, R. 2005. Drying Kinetics of Red Chillies in a Rotary Dryer. Biosystems Engineering 92(1):15-23.

Kaleemullah, S. and Kailappan, R. 2006. Modelling of thin-layer drying kinetics of red chillies. Journal of Food Engineering 76: 531-537.

Kozlowaski, T.T. 1972. Seed Biology. Vol. III, Academic Press, New York, pp.351-356.

Krishnamurthy, V. 1995. Effect of harvesting stages, drying, seed extraction and size grading on seed yield and quality in chilli (*Capsicum annuum L.*). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore.

Laul, M.S., Bhalerao, S.D., Rane, V.R. and Amla, R. 1970. Studies of the sun drying of chillies. Indian Food Packer. 24(2): 22-25.

Lowry O.H., Rosebrough N.J., Farr A.L. and Randall R.J. 1951. Protein measurement with the Folin phenol reagent. J. Biol Chem. 193 (1):265–275.

Manzocco, L., Calligaris, S., Mastrocola, D., Nicoli, M.C. and Lerici, C.R. 2001. Review of non-enzymatic browning and antioxidant capacity in processed foods. Trends in Food Science and Technology 11: 340-346.

Miao, S. and Roos, Y.H. 2006. Isothermal study of nonenzymatic browning kinetics in spray-dried and freeze dried systems at different relative vapor pressure environments. Innovative Food Science and Emerging Technologies 7: 182-194.

Mini, C., Meagle Joseph, P. and Sadhan Kumar, P.G. 2003. Seed extraction and drying techniques in ash gourd (Benincasa hispida). Seed Research, 31(1): 53-57.

Palacio, J J R. 1977. JAOAC **60** 970.

Ponting, J. D. and McBean, D. M. 1970. Temperature and dipping treatment effects on drying rates and drying times of grapes, prunes and other waxy fruits. Food technology, 24 (12):85-88.

Rajkumar, 1973. Design, development and testing of a baffle type mode chilli drier. M.Tech. Thesis, Indian Institute of Technology, Khargapur.

Ravi hunje, B. S. vyakarnahal and R. C. Jagadeesh, 2007. Influence of Drying Methods of Fruits on Seed Quality in Chilli (Capsicum annuum L.). Karnataka J. Agric. Sci., 20(2): 269-271.

Roopa, V, 2006. Influence of post harvest handling techniques on seed quality and storabilityof muskmelon (*cucumis melo L*.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Selvaraj, J.A. 1988. Studies on sun drying of brinjal seed. South Indian Horticulture, 36(5): 273-276.

Sigge, G.O., Hansmann, C.F. and Joubert, E. 1999. Optimizing the dehydration conditions of green bell peppers (*Capsicum annuum L.*): Quality criteria. Journal of Food Quality 22: 439-452.

Simal, S., Dey A. E. and Rosello, C. 1997. Simple modeling of air drying curves of fresh and osmotically predehydrated apple cubes. Journal of Food Engineering, 33(1-2): 139-150.

Singh Oberoi, H., Ahmad Ku, M., Jaspreet Kaur and Bangali Baboo. 2006. Quality of red chilli variety as affected by different drying methods. Journal of Food Science and Technology, 42 (5): 384–387.

Singh, H. and Alam, A. 1982. Techno-economic study on chilli drying. Journal of Agricultural Engineering. 19: 27-32.

Vega, A., Fito, P., Andrés, A. and Lemus, R. 2007. Mathematical modeling of hot-air drying kinetics of red bell pepper (var. *Lamuyo*). Journal of Food Engineering. 79:1460-1466.

Wong, S.Y. 1928. Colorimetric determination of iron and haemoglobin in blood.II. J. Biol Chem. 77:409–412.